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THE *X*-RAY DIAGNOSIS OF ACCESSORY SINUSITIS*

BY JAMES GERRITT VAN ZWALUWENBURG, M.D.

University Hospital

ANN ARBOR, MICHIGAN

THE examination and interpretation of roentgenograms of the pneumatic structures of the head are beset with so many difficulties that the method has never enjoyed the wide application that it deserves. Much serious study has been applied to this field and there are numerous publications on the subject. Many special positions and projections have been proposed, and in the hands of experts these are undoubtedly of great value. The beginner, however, is apt to be confused by all this, and, after all is said and done, the surgeon and the internist are not impressed with the authority of the average roentgenographer and pay scant attention to his opinions.

This paper was undertaken in the hope that some improvement in this situation might result through the application of old principles rather than through the contribution of anything essentially new, and through the adoption of a simpler but more comprehensive routine technique.

TECHNICAL DISCUSSION

After struggling for some time with the methods available and in the face of an unsympathetic surgeon, we took stock of the situation and drew up the following requirements as essential to accurate judgment.

1. The structures of the nose and of all the sinuses should be demonstrated at a single routine examination.

2. Opportunity should be offered for the direct comparison of symmetrical parts.

3. Since the confusing shadows of the structures of the base of the skull and the cervical spine cannot be obviated by any one position or projection, sufficient differentiation of these structures should be offered so that their shadows may be recognized and separately appreciated and evaluated.

We believe these requirements are very nearly met by the technique that was finally adopted. While not new in any particular, we wish to lay emphasis on certain features that we believe important. It provides for a strictly sagittal projection, covers all of the region under examination at one time, demonstrates satisfactorily the structures of the nose, and depends on stereoscopic vision to differentiate the petrous portions of the temporals and the cervical spine and to lift them out of the region that is the subject of special study. This differentiation depends on the sharpest possible definition and this can be attained only by using a very small focus spot at a considerable distance and with a narrow cone. Further, we aim to project the petrous portions of the temporals into the lower portions of the orbits where their shadows will nicely dovetail with those of the butterfly-shaped ethmoid labyrinth without serious overlapping of shadows.

* Read at the Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

Everything depends on the fineness of the detail in the posterior portion of the field. This, we believe, can be accomplished only by the use of the fine focus radiator type tube. In our experience the 30 ma. tube will not do. The broader focus spot increases the width of the penumbra—to borrow an optical expression—"the circle of confusion" is too large. Theoretically, an improvement in the definition may be produced by increasing the focus-plate distance. But one loses all the advantages of the greater capacity of the tube in the added energy requirement, and an identical exposure time is necessary.

Our practice is to use the 10 ma. radiator type tube, loaded to 8 ma. under a tension equivalent to about a 5½ or 6 inch back-up spark. A long cone with small diaphragm is employed providing a circle of illumination on the plate not exceeding 5 inches in diameter. The patient lies prone with the forehead in contact with the plate changer, which is inclined at an angle of 22 degrees from the horizontal The position of the focus spot in the sagittal plane is determined by a line passing from a point just below the outer canthus of the eye through the external auditory meatus and upwards. The head is fixed by a thin pad of cotton, this is in turn covered by an aluminum hemisphere and held in place by the pressure of the cone which is lowered upon it. The exposure time is approximately 240 ma.s. For the second plate of the stereo set the tube is moved cephalad 2½ or 3 inches.

A slight deviation from the strictly sagittal position is not so serious in the individual with a well-rounded neck, but many individuals have necks that are far from circular in cross section and under such circumstances the extra shadows of the soft tissues projected to one side produce serious confusion. Such oblique projection is further apt to cover the more lateral of the posterior ethmoids with the shadow of the processus pyramidalis. Sagittal projection on both plates is very important.

The importance of the small focus spot cannot be over-emphasized. Upon it depends the greater "depth of focus," if I may borrow another optical expression, and this "depth of focus" is the fundamental basis of the superior stereoscopic image of the plates made by this technique. The ordinary practice aims principally at a sharp focus only in those structures in which one is primarily interested and attempts to bring them into definition by placing them close to the plates. It then attempts to remove the bothersome shadows from behind by oblique projection. We, however, depend rather on lifting them out of the way by the superior stereoscopic vision made possible by the greater definition in the objectionable overriding shadows.

Stereoscopic vision depends directly on the sharpness of definition. It consists in the subconscious summation of innumerable triangulations, each based on some sharply defined point. In the absence of such fine points, stereoscopic vision fails, and in the presence of only a few poorly defined points, the image is correspondingly indefinite. The further back in the skull we can carry the requisite definition the less trouble we shall have with the confusion caused by overlying shadows. The eye and the visual centers will then subconsciously evaluate the densities traversed by the visual rays and leave the attention free to estimate the densities of the structures in which we are primarily concerned.

In this connection it should be noted that the tube shift in the sagittal plane of the body contributes in no small degree to the sense of depth in the stereo image. It is, I believe, a well-recognized principle that undifferentiated lines running in the horizontal direction across the field of vision cannot be located with reference to their depth and therefore the general rule that the tube shift must always be carried "across the principal lines of the picture." It so happens that the structures that we are most anxious to place accurately, viz., the floor of the anterior fossa, the sphenoid, the tegmen of the petrosal, the condyles of the occiput, the lateral bodies and the transverse processes of the cervical vertebrae, are all better differentiated along horizontal lines. It is fortunate that the longitudinal tube-shift also gives a rigidly sagittal projection on both plates of the stereoscopic set.

However, the physical limitations of the tube leave us considerably short of the perfect plate and we are obliged to exercise considerable care to place the most conspicuous and troublesome shadows (those of the petrous portion of the temporals) where they will cause the least confusion, viz., in the lower portion of the orbits.

We demand that our plates shall show clearly and in good stereoscopic vision the lateral processes of the atlas and axis and the tip of the odontoid process. The latter should lie in the mid-line and should not reach above the lower third of the septum of the nose. It is necessary to recognize clearly the structures of the upper nasal passages as well, if one is to judge of the associated conditions in the sinuses.

It is not necessary to catalogue the large number of other structures that one can recognize. The list grows longer as we see more and more plates.

The position here advocated necessarily throws the long axis of the ethmoid labyrinth almost directly in the line of vision and superimposes the posterior ethmoid shadows on the anterior group. This is the most frequently heard objection to this technique. Here again we depend on the greater brilliancy of the stereoscopic image to distinguish the position of the shadows which we believe abnormal. This is the more feasible, because, as I expect to show later, we depend for our interpretation on the changes in the bony structures more than on the hazy opacities that are caused by the exudates and the soft tissue changes in the diseased pneumatic cells. The frontal sinuses are not spread over so wide an area as in the other positions, but this objection is more than compensated by the superior view one obtains of the infundibulum and the associated ethmoid cells of the anterior group. We have experienced little difficulty in recognizing disease in this neighborhood since adopting the technique described.

PATHOLOGY

All that we know of the clinical history, the etiology, and the pathological sequences in chronic sinus infections teaches that they are complications or sequelae of disease processes that have their inception in the nose or teeth. When the accessory sinuses become involved in an acute inflammatory process extending from either of these points, healing is prompt and complete unless there are causes in the nose prolonging the infection. In the normal sinus there is little tendency to chronicity. It is only when structural changes in the turbinates, in the septum, or in the mucosa of the nose interfere with the proper drainage and aeration of the sinuses or constantly supply fresh accretions of infective materials to the sinuses that the latter fail to recover.

Perhaps the most common sequence is something like this: A primary deviation of the septum, secondary and to some degree compensatory hypertrophy and atrophy of the turbinates, contacts, spurs, and consecutive changes in the nasal mucosa, occlusion of the ostia of the sinuses by swelling of the mucous membrane and finally, infection of the accessory structures of the labyrinth.

The discovery of any one of these changes in the roentgenogram of the nose therefore has an important bearing on the diagnosis of the condition of the sinuses and we need not be entirely dependent on the rhinologist for their demonstration. Many of them can be clearly recognized on the *x*-ray plate. Therefore, the nose deserves as much attention as the sinuses and reliable judgment can only be based on a consideration of the entire related region as a whole.

The first effect of an acute infection of the sinuses is seen in the hyperemia, edema, and cellular and fluid exudates within the mucous membrane and on the surface. The nature and extent of these changes probably vary as do those in the mucosa of the nasal cavity with the nature of the virus and the virulence of the infection. To the roentgenologist, the cells should appear denser than normal through the replacement of the normally contained air by a denser material.

With a greater duration of the process, rather divergent processes appear, depending on factors with which we are not entirely familiar. On the one hand, the process may become frankly purulent, the mucous membrane become atrophic, the submucous layers become sclerotic, and through the irritation of the periosteal layers of the submucosa, extensive sclerosis and osteoplastic changes result in the bony septa and walls of the sinuses. These processes are extended by continuity along the bony structures of the lateral walls of the nose to the origins of the turbinates, causing hypertrophies and increased densities. These in turn encroach upon the air spaces of the nose and by their deformities and the attendant hypertrophies of their mucous membranes interfere with the drainage of the sinuses and establish a vicious circle. The formation of polyps at the points of greatest irritation by the escaping exudates further complicates the situation and tends to maintain the inflammation in the sinuses.

On the other hand, the changes in the mucous lining of the sinuses may take the form of an extensive edema, with a hypertrophy of the lymphoid elements and the mucous cells of the membrane leading to the so-called polypoid degeneration. The effect upon the underlying bony tissue is not that of an osteoplastic but an osteoclastic and osteoporotic change—the septa lose their lime salts and appear to shrink. These changes also are transmitted to the adjacent nasal structures with a corresponding reduction in the density and size of the turbinates. In the cases of the upper and middle turbinates the mucosa is usually reduced in thickness and in density. The effect on the *x*-ray plate is therefore the entire occlusion of the upper nasal passages with an abnormally free space below the level of the lower margin of the middle turbinates.

The differences in the histological pictures within the sinuses are well summarized by Skillern on the following counts:

1. The purulent type shows a general metaplasia of the ciliated epithelium where it comes in contact with the secretions; the hypertrophic type shows such changes only at points of pressure or contact.

2. The purulent type shows a sclerosis of the submucous connective tissues; the hypertrophic shows a dilation of its meshes and lymph spaces.

3. The purulent type shows extensive round cell infiltration; the hypertrophic does not.

4. The purulent type produces a primary atrophy of the glands; the hypertrophic type produces a hypertrophy of these structures.

5. The purulent type leads to deposition of bony tissue in the subperiosteal layer; the hypertrophic leads to osteoporosis.

This last item is of supreme interest to the roentgenologist.

While polyps occur in both types of disease, they are largely confined to the intranasal structures in the purulent type of the disease, while the entire ethmoid labyrinth and the maxillary sinuses are usually filled with large masses of these structures in the hypertrophic type. For this reason, it is usual to speak of the latter as "polypoid disease." We greatly prefer this designation because of the contradiction between the predominant *x*-ray findings and the descriptive content of the adjective "hypertrophic."

On clinical grounds the nasal surgeon also recognizes these two types of chronic infection of the accessory sinuses. This classification is apparently made principally on the changes in the mucosa and the nature of the exudate found in the cavities of the sinuses.

The purulent type is distinguished clinically by a distribution limited to one or a few related cavities, by deformities of the septum and hypertrophies of the turbinates, the occurrence of a few polyps about the ostia of the sinuses and the escape of free pus from their interior. The latter feature is the principal evidence on which the surgeon bases his diagnosis.

The hypertrophic or polypoid type has a more widespread distribution; it is less commonly associated with deformities of the septum, shows atrophy instead of hypertrophy of the lower turbinates, involving the bony as well as the soft tissue elements of these structures; but the outstanding feature of many cases is the extensive degeneration of the mucosa of the upper nasal passages and of the accessory sinuses. The picture within the nose is often that of an "atrophic rhinitis."

The above statement that polypoid

disease is usually widely distributed is at variance with the usual texts. For instance, the best text at hand makes the following statement:

"While pansinusitis of one side is uncommonly met with, that where all the sinuses are simultaneously involved belongs to the greatest rarity."

My experience is that true polypoid disease is more commonly general than limited in distribution. I recall very few cases that were not symmetrical in distribution, and while under such circumstances the demonstration of the completeness of the involvement is obviously difficult, my impression is that incomplete involvement is the exception. Not unusually the maxillaries seem to be less extensively diseased, but this may represent merely an earlier stage of the disease. Except for this, no clear stages of the disease have come to my notice. Partial or limited involvements which might be interpreted as chronological stages of the disease are rare and of questionable significance. Once the ethmoid labyrinth is involved, all of the cells seem to be involved at once, although the degree of involvement and of the pathological changes present may vary considerably.

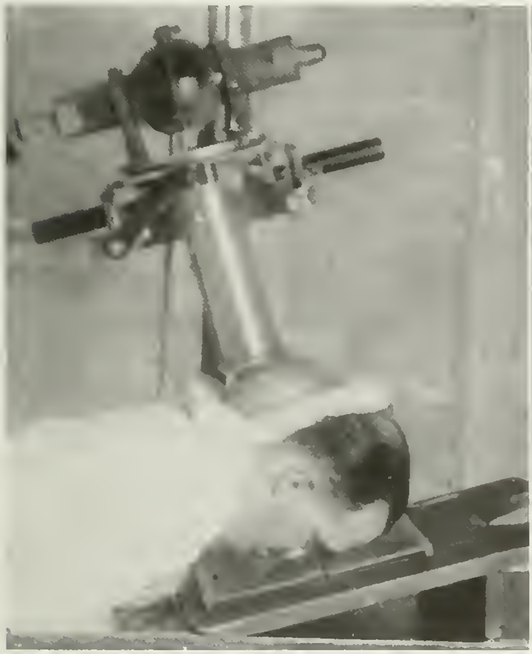

Fig. 1. First position.

Fig. 2. Second position.

The two types of disease are not recognized as occurring together as one would expect if the one were the sequel of the other as has been suggested, nor are we able to recognize anything that can be accepted as a transition stage from the one to the other. Moreover, it seems difficult to believe that a process that at one stage has laid down considerable bony tissue should at a later stage result in the disappearance of this excessive tissue together with some of the normal supply and that without leaving any residua. We are therefore convinced that the two processes are essentially distinct from the beginning and represent a different response to similar stimuli or different response to different stimuli.

The clinical associations of the two diseases seem to be different also. Dental abscess, deformity of the septum, and intranasal pathology appear to lead to the purulent type of the disease. Acute infections also are followed by the purulent processes. The focal infections leading to arthritis, iritis, retrobulbar optic neuritis, etc., appear to be of the purulent type. On the other hand, asthma is clearly associated with the polypoid type.

The exact relationship of these two conditions is still far from clear. Perhaps the majority of surgeons favor the theory that polypoid disease is only a later stage of the purulent type, largely by analogy to the known formation of the isolated polyps about the ostia in the purulent type. Perhaps the distinction is more important to the roentgenologist than to the surgeon, because the roentgenographic evidence is so divergent and because he is attempting to draw a distinction without a difference. It seems to me that the question might well be reopened and the evidence of the roentgenologist might go far towards its solution, as it is the only method short of a mutilating operation that will sharply differentiate between the two.

Effect on Development.—A frequent observation and one that appears to me to be of first-rate importance is the relatively small size of the chronically diseased sinus. This feature is always well marked in the juvenile cases, and when it is found in the adult, a history of long-standing disease dating back to childhood may almost invariably be elicited. This is clearly the result of the inhibitory influence of the inflammatory process on the normal growth and development of the pneumatic structures. The result is frequently a high degree of asymmetry.

It is not impossible that juvenile sinusitis is one of the most frequent and important factors in the causation of facial asymmetries, and undoubtedly plays a large part in the failure of development of the pneumatic structures of the head in congenital syphilis. The sinusitis in these cases need not be primarily syphilitic, but the luetic processes in the nose must commonly result in chronic infections of the accessory sinuses of the purulent type.

This also is a subject that is well worth investigating and in which the roentgenologist can be of distinct service to the surgeon.

Acute Purulent Sinusitis.—As has been noted in the section on the pathology of acute sinusitis, the only changes that can be anticipated in the roentgenographic picture represent the shadows of the edema and exudates in the sinuses replacing the air usually found there.

Unfortunately, the presence of such exudates in the smaller cavities of the head adds so little to the already considerable density of that portion of the head which the *x*-ray beam must traverse that they leave little record on the plate. This is in agreement with the experimental and clinical experience of others, and is exactly what one would expect from the relatively small cubical capacity of these cells. Experiments show that a similar amount of foreign fluids introduced into the sinuses or applied to the face cast a shadow no greater than that of some of the soft tissue elevations on the face that regularly escape observation.

In exceptional cases the diffuse shadow of what apparently is the exudate of an acute infection is conspicuous and unmistakable. Having seen the opacity of the posterior ethmoids which has followed surgery of the upper nose and having compared them with the density of the same parts before operation and after recovery, I am convinced that these opacities are not the result of bony changes induced by previous infections but are actually due to the recent accumulation of exudates in the tissues and in the free spaces of the sinuses. That pus does produce some shadow is also evidenced by the observed reduction of density of a chronic maxillary empyema after thorough drainage. This is an observation that I have been able to confirm on several occasions.

As to the true explanation of these apparently contradictory findings, your speculations are as good as mine. The significance to the roentgenologist lies in the fact that a negative diagnosis with respect to acute sinusitis is extremely hazardous.

The situation is not improved by the observed fact that acute sinus infections are frequently bilateral, in which case the roentgenologist is deprived of the assistance gained by the observation of symmetrical parts and is forced to judge of the actual and not the relative density of the field under observation. This is especially true in juveniles where the conditions are particularly unfavorable from the relatively small size of the sinuses and the presence of the germs of unerupted teeth.

Sometimes the upright position and the horizontally directed ray will demonstrate a horizontal fluid level in the antrum. But the shadow is surprisingly faint and the method is not regularly used in this laboratory.

Fortunately for the patient, the surgeon usually does not need the help of the roentgenologist in the diagnosis of the acute conditions, since it is made with comparative certainty on clinical grounds. Not infrequently the *x*-ray is of service in demonstrating some intranasal condition that is apt to favor chronicity and that is likely to escape the surgeon because of the swelling. The roentgenologist will do well to direct his effort to the demonstration of such changes.

Acute Polypoid Disease.—Apparently there is a small group of cases in which the process is from the beginning one of polypoid degeneration of the mucous membranes which come for observation early in the disease and before the secondary osteoporosis is manifest. A few of this group have followed obvious dental pathology and the disease has been limited to the antrum. Operation has shown the mucosa greatly thickened with numerous fungus growths bathed in a comparatively small amount of purulent exudate. Such cases have invariably escaped detection by the *x*-ray, and a review of the plates after operation has revealed no recognizable differences from the density or outline of the opposite normal antrum. Perhaps one may assume a nice compensation for the increase in density, due to the thickened mucosa, by an equal loss of density in the bony wall.

Aside from their difficulty of recognition, these cases are interesting in connection with the question of the relationship of the two types of infection, the purulent and the polypoid.

Acute Purulent Sinusitis.—The signs of chronic purulent sinus infection are precisely those of an osteoplastic process in the corresponding chambers and in the contiguous portions of the nose and frontal bone. The increase in the density of the shadows appears to be due largely to the increased thickness of the walls of the sinuses. The contents of these chambers play little part in the total density. The diffuse haziness that fills this region is apparently due rather to the thickening of the anterior and posterior walls than to the presence of retained secretions, except that in the larger cavities of the maxillaries the contribution of the latter may be appreciable.

The process is usually unilateral, and the greater density of the entire affected region and the accentuation of the outlines of the individual cells are usually well marked. While solitary infections occur, they are not so common as is usually supposed, and group infections are the rule. The contiguous portions of the nasal wall and in particular the origin, or "root," of the middle turbinate partake of the sclerosis, often with considerable deformity of the nasal fossa. The association of the posterior ethmoid infections with that of the maxillary is so constant that its failure strongly suggests the origin of the maxillary sinusitis in some dental pathology. Actual necrosis of the bone and osteomyelitis occur as an extension of the process in the frontals, but the remainder of the bony structures appear to be too thin to favor such a process elsewhere.

Imperfect development of the chambers involved is of frequent occurrence and is attributed to the inhibitory influence of the infection on the development of the pneumatic structures during adolescence or childhood.

In the antrum the thickening of the walls is most marked along the floor and on the nasal side. Not infrequently the floor of the antrum appears considerably raised above the level of its mate. The diffuse opacity of the entire chamber is due in part to the retained exudates, but mostly to the thickening of the anterior and posterior walls, those portions that are not tangentially projected on the plate. The origin of the inferior turbinate and that of the middle turbinate may show considerable increase in size, thickness and density through an extension of the inflammatory process by continuity. The posterior ethmoids rarely escape involvement except after infection from the teeth.

In the ethmoidal group, the general opacity is not so striking because of the smaller area of bone and the smaller cubical capacity of the cells involved. The increase in density is usually easily appreciated by comparison with the opposite cells in the comparable positions, while the changes which involve the middle turbinate confirm the diagnosis. In this connection, it should be mentioned that it is necessary to differentiate these changes from the hypertrophies of the turbinates that appear to be compensatory for deviations of the septum. The latter do not, as a rule, show the same increase in thickness and density as do the changes following infection of the ethmoids.

Solitary infections of the ethmoids are uncommon and are most frequently found in the most posterior and external of the ethmoid cells. The changes in the turbinates are either entirely absent or very limited in extent.

Involvement of the anterior ethmoids is less common than the posterior and is rarely seen except as a complication of a frontal sinusitis. The changes are most easily seen about the infundibulum and in the supra-orbital ethmoids. Changes in the turbinates are not a constant feature in this location.

The frontal sinus is peculiar in that its superior and lateral walls are continuous with the diploic structures of the frontal bone and the thickening of the parietal wall is not projected by the tangential ray. There is often, however, a considerable zone of increased density in the frontal bone about the cavity of the cells, and the thickening of the anterior wall is usually sufficient to cast an appreciable shadow. The main reliance for diagnosis must rest on the condition of the infundibulum which invariably shows distinct changes.

Satisfactory plates will show this structure beside the lateral walls of the upper nasal fossa except when they are entirely normal. The infundibular walls are early thickened and the cavity obscured. The irregular members of the anterior ethmoid cell group, which lie in immediate relationship to the infundibulum, regularly show a simultaneous involvement. On the whole, one is rarely left in doubt about the condition of the frontal.

The sphenoid is readily recognized in this technique. Its floor lies on the level of the rostrum sphenoidale and its roof lies slightly below the level of the lamina cribrosa. It is usually roughly quadrilateral in shape, but varies much in extent and contour, often showing wide extensions into the contiguous portions of the maxillary bones. Normally the walls are paper thin and the cavity is strikingly clear. When infected, the increased thickness of its wall is conspicuous and the general density is much increased. In exceptional cases the entire structure is represented by a uniform opacity in which the differentiation between the wall and contents is not possible. The distinction between a sphenoiditis and the occurrence of an intranasal opacity such as a polyp may be extremely difficult.

The septum of the sphenoid is rarely made out because of its obliquity but may occasionally be seen. Unilateral sphenoiditis presumably does occur but has not been recognized in this laboratory, and an early extension to the other cell appears to be the rule.

It will be noted that the approximate location of chronic purulent disease may usually be reached by the observation of the associated involvements. In this judgment the stereoscopic image is of material assistance. This feature, however, is secondary in importance to the assistance the stereoscope affords in the differentiation of the shadows of those portions of the skull that lie posterior but override in the projection of their shadows.

The differential diagnosis must also take into consideration the rare cases of failure of aeration of the accessory sinuses and the persistence of cancellous bone throughout life. This is most frequently seen in the maxillary and presents a very confusing picture. It may usually be recognized by the uniform distribution of its shadows, the smaller size of the maxillary on the affected side, with resulting asymmetry, and the failure of a definite cortical layer on both sides of the relatively thin wall of the normal antrum.

Chronic Diffuse Polypoid Sinusitis.—The roentgenological appearance of polypoid disease of the accessory sinuses is in marked contrast to the description of the purulent type given above. The main features of the picture are produced by the osteoporosis of the bony walls and the exclusion of air by replacement by the overgrowth of the mucous membrane.

The effect on the *x*-ray plate is to destroy to a large degree all the differentiating contrasts and details of the normal sinus cavities. This polypoid process involves not only the cells and their cavities but also completely fills the upper nasal passages with hypertrophied and polypoid mucosa, entirely closing the upper and middle meatus. By contrast the excessive width of the lower nasal fossa through the atrophy of the bony and soft tissue elements of the lower turbinates is accentuated.

The result is a diffuse, hazy plate almost entirely lacking in differentiation and showing only the more massive and more conspicuous structures of the nose. The first impression is that of a technically unsatisfactory set of plates. A study of the detail in the remainder of the plate and a comparison of the relative densities of the sinuses with that of the orbits will convince the student that the trouble is in the former. The atrophy of the inferior turbinates completes the picture.

The process varies considerably in degree in different cases, apparently with the chronicity of the disease. As has already been mentioned, the process is usually bilateral and symmetrical and it is rare indeed that one can say with conviction that any one of the sinuses has escaped involvement. The changes in the maxillaries are often less well marked than in the remainder of the cells, but whether this represents an earlier stage in the development or results from the operation of some protective factor is not clear. The major process is apparently always in the ethmoid regions.

The distinction between this condition and the polyps secondary to the purulent type of the disease and the fibromata and myxofibromata arising from the mucous membranes of the nose must be sharply drawn. The latter are of the nature of neoplasms, although usually considered the result of chronic irritation of some sort. Whether they are true neoplasms or whether they depend on infection should not confuse us as to their essential differences from the condition here described.

Fundamentally, such changes in density as have been described in connection with the purulent and in the polypoid types of disease represent only the structural changes that have occurred in the bones of the skull. These require time for their development and have resulted from infections of considerable chronicity. They do not regularly follow an acute sinusitis or repeated attacks of acute sinusitis which are of short duration. The *x*-ray of the sinus susceptible to recurrent attacks is quite as apt to show no appreciable changes during the free intervals.

These changes are in the nature of scars and may be expected to persist after the process which induced them is concluded. It is therefore entirely conceivable that the sinuses in question in which definite changes have been demonstrated are entirely free from infection at the precise time when they are examined. The diagnosis of "sinusitis" then does not strictly apply. But from what we know of the pathogenesis of the affection one may reason that it is unlikely that the observed changes represent the result of a single acute infective process, and that the persistence of such a suppuration for a time sufficient to induce such changes argues for some impediment to its proper drainage and healing, and for a liability to future recurrences of the infection under similar conditions. It may well be questioned whether a cavity that has once been the seat of a chronic infection is ever again entirely free from infection except through the efforts of the nasal surgeon and by the removal of those factors which contribute to its liability to recurrence.

The sinuses so recognized are therefore constructively, if not actually, inflamed and deserve precisely the same consideration and treatment by the surgeon as those actually the seat of a purulent process.

Unfortunately, the surgeon not infrequently fails to confirm the diagnosis made by the roentgenologist. But one is entitled to accept with reservations the conclusions of the surgeon as to the freedom from inflammatory processes of the indicated cavities, on the grounds that puncture and irrigation have failed to produce any evidence of a purulent secretion. For the process may have been in a quiet interval at the time of puncture and still be a source of future danger through its liability to recurrent infection.

The situation, as I see it, is entirely similar to that of the chronic and latent appendix, and similarly the ultimate judgment as to the potentialities for future trouble and the advisability of operative interference must be viewed with respect to all the facts, including the unsupported evidence of the *x*-ray findings. This judgment must in the last analysis be left to the surgeon. But when the problem is that of a search for a hidden focus of infection, I feel that the roentgenologist is justified in urging surgical procedure on the grounds that his evidence is of as great value as that of the rhinologist, and of similar authority. There have been several instances in my experience where the *x*-ray evidence was the only clear indication of such a focus of infection.

In this connection it may be remarked that a simultaneous involvement of more than one cavity in a purulent process is much more common than the literature would lead one to believe. This is evidently due to the failure of the surgeon to recognize the minor changes in the adjacent cells. This failure may be due to his disinclination to explore farther than he has distinct indications for going, or to obscurity of the field by hemorrhage from the region first attacked. It is also quite conceivable that the adjoining cells are inflamed only intermittently and coincidently with the exacerbations of the process in the sinus primarily involved. Thus, while the *x*-ray evidence persists, the clinical evidence may be lacking at the time of operation. The surgeon is virtually dependent on the finding of pus for a definite opinion, and the sinus in question may be temporarily dry. Whatever the cause, it is obvious that the surgeon is inclined to underestimate rather than overestimate the extent of the process.

More serious differences with the surgeon are apt to arise in the earlier stages of the disease before the osteoplastic changes are sufficiently pronounced to allow of clear roentgenographic demonstration. Nor is it always clear that the time element is alone to blame for the differences in opinion, since the history will occasionally indicate that the infection has persisted for a considerable time. These cases may be very obvious to the surgeon, and he may find it difficult to understand why the *x*-ray does not confirm his diagnosis.

Until we know more about the rate of production of the osteoplastic changes and what are the factors that influence their development, and until we understand more clearly the rôle of exudates and secretions in the production of pathological shadows, we shall be unable to explain every case of disagreement and shall be obliged to acknowledge our limitations with the best grace possible.

In the meantime, it is not necessary in order that the roentgenologist may be of assistance to the surgeon that he agree with him in every case. Such perfect agreement might give a timid surgeon added confidence but could scarcely add to his knowledge and understanding of the case. Identity of observations and opinions means only a reduplication of effort. A certain degree of difference is essential to helpfulness. Difference of opinion may be adjusted, but differences of observation must be explained. If the problem can be approached by both in a spirit of mutual respect for the observations of the other, both must profit by the study of their differences in opinion, with ultimately a closer approximation to the truth on the part of both.

DIAGNOSIS OF PULMONARY CONDITIONS IN CHILDREN*

BY JOHN W. PIERSON, M.D.

BALTIMORE, MARYLAND

IT is not within the province of this short paper to discuss all the pulmonary conditions in children; so that I shall limit myself to the discussion of some of the problems we are called upon to solve in that particular field. I am frank to confess that I have no solution to offer in most instances, but I wish to call to your attention certain types of lesions which have caused considerable confusion in their diagnosis, hoping that you may aid in the clearing up of some of the obscure points.

We are all perfectly familiar with the markings which we find at the roots of the lungs in the adult; we have come to regard them as normal, if we may use that term in this instance, and we have been interested in determining how early these changes appear in the lungs. With that object in view we have examined a series of children varying in ages from one day to eighteen months. We have observed, as early as the first day, very tiny circular shadows about 2 or 3 mm. in diameter at the ends of the major divisions of the bronchi. It has been suggested that these shadows were minute areas of atelectasis produced in childbirth. If such were the case one would naturally expect the shadows to disappear in a very short time. On the contrary, they remained, became more clearly defined, and as time went on the divisions of the bronchial tree became more and more in evidence, so that at the end of a few months the major divisions of the bronchi could be easily made out. Those children who suffered pulmonary infections showed upon recovery a much heavier outlining of the bronchial shadows. A few developed tuberculosis during the course of the examination and we were able to watch the disease from beginning to end, because all of them died. It is interesting to note that those cases which developed tuberculosis did not show any changes before the sixth month.

We concluded from these observations that one must expect to find certain minor changes in the lungs of all children; the extent of the changes varying under different circumstances.

Granted that we find these changes in all children's lungs, the interesting point to determine is how extensive they may become before we regard them as pathological. The clinicians are in a position somewhat analogous to that of the roentgenologists with regard to the interpretation of the various differences which they find in the physical examinations. They too regard certain minor changes as of no significance, but they also wish to establish what may be termed the normal chest of a child. So the clinicians and roentgenologists have joined forces and a combined examination is being conducted in a number of clinics throughout the country.

A part of the work is being conducted in the clinic with which I am connected, and so far 80 children, above the average in physical condition, have been examined. Their ages varied from three to thirteen years, 17 being six years or less, and they were subjected to the *x*-ray and physical examinations, as well as to the tuberculin test. The examinations were conducted in a routine manner, entirely independently of one another, and the results were afterward correlated. The *x*-ray reports were purely objective, nothing being known of the history of the case; so that an absolutely unbiased report was given.

Of the 80 children examined 32 were considered as normal by the *x*-ray and physical examinations, and 5 had a positive Pirquet reaction with negative *x*-ray and physical examinations. So that out of 80 supposedly healthy children only 32 were regarded as normal by all three tests. It would seem that our tests were too rigid, for while a small number were definitely proven to be diseased, it would be hard to conceive that so large a proportion of the children were abnormal.

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Two cases were regarded as tuberculous by the physical examination and skin test and two more were so diagnosed by all three tests, so that we had what might be termed an accidental finding of tuberculosis in 5 per cent of the cases.

Eight cases showed signs of old non-tubercular lesions by means of the *x*-ray and physical examinations. Most of these children had had nose and throat infections.

Thirty cases were regarded as pathological by the *x*-ray examination, but nothing abnormal was noted by the physical examination. Three of this group had a positive Pirquet. The *x*-ray reported 14 of this group as tuberculous, 11 had non-tuberculous lesions at the bases, and 8 had enlarged mediastinal glands but with clear lungs.

Summarizing, we see that 48 out of 80 showed changes in their lungs which were regarded as pathological by the *x*-ray, whereas pathology was demonstrated by the phycsal examinations in 15 cases only. It is no doubt true that some of the lesions were so situated that they could not be detected by the physical examination, but that number must have been very small.

It will be seen that the results of the *x*-ray examinations were much too critical in spite of the fact that a conservative attitude was adopted in the interpretation of the findings. Therefore, it is impossible for us to adopt certain criteria and say that any variations from them mean that the child has a pathological condition which is producing symptoms. A solution of this problem is very difficult to obtain because there are so many factors causing changes in the lung picture which do not have any immediate bearing upon the case. As was shown in our work with the very young children, pulmonary infections leave their marks upon the lungs after they have healed. Environment, too, seems to play a very important rôle. Children raised under poor conditions show more extensive lung markings than those whose surroundings are more ideal. Consequently, there should be a close collaboration between the roentgenologist and the clinician and a diagnosis should not be given, much less any therapy suggested, upon the *x*-ray findings alone.

ACUTE INFECTIONS OF THE LUNGS

Two of the acute pulmonary infections we shall dismiss with just a passing word.

The first, acute bronchitis, does not cause any changes which are demonstrable by means of the *x*-ray examination. The second, lobar pneumonia, is usually very easy to demonstrate. We may remark in passing that pneumonic consolidations are detected much earlier by the *x*-ray than by the physical signs because they so frequently begin at the periphery of the lung and extend in toward the mediastinum, and the changes in the physical signs cannot be demonstrated until the consolidation has reached one of the larger bronchi.

Bronchopneumonia.—While the diagnosis of lobar pneumonia is comparatively easy, it is often very difficult in bronchopneumonia, and while the former usually clears up promptly without leaving any markings in the lungs, the latter may frequently cause changes which persist for a long time. This is true because lobar pneumonia involves chiefly the parenchyma of the lungs, whereas bronchopneumonia attacks the bronchi and interstitial structures of the lungs.

Bronchopneumonia in its acute stage is characterized by areas of consolidation of varying size with rather indefinite outlines which may occur anywhere in one or both lungs, though they are more frequently found at the bases. At this stage it is to be differentiated from tuberculous consolidations and metastatic sarcomata. It is sometimes impossible to differentiate bronchopneumonia from the consolidations of tuberculosis, though the latter more frequently spring from the mediastinum and are usually associated with enlarged mediastinal glands. The outlines of the sarcomata of the lung are more clearly defined and their distribution is more widespread and regular than bronchopneumonia.

If the disease progresses to the chronic stage we have great difficulty in differentiating it from tuberculosis. The *x*-ray examination at this stage shows that most of the areas of consolidation have cleared up, but there is a very extensive fibroid infiltration which outlines the bronchial tree, with thickened and dilated bronchi and groups of enlarged, very dense glands scattered throughout the lungs. In more severe cases bronchiectasis develops and cavitations sometimes occur. Tuberculosis frequently gives just such a picture.

The pathology of the disease seems to offer a logical explanation of our findings. Bronchopneumonia is usually a secondary disease, and, as has been stated, causes marked, changes in the bronchi. This is particularly true if it follows influenza or pertussis. Hemorrhages occur in the walls of the bronchi followed by a breaking down of the tissues so that an actual ulcer develops. If the bronchus becomes plugged up and its wall weakened below the obstruction, bronchiectasis occurs, and if the infection extends through the wall of the bronchus into the lung tissue an abscess is formed which results in a cavity. Since the influenza epidemic, bronchiectasis and lung abscesses occur more frequently than formerly. When the process of repair starts, fibrous tissue appears, scar formation takes place, and the adjacent glands react to the infection.

We know that tuberculosis causes a fibrosis in the lungs with an enlargement of the glands, and we have just seen that bronchopneumonia also causes a fibrosis, so that we can readily understand why they give such identical results upon *x*-ray examinations. We may judge of the difficulties in differentiating bronchopneumonia in this stage from tuberculosis, when the pathologists state that such a differentiation frequently cannot be made by them until the microscopical sections are examined.

Tuberculosis.—There is a period in the child's life which extends from about the sixth month to the sixth year, in which tuberculosis is very active. Then comes a period of quiescence, which lasts until the age of puberty, when the disease again becomes very active. Of course, a good many cases of tuberculosis are seen in the quiescent period, but they are not usually so active as they are either earlier or later in life.

The vast majority of tuberculous infections in adults are found in the upper portions of the lungs, but such is not the case in children, especially in those infections which occur very early in life. At that time one may expect to find the primary lesion anywhere in the lung, and a tuberculous consolidation at the base is not at all uncommon. As we believe that most of the tuberculosis that occurs in adults is the result of childhood infection, one might inquire why they do not present basal lesions. The reason is that practically all the children who have a very early infection die.

Tuberculosis, occurring very early in life, shows all the signs of activity, that is, soft snowflake or miliary infiltration with perhaps areas of caseous consolidation and cavitation. Pleural reactions are not infrequent.

As the child gets older and we find the disease in its less active form, we commence to see the localized, fan-shaped areas of infiltration that are associated with tuberculosis in adults. Unless the infiltration is localized, the diagnosis is extremely difficult, but we have one sign which we regard as very helpful; that is, the enlargement of the mediastinal glands. No other infection of the child's lung seems to cause such an enlargement of the mediastinal glands as tuberculosis, and we have come to regard it as almost pathognomonic of the disease, especially in young children. Gohn's theory of the transmission of tuberculosis by the lymphatics of the lung would seem to account for this enlargement of the mediastinal glands.

Children often have tuberculous infections which later become arrested or inactive, yet definite anatomical changes are produced which are seen on *x*-ray examination. Just because we find evidences of what we regard as a tuberculous infection we are not able to conclude that the child is suffering from tuberculosis. While a tuberculous infection is always a potential source of danger and such a child should be carefully watched, it by no means follows that its whole scheme of life should be changed upon the bare evidence of the *x*-ray findings. Bearing in mind the experiences with the healthy children which I have previously quoted, we can see that there is room for a large source of error.

Thymus.—The diagnosis and treatment of persistent thymus has caused considerable discussion. For a number of years we reported all cases as persistent thymus that had a very definite enlargement of the mediastinal shadow. Except in a very few cases the pathologists were unable to find any evidence of a thymus but did find many cases of enlarged tuberculous glands. The clinicians, too, did not give us much encouragement because they could not find any clinical evidence of persistent thymus. In the light of such evidence we were compelled to render a diagnosis of enlarged tuberculous mediastinal glands in cases of the type under discussion. However, we have seen from time to time a number of cases of stridor having an enlargement of the mediastinal shadow. We have radiated these cases and have observed the results.

One group of these cases failed to respond to radiation in any way. Their stridor did not improve and there was no diminution in the size of the mediastinal shadow. If any of this group had a thymus, the amount of radiation was not sufficient or the thymus was peculiarly resistent to radiation.

Another group showed marked improvement in their stridor but the mediastinal shadow remained the same. Some of this group may have had a thymus, but if they did one would expect a diminution in the size of the mediastinal shadow with improvement in their stridor. We must remember that a large number of children with stridor improve without any treatment whatsoever.

Finally, a third group showed improvement in their stridor and a complete disappearance of the mediastinal shadow. It is a well-known fact that tuberculous glands respond rather readily to radiation, which may account for the improvement in some of these cases, but there were a few, too young to have tuberculous glands, who must have had a thymus. We therefore concluded that the majority of these cases had tuberculous glands, while a very small number had a persistent thymus.

Pulmonary Findings in Rickets.—The pulmonary changes associated with rickets usually occur within the first three years of the child's life, when the disease is most active. They are produced by a softening and weakening of the ribs so that the negative pressure exerted during inspiration with the elasticity of the lungs and pull of the diaphragm cause a partial collapse of the thoracic walls. Moreover, the disease does not attack the cartilages as it does the ribs, so that the latter yield to the pressure and are displaced inward. This may take place to such a degree that instead of the ribs articulating with the cartilages on the same plane they are displaced inward and are sometimes actually overlapped by the cartilages. A distinct knuckle is formed on the internal surface of the thoracic wall at the costochondral junction, and when the process of repair commences a large amount of new bone is deposited in the ends of the ribs, which greatly enlarges the knuckles.

The partial collapse of the thoracic walls which produces great pressure on the lungs and the knuckles at the costochondral junction, causes marked localized pressure. The pressure of the knuckles is evidenced at autopsy by a distinct groove which is seen on the anterior surface of the lungs, running from the top to the bottom and lying immediately under the costochondral articulations. An area of atelectasis of the lung is seen immediately posterior to the groove. Anterior to the groove the lung may be emphysematous, and areas of atelectasis and lobular pneumonia may be scattered throughout the lungs, which are somewhat edematous.

The *x*-ray examination of these cases shows a marked deformity and increased porosity of the ribs with a marked enlargement of their anterior ends. The lungs show longitudinal shadows of irregular outlines, 1 or 2 cm. in width, extending from above downward on both sides of the heart. They extend from the clavicle to the base and are separated from the heart by a narrow, clear area. Numerous small areas of consolidation may be seen scattered throughout both lungs. The whole lung field frequently presents a hazy appearance. The small areas of consolidation already noticed may be so diffuse as to give the appearance of a tuberculous infection, and the longitudinal areas may be so large as almost completely to obscure the lung fields.

The difficulties of the diagnosis of any concurrent lung infection in a child who has rickets are obvious.

UNSUSPECTED DERMOID CYST DIAGNOSED BY ROENTGEN EXAMINATION

BY LOUIS EDEIKEN, M.D.
Assistant Roentgenologist, Mt. Sinai Hospital
PHILADELPHIA, PENNSYLVANIA

MISS D. G. Aged seventeen years; stenographer.

History. Chief complaint, sharp shooting pain in right inguinal region. Vaginal discharge (leucorrhea) and burning sensation on micturition.

Present Illness. Dates back two weeks when patient had sudden attack of severe sharp shooting pain on the right side of the abdomen, markedly increased upon retiring, and continuous.

Menstrual History. Menstruation began at the age of thirteen. Menstruated regularly until six months ago when she missed this period but has menstruated regularly since then to date. Each period lasted from six to eight days.

Medical History. Three years ago had psoas abscess. Two years ago had influenza and pleurisy.

The patient was referred for roentgen examination of the urinary tract with a provisional diagnosis of ureteral stone.

Roentgen Report. No evidence of calculus anywhere in the urinary tract. Kidneys are normal in size, shape and position. Just to the left of the lower border of the sacrum there are a number of undeveloped teeth imbedded in a matrix of bone. Diagnosis: Dermoid cyst.

Operation was performed by Dr. J. C. Hirst, who found a large left ovarian cyst (dermoid) which was removed. The right ovary also showed some cystic degeneration and the diseased area was removed. The appendix was found to be the seat of a chronic inflammation, which in all likelihood was the cause of her present illness, and which was removed.

FIG. 1. Showing dermoid cyst revealed by roentgen rays.

THE LUMBAR SPINE AND SACROILIAC JOINTS*

BY MYRON B. PALMER, M.D.

ROCHESTER, NEW YORK

THE roentgen-ray examination of the lumbar spine and sacroiliac joints still offers many possibilities for future study. Of the patients who come to the orthopedic surgeon for consultation, a fairly large proportion present symptoms referable to the lower back.

It is not my intention to go into a discussion from the orthopedist's standpoint, but rather to present for your consideration the interpretation of anatomical variations or developmental conditions noted in the lumbar spine of patients with lower back pain.

There is very little to be found in the textbooks in regard to anatomical variations of the lumbar spine and their relation to lower back pain.

In the last few years there have appeared in the various journals, especially the orthopedic journals, articles and discussions on the variations noted in the lumbar spine and sacrum as a causative factor in back pain. Several members of this Society have at various times discussed the lumbar spine, but more particularly in regard to fractures.

Professor Dwight's work has shown what a variety of anatomical anomalies may exist in the bony structure, particularly in the lumbar spine. He once said that anomalies of the fifth lumbar vertebra are so common that we hardly know what the normal should be.

Boehn has advanced several theories as to variations in the fifth lumbar as a possible cause of certain types of scoliosis. He also emphasized the possibility that asymmetrical sacralization might cause a lateral tilting of the top of the sacralizing vertebrae and thereby cause scoliosis.

Adams,[1] in a very able article on scoliosis, says that though Boehn's theories are interesting, in the work done at the Massachusetts General Hospital on the backs of scoliotics, asymmetrical sacralization was frequently found in normal cases, or cases presenting no symptoms, and that at the Children's Hospital in the cases that did have scoliosis and asymmetrical sacralization, no tilting was noted. He did, however, consider the possibility of congenital defects of the articulating processes as being a more logical cause of scoliosis.

The work of Dodd and Holmes at the Massachusetts General Hospital shows how well they had studied variations in the last lumbar joints and the sacrum.

Davis[2] says that while anatomy, per se, is an exact science, our knowledge of the anatomical lesions causing backache is so limited that any attempted explanation of cause and effect must be largely theoretical even though we do our best to make them rational. He emphasizes the fact that fracture of the lumbar vertebrae is rare and places much emphasis on the injury to nerves and ligamentous structures as the cause of pain.

Other writers lay great stress on injury to muscles rather than to ligaments or bony anomalies.

Goldthwait[3] calls attention to dorsal lumbar pain which may be confused with lower back pain, or pain from kidney pathology, and shows many illustrations of variations in the articular processes and the transverse processes which should be given consideration in the study of each case.

O'Reilly[4] has analyzed quite a series of general clinical cases, that is, cases presenting no back symptoms, and has shown a large number of anatomical variations in the lumbar spine, more especially the transverse processes. He classifies the sacrum as to three types, according to size and shape; taking into consideration the various types of anatomical variations, no general type could be called normal.

It has been the writer's good fortune to be associated with orthopedic surgeons and to know case histories; to be able to

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sit down, as it were, and talk over the various conditions found in the lower back. In this way one can obtain a much better understanding of this perplexing lower-back problem. Although all types of variations are studied, more attention has been given to the articulating processes.

Goldthwait has described two types of articulations: the transverse or flat type, and the vertical or crescentic type. We have designated the vertical or crescentic as the true lumbar type and the flat as the sacral or dorsal type (Figs. 1, 2, 4). Nearly all cases presenting symptoms referable to the lower lumbar vertebrae have a mixed type of joints. There may exist lumbar types of the first, second and third joints, while the fourth may be sacral, or lumbar and sacral; likewise the fifth may be sacral or the mixed type. Rarely is it possible to see two lumbar joints at the lumbosacral articulation (Fig. 3). The true lumbar is well shown on the film as a vertical line between the processes, whereas the sacral or dorsal type faces you and gives an indistinct joint outline with irregular borders which may at times resemble bony overgrowth (Figs. 1 and 4). There are noted also the position and shape of the transverse processes: attempts at sacralization or lumbarization of the upper sacral segment; whether there is a large fan-shaped transverse process; if it fuses with the sacrum or has a distinct articulation which overrides the superior wing of the sacrum. Stereoscopic films will show with considerable accuracy whether the fifth transverse process impinges on the upper sacral wing or on the iliac crest. Rarely is the fifth transverse process seen to override the crest of the ilium, though the single roentgenogram seems to show that it does.


Fig. 1.


Fig. 2.


Fig. 3.

Fig. 1. True lumbar type of joints with the exception of the articulations between the third and fourth, and the fourth and fifth, which are the mixed type. The lumbosacral articulations are of the true sacral type. Fig. 2. Lumbar type articulations persist throughout lumbar vertebrae with exception of the lumbosacral joint, the left being the lumbar and the right the sacral type. Fig. 3. True lumbar types in all articulations.

Certain cases show a well marked projection or tubercle on the ilium for the attachment of the lumboiliac ligament.

The general size and shape of the sacrum are considered, and the height of the fifth lumbar above the line of the iliac crests; all these conditions are taken into consideration in cases having lower back injuries with pain.

My belief is that the roentgenologist's duty ends in mentioning only what he sees on his films, but that close association with the orthopedist will greatly aid him in interpretation and general diagnosis.

What shall be the evidence necessary for the interpretation of an arthritis? Acute infectious arthritis of the lower lumbar and sacroiliac joints is not common in the general class of cases with acute back symptoms. When seen in the sacroiliac joints it gives a distinct picture, unless it be in the very early stage. In the lumbar articulation the interpretation is much more difficult. In hypertrophic or osteoarthritis more than one joint is involved and the interpretation is more easily made from characteristic lipping or bone production. Is it not possible for error to be made in interpretation of an osteoarthritis of the lumbar joints or the lumbosacral joints? Such errors have been seen repeatedly.

To the orthopedic surgeon arthritic joints give symptoms of a different character than those of lower back strain. Although certain cases may be confusing, a careful study of the case will easily differentiate the two types.

The overgrowth of bone about the flat or sacral joints has the appearance of production from arthritic change, but careful observation of roentgenograms of symptomless backs will demonstrate that these flat articulations are common.

What evidences should be required to interpret injury? Extreme violence may produce fracture of one or more of the bodies of the lumbar vertebrae, though compression fracture is less common than in the dorsal bodies. Fracture of the transverse process is somewhat common, occasionally accompanied by fracture of the spinous processes. Fracture of the articulating process and the lamina are very uncommon or may be difficult of recognition. Fracture of the lumbosacral articulation is apt to be accompanied by a slipping forward, or what might be called a unilateral dislocation, or when both processes rupture, a bilateral dislocation. In such injuries lateral views are valuable, while stereoscopic anteroposterior views should show a complete distortion of these flat sacral articulations. There may exist with a unilateral slipping forward of the process, a similar picture to that seen in certain types of congenital scoliosis. These injured cases eventually show degrees of lumbar curvature and rotation which are difficult to differentiate from the deformed congenital type of spine (Fig. 6). Distort one articulating process either by elevating it or carrying it forward, and rotation will take place with the change in the spinal balance. How are we to differentiate these types?

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4. Large flat sacral type of articulations between third and fourth, fourth and fifth and the fifth and sacrum. Fig. 5. Prevailing types of articulations are sacral, exception being the right articulation between the fourth and fifth. Fig. 6. The three legged stool type. Elevation of right lamina and articulating processes. Noted in certain types of scoliosis.

In the middle-age period it is difficult definitely to diagnose fracture ot the articulating processes which show what seem to be anatomical variations accompanied by sacralization of the upper sacral segment or an old spina bifida. Our problem becomes one of extreme difficulty in passing judgment on these industrial cases. What influence will anatomical variations have in the interpretation as regards lower back pain? These variations are seen so frequently in the symptomless back, that in our present knowledge of these conditions we cannot justly say that the cause is due to these developmental defects. However, a general conclusion should be drawn from the history of the case and symptoms; occupation and its relation to posture; pain, its location and if referred; straight leg raising and the degree; conditions which may change the weight bearing, bringing into play a joint which has always been improperly built or weak for the work which it is required to do. Such a joint in time of stress fails to perform its proper function. This may be especially true of the lumbosacral joints. Let us suppose one lumbosacral joint is of the true lumbar type and the other of the sacral type, very flat. The lumbar joint will be free for forward and backward bending, while its fellow, the flat one, tries to operate at right angles. Undue stress is therefore placed on one or the other. Inflammatory change may take place with the accompanying nerve and muscle pain.

The cervical and lumbar joints have the greatest range of motion, especially forward and backward bending, while the dorsal has less motion and the motion becomes quite limited in the lumbosacral articulations.

The plane of the fifth lumbar on the sacrum has a tendency to slide forward, being placed at about 40° from the horizontal. It is held by the bony support of the superior articulating facets and the various ligaments and muscles. The processes vary as to the position at which they are placed. They incline forward and inward and the pressure is downward and forward.

The structures which prevent this slipping forward are the ligaments; the fibers of the intervertebral disc, which allow, of course, a certain degree of motion; the anterior and posterior common ligaments; the iliolumbar, the lumbosacral, and the ligamenta subflava of the spinous processes. Any or all of the ligaments may slowly stretch, as is possible for a ligament about other joints. Certainly the joint is called upon to do quite unusual duty.

Elevate one process or place it at a different plane anteriorly, and what do you do? The entire spinal balance is altered, even though the change in the joint be so slight as to be hardly perceptible. This may be theorizing to a certain extent, but it is the belief of many, and, so far as it has not been disproved, it seems rational to accept this theory as a cause, at least in those cases showing varying degrees of rotation without marked deformity either of the transverse processes or the sacrum.

CONCLUSIONS

Anatomical variations or developmental defects are seen in a great number of patients presenting symptoms of lower back pain following injury. These variations are also seen in cases that have no back symptoms.

It is reasonable to consider that anatomical variations in the lower lumbar joints may under stress and varying influences be a factor in the causation of lower back pain.

Arthritis should show a definite picture and should not be confused with anatomical variation of the processes.

A more definite conclusion can be arrived at with the close association of roentgenologist and orthopedist.

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THE TREATMENT OF CARCINOMA OF THE THYROID BY THE ROENTGEN RAYS AND RADIUM*

BY GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

A SEARCH through the "Quarterly Cumulative Index to Current Literature" during the past five years, and a hasty review of other medical indices, have failed to show a record of the treatment of carcinoma of the thyroid listed under this heading. It is likely that many cases have been treated and are probably recorded in literature under such general terms as the "Treatment of Carcinoma," but it has been impossible for me to review all these general papers. We shall obtain a more definite idea of the value of this treatment, therefore, if those who have had the experience will describe their results in the discussion of this paper, or place them on record by correspondence with the Journal after the paper is published. As will be shown by subsequent case reports, my experiences have extended over a period of eleven years, and the results have been generally most gratifying, for in nearly all instances the treatment was used in an otherwise hopeless group, and yet the results have been in some cases brilliant. I want to place on record ten cases. In addition to these there were two other patients treated too short a time to make their records of any value, having only started the treatment and the patients having failed to return.

Case I. M. G., female, aged thirty-six, referred by Dr. John B. Deaver, June 14, 1910. She had been operated upon by Dr. Deaver three times; first, July, 1908, for carcinoma of the thyroid, and March, 1909, and May, 1910, for recurrences, and she was referred to me on account of a recurrence consisting of an indurated mass in the region of the wound immediately above the clavicle on the right side, and another indurated movable tumor mass, 1 inch in diameter, located below the mastoid on the right side. She was treated by fractional doses through 4 mm. of filter, the applications being made twice a week, so that each side of the neck was treated once a week and the dosage amounted approximately to half an erythema dose. Four different gas tubes were used at each visit in order to give this half erythema dose, because the gas tubes did not hold their vacuum sufficiently long to continue the penetration during the whole treatment. Under treatment the patient apparently regained health for about a year, and there was no local recurrence at any time; but about eighteen months after beginning treatment she developed signs of metastasis in the neck, and died July 5, 1912, with complete paralysis of the body below the cervical vertebrae, or approximately two years and one month after beginning treatment.

Remarks.—In a sense the result in this case was a failure; but the malignant disease which was palpable had disappeared and the patient undoubtedly had her life prolonged. She was given a year of reasonable comfort, and finally died of metastatic disease in the spine which had probably been growing slowly over a long period. It must be borne in mind that treatment was started in this case after the third recurrence had developed. This is an argument in favor of active treatment of the primary growth, or of very prompt and thorough treatment to be given immediately after the operation.

Case II. J. P. P., female, aged fifty-one, was referred November 16, 1911, by Drs. J. M. Anders and F. S. Parke. She had noticed a swelling of the neck and tightening of the collar during a year, but more rapid swelling of the right side of the neck during four months. This was associated with shortness of breath, palpitation and dyspnea, and she broke out into cold sweats. Examination showed a tumor involving the right lobe of the thyroid about 3 inches in diameter, which by *x*-ray examination was found to extend down into the upper mediastinum. It was indurated

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and fixed to the surrounding tissues. Dr. Anders believed it to be a carcinoma and that her condition did not warrant an operation. Dr. L. Webster Fox made an examination of the eyes and reported that he did not find the ocular symptoms of exophthalmic goiter. Her pulse was 160. *X*-ray treatment was undertaken with little hope of success. She was treated three times a week for one month by fractional doses, each dose amounting practically to 1/3 of an erythema dose. Twenty ma. minutes were given at a distance of 12 inches, filtered through 4 mm. of aluminum, and a 7 inch parallel spark gap was used. The treatments were given alternating left and right. Within three weeks her pulse was reduced from 160 to 120. Treatment was discontinued at the end of a month, but her improvement was progressive, and within three months she had regained her health. A letter of inquiry in 1918 (seven years after the treatment), brought the following report from the daughter: "Mother is in better health than she has been for the last twelve years. She has had no other treatment than the *x*-ray treatment given by you." Presumably she is still living and well, though the address has been lost.

Remarks.—The diagnosis in this case is, of course, open to question. There was no operation and there were no microscopical studies, but the clinical diagnosis seemed to be that of carcinoma and at the beginning of treatment none of us had much hope. She was, however, inoperable, and the probabilities are that if the treatment had not been given she would not be living. We have, therefore, almost certainly prolonged her life at least seven years according to the last report, and probably many more.

Case III. L. S., female, aged forty-six, referred by Drs. Geo. P. Katzenstein and John B. Deaver, February 10, 1913. She had had a goiter for twenty years. She was operated upon by Dr. John B. Deaver two weeks previous to the time she was referred to me, at which time he encountered much hemorrhage and degeneration of the tumor, and on section it was found to be carcinomatous. He stated to me that it was impossible for him to remove all of the tumor tissue, and that he knew he had left part of the carcinoma behind. The wound had not entirely healed at the time of beginning treatment. Her pulse was still 130. She was nervous, excitable, and had symptoms of hyperthyroidism. She was given 1/9 of an erythema dose at each visit, and she was treated nearly every day, making use of a coil and treating her successively on the right side, the median section and the left side, including treatment also in the supraclavicular regions and the upper sternal region. This treatment was continued almost daily for three months, then three times a week for three months, and treatment was discontinued completely December 2, 1913, ten months after beginning treatment. She has been observed from time to time since then and was last seen September 19, 1921. She is in perfect health, pulse normal, neck normal, excepting very slight and scarcely visible telangiectasis.

Remarks.—This patient is alive and well, eight years after beginning treatment of the remnants of carcinoma which were known to be left in place by one of our most competent surgeons, who stated at the time that he knew he had left carcinoma in the neck. The treatments were given in fractional doses with moderate filtration and spark gap approximately 6 or 7 inches in length. The results are probably equal to any that could be produced to-day by our more modern and more violent treatment.

Case IV. P. K., female, aged thirty-one, was referred for postoperative treatment by Dr. Charles H. Frazier, October 12, 1917. She had been operated upon June 13, 1917, by Dr. George Ross, for a branchial cyst involving the right side of the neck. September 25, 1917, Dr. Charles Frazier operated for goiter of the right lobe which, when examined by the pathologist, was found to be adenosarcoma. A section was then made of what was supposed to be a branchial cyst at the time of its removal in June, and this too was found by Dr. Allen J. Smith to be malignant. *X*-ray examination of the chest showed an abnormal amount of thickening or dense material about the root of the right lung and extending up along the right mediastinum. The right side of the diaphragm was retracted upwards. This was believed to be due to thickened pleura, but on account of the diagnosis of malignancy in the neck, treatment was advised to be applied to the mediastinum as well as to the tissues of the neck. The neck was divided into six portals of entry, and in addition to this the patient was treated through each side of the chest anteriorly, through the axilla, and posteriorly, making twelve portals of entry in all. She was given one full dose of rays through each of these portals of entry in the first series, each dose consisting of eight minutes' exposure at a focal skin distance of 8 inches, with a 9 inch parallel spark gap, 5 ma., and 6 mm. of aluminum filter. During the second series fourteen portals of entry were used; during the third series ten portals of entry; the fourth series, ten portals of entry, and the fifth series, eight portals of entry. At this time, December 15, 1917, the patient seemed to be free from any evidence of disease, and active treatment was discontinued. This was approximately two months after beginning treatment. March 20, 1918, she returned complaining of pains in the neck; and on account of the experiences of the first case, which developed metastasis in the neck, an *x*-ray examination was made and there was suspicion of disease in the lamina of the second cervical vertebra. Therefore, a sixth series of treatments was given through fourteen portals of entry. A seventh series was given May, 1918, and she has had no treatment since. She was re-examined September 19, 1921, and is in perfect health.

Remarks.—This patient had two operations on the neck for malignant disease. One of these was supposed to be for a branchial cyst, the second for carcinoma of the thyroid. The patient is well and free from disease more than three years after discontinuing treatment, approximately four years since her last operation.

Case V. G. S., male, aged sixty-two, was referred to me by Dr. Geo. P. Muller, November 17, 1917, after an operation three weeks previously for carcinoma of the left lobe of the thyroid. Dr. Muller reported that he was unable to get all of this carcinoma out. It was found to be infiltrated about the great vessels so extensively that it was impossible to remove all of it. Microscopical examination proved it to be malignant. At the time that he was sent for *x*-ray treatment he had some lymphedema and the tissues were indurated about the line of incision. The patient received his first series November, 1917, consisting of treatment through seventeen portals of entry. A second series was given through sixteen portals of entry during the succeeding month, and a third series through eighteen portals of entry during the month of January, 1918; a fourth series consisting of twenty doses during March, 1918; a fifth series through eighteen portals of entry during April, 1918; a sixth series during July, 1918, and a seventh series, consisting of fifteen doses, during October, 1918. At this time he looked perfectly well though the anterior portion of the larynx was still rather firm, but it did not feel like malignant disease. His voice was still rather hoarse, but no more so than at the beginning of treatment, and probably less. *X*-ray examination still showed some thickening in the upper mediastinum. The patient discontinued treatment and left my care at this stage, but I learn that he died November, 1919, with paralysis of the lower extremities.

Remarks.—This patient had two operations in the region of the thyroid for carcinoma; malignant disease found; left in place at the time of the second operation; yet as a result of treatment the disease in the neck was controlled; the patient lived comfortably for about a year, and died two years later with metastasis in the spinal column.

Case VI. J. W. A., female, aged sixty-one, was referred for treatment by Dr. John B. Deaver, June 27, 1917. Within two and a half years she had been operated upon four times for carcinoma of the thyroid and recurrences. The last operation was June, 1917. The patient was given nine courses of treatment within a period of six months. In each series treatments were given through fifteen to twenty portals of entry. The patient had difficulty in respiration at the very beginning. She suffered from hoarseness which gradually developed into aphonia. She had distinct evidence of mediastinal disease, as shown by the roentgen rays, at the beginning of treatment. There were periods of improvement, and by x-ray examination the mediastinal disease seemed to diminish, but as a whole the progress was downward, and the patient died December 13, 1918, almost six months after she was originally referred for treatment.

Remarks.—This patient was referred for treatment late in the disease, after having had four operations; first for the primary disease and three times for recurrences. The disease had invaded the mediastinum at the time of beginning treatment, and progressed without appreciable improvement or control until death.

Case VII. C. P., male, aged sixty, was referred by Dr. H. L. Foss of Danville, Pa., and Dr. F. G. Runyeon of Reading, Pa., January 31, 1919, on account of carcinoma of the thyroid. During several years the patient had suffered from goiter, but during the preceding eight months the growth had interfered with his breathing. Dr. Foss operated January 15, 1919, but was unable to remove any part of the tumor excepting a section for microscopical examination which showed it to be malignant. He reports as follows: "Exposed the gland which grossly was carcinomatous and removed two sections for diagnosis. One was sent to the Pathological Laboratory at the Mayo Clinic, the other to our consulting pathologist, Dr. Kolmer. From both places I got a positive report of carcinoma."

The entire thyroid was involved. The entire neck was thickened. The tumor tissue involved the surrounding tissue and seemed to mat everything together. I made an x-ray examination of the chest and found that this growth extended down the neck into the upper mediastinum. Briefly, he was given ten series of treatments within sixteen months, when he seemed to be well. He has had no treatment since April, 1920. Each series involved treatment through eighteen to twenty portals of entry and treatment was given not only through the neck but into the mediastinum from all parts of the chest. We believe that he is well. He is attending to business every day and feels well excepting that occasionally he expectorates blood. On account of this expectoration of blood I sent him to Dr. Chevalier Jackson, April 21, 1921, who reports as follows: "The motility of the larynx is perfect. The laryngeal mucosa is very much engorged and the vessels seem relaxed, but there is no infiltration, no ulceration and nothing to indicate malignancy. The source of blood is most likely from the rupture of capillaries in the trachea, but this, of course, is an inference."

Remarks.—This patient is apparently well, nearly three years after a definite microscopical diagnosis of carcinoma of the thyroid without operation and with nothing removed excepting the sections. His general health is perfect. He is feeling comfortable. The occasional expectoration of blood is probably due to the dilated capillaries, and the dilated capillaries are probably similar to the telangiectasis which develops in tissue that has been much treated on the surface of the body. He is kept under continuous observation; but we can be quite sure that he has been given at least several years' prolongation of life, with the hope of a real cure.

Case VIII. P. W. B., female, aged thirty-two, was referred by Drs. John B. Deaver and Wm. Jennings, June 14, 1919. Three weeks previously Dr. Deaver had operated on her for carcinoma of the thyroid, which had been noticed only three months previously. At the time of coming for treatment, x-ray examination showed no evidence of mediastinal or pulmonary disease. The patient had some general induration about the tissues of the neck which was believed by us to be inflammatory and not a recurrence. She was given four series of treatments involving twelve doses, each given through twelve portals of entry, each portal of entry receiving a full erythema dose filtered through 6 mm. of aluminum. On November 6, 1919, on account of soreness in the neck of which she complained, she was given a fifth series. She has had no treatment since. She was examined last by me personally, May 7, 1920, approximately a year after her original operation, when she seemed to be entirely well. Letters received from the patient and from her doctor state that she is still well, September 9, 1921.

Remarks.—More than two years have

passed since this patient had an operation for carcinoma of the thyroid. She has been given, in all, five courses of treatment and has apparently recovered.

Case IX. T. H. B., male, aged forty-five, was referred by Drs. W. R. Paulis and H. S. Foss of Danville, Pa. December 10, 1919, he was operated upon for carcinoma of the thyroid, but only sufficient tissue was removed for microscopical examination, because Dr. Foss found the disease to be malignant and totally inoperable. Microscopical examination showed it to be carcinoma. He had had a goiter approximately ten years, but it had been growing during six years and quite rapidly during the four months before operation. When lifting he suffered very severe pain. The neck measured 17½ inches in circumference, but all the tissues were matted together into a nodular tumor mass. Roentgenogram showed a tumor extending 5 inches downward into the mediastinum and 4 inches in front of the spinal column, and upward to the top of the thyroid cartilage. He showed improvement both locally and symptomatically after the first course of treatment, consisting of 22 doses given through twenty-two different portals of entry. There were twelve portals of entry through the neck, and the remainder of the treatment was given through the chest directed towards the mediastinum. He was given four such treatments within five months. The disease then seemed to be at a standstill, and in June, 1920, sixteen radium needles containing 10 mg. each were inserted into the tumor tissue and left in place fourteen and a half hours. This was repeated again August 19, 1920, two months later. He received a seventh series of x-ray treatments, consisting of 6 doses, in October, 1920, and again an eighth series, consisting of 4 doses, in December, 1920; a ninth series, consisting of 2 doses, in February, 1921, and a tenth series, consisting of 2 doses, in April, 1921. He has had no treatment since. He is working every day on a farm and seems to be in excellent condition.

Remarks.—One year and nine months have passed since this patient had an exploratory operation at which only sections could be removed for microscopical study, and at which time he would otherwise have been left to pass the usual course of malignant disease. Under x-ray treatment he has shown progressive improvement, and while he has much fibrous tissue still about the neck, he is able to carry on his usual duties and is feeling comfortable. We are hoping that this condition will continue. At any rate, his life has been much prolonged and the case has been transformed from a hopeless to a hopeful one.

Case X. M. S., female, aged sixty-eight, referred by Dr. M. Frank, Egg Harbor City, N. J., May 12, 1921. She had noticed a tumor two months previously, involving the right side of her neck, which had grown progressively larger, and five weeks previously began to give her a choking sensation and breathing difficulty. At the time she was referred for treatment there was general enlargement of all the lobes of the thyroid, but more particularly of the right. The tumor was large, irregular in outline, not clearly defined, and infiltrated the surrounding tissue, which led us to the diagnosis of malignancy. We treated her through three portals of entry including the thyroid and upper mediastinum, and gave her four doses through each of these three portals of entry within a period of two weeks, consisting of the following technique: at a distance of 30 cm., 6 mm. of filter, 9 inch spark gap, 5 ma., twenty minutes' exposure. July 12, 1921, two months later, all visible and palpable evidence of the tumor had disappeared. However, she was given a similar dose over each of these areas during the month of July, and again during the month of September, though at no time since the first month has there been any palpable evidence of disease, and apparently she has completely recovered.

Remarks.—This latter case also belongs to the group in which the diagnosis is not positive, though clinically I have no doubt as to the malignant nature of this tumor, and in this last case we have obtained the most brilliant results of any. It would seem to me that with these results, as described, if a diagnosis can be made reasonably early the best possible treatment will consist of active radiation, either by the roentgen rays or by radium.

TECHNIQUE

In general, as a result of my experience in these tumors and other tumors, I believe that it is advisable to treat these patients through three or more portals of entry, according to the amount and distribution of the disease, with a focal skin distance of 30 cm., using a 9 inch parallel spark gap, 5 ma. of current, 6 mm. of filter, and with an exposure of twenty minutes, to be repeated over each area a week apart if possible and to treat each area three times, then to stop treatment completely for three or four weeks, when each area can be covered again twice in a similar manner. If the disease localizes itself to a single nodular mass which ceases to respond to further treatment, it is entirely practical then to introduce radium needles directly into the tumor tissue and thus bring about a more thorough destruction of the cancer cells in the deeper portions. Ten mg. of radium element in the form of needles can be introduced into the tumor tissue approximately 1 cm. apart and left in place six to eight hours, or 2 cm. apart and left in place twelve to fifteen hours.

CONCLUSIONS

1. Every case of carcinoma of the thyroid that has been operated upon should receive, as soon as possible, at least two thorough courses of roentgen-ray treatment, and more if the disease has not been completely removed so far as the surgeon can recognize.

2. If a diagnosis of carcinoma of the thyroid can be made without operation, a reasonably good hope of success can be entertained by radiation treatment.

3. Recurrent cases can be made to respond to treatment and the recurrence can be made to disappear, but the definite metastases are not likely to be controlled in late cases.

4. Radium can be combined with roentgen-ray treatment to good advantage in carcinoma of the thyroid when the tumor has become definitely localized or when it ceases to respond to the roentgen rays.

ROENTGENOTHERAPY OF THE THYROID*

BY A. F. TYLER, M. D.

OMAHA, NEBRASKA

IN the discussion of this subject we shall consider only cases of hyperthyroidism, including of course under this title, the typical exophthalmic goiter, the hyperplastic type of toxic goiter and toxic adenoma. All other types of goiter should be treated by surgical or medical means rather than by roentgenotherapy.

Goiter is an exceedingly common malady in America. There are numerous areas where the disease is endemic; this is especially true in the Great Lakes region around Lake Erie and in certain other parts of the country. There is even an area in which it is endemic in Iowa and a portion of Nebraska, where practically every young woman who reaches the age of twenty-one develops goiter, generally of the toxic variety. This means that the disease is almost universal in our country, being more common, of course, in the endemic areas. The disease is so serious in its effect that the patient deserves our utmost skill in the treatment.

Historical. The employment of *x*-ray in treating this condition dates from 1898, about the time *x*-ray machines were manufactured in suitable form for medical purposes. The mechanical limitation of the apparatus at that time made the fractional dose method with low penetration compulsory. Even with this technique, which is now considered inadequate, many brilliant results were reported. Pfahler[1] in 1916 reviewed the literature, bringing up to date *x*-ray therapy of toxic thyroids and reporting the results of his work. Later, Holmes[4] reported the results of roentgenotherapy of toxic thyroid at the Massachusetts General Hospital and I believe

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he was the first roentgenologist to control the treatment by estimation of basal metabolism. Both these men emphasized the inadequacy of the low voltage fractional dose method of treatment as compared with the more modern technique, and in closing Pfahler says it has been customary for him to use a spark gap of 9 inches, anode skin distance 8 inches, 5 ma. and five minutes time over each area with the rays filtered through 3 mm. of aluminum and 1 mm. of sole leather. He recommends that this dosage be re-

Chart 1. Mrs. W. The result of the metabolic estimation made before treatment and at the end of treatment, four months later. Notice the rapid decline from plus 59 per cent to minus 3 per cent, the patient being entirely well and free from any signs of toxicity at the time the last test was made.

peated once every three or four weeks and that we should treat both lobes of the thyroid and the thymus as well. This employment of *x*-rays produced by higher voltages and passed through heavier filtration marks a distinct step forward in *x*-ray therapy of toxic thyroid.

Cases Suitable.—There are three distinct clinical types which are amenable to radiation therapy. First, the exophthalmic goiter; second, the hyperplastic toxic goiter; and third, the toxic adenoma. In our experience the response to roentgenotherapy is in the opposite order from that in which I have named them above; that is, toxic adenoma responds the most quickly, hyperplastic goiter next, and exophthalmic goiter last. This may be due to the fact that exophthalmic goiter usually comes after the symptoms have become more pronounced and after cardiac degeneration has occurred, or even after mental symptoms have begun to show.

Method of Selection.—Due to the fact that we must distinguish very carefully as to the type of goiter which presents itself for treatment, it is compulsory for us to use every means at our command for arriving at an accurate diagnosis. We must make a very thorough physical examination. If we feel that we do not care to undertake this part of the work ourselves, we should call into consultation a competent medical consultant who will do this work for us. Those of us who are working in close association with a group of men

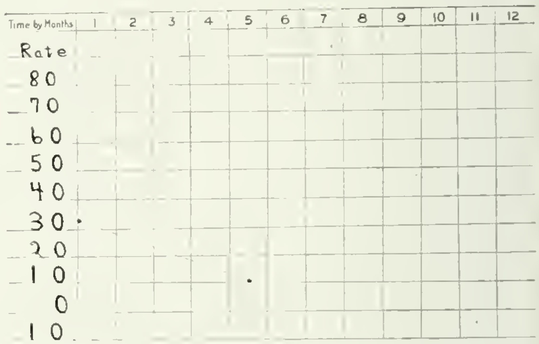

Chart 2. Mrs. F. The result of the basal metabolic estimation before treatment and at the close of treatment five months later. Notice the rapid decline from plus 32 per cent to plus 10 per cent. This patient has remained well to date.

have the advantage of this consultation with the greatest of ease. Those of us who are working independently should train ourselves to be thoroughly familiar with the different physical findings in the different types of cases.

We should examine every patient carefully for cardiac changes. This has been especially impressed upon me by a recent case of exophthalmic goiter with a history of having passed through three crises previous to coming to me. She was left a widow on a farm with several small children and for years had reared the children and managed the farm and thought she could not give up. When she presented herself to me, however, she had a typical exophthalmic goiter with myocardial degeneration, arhythmia and fibrillation. This of course presented a very serious problem and we were compelled to hospitalize her at once. Under hospitalization the heart slowly returned to normal rhythm, the myocardial changes gradually recovered, and roentgenotherapy over the thyroid gland caused almost entire disappearance of the tumor, together with reduction in the pulse rate, a sense of well-being, and a lowering of the basal metabolic rate. This patient, however, will always have degeneration of the heart muscles and doubtless some time in the not far distant future she will die of heart disease secondary to the exophthalmic goiter.

There is another type of case which frequently presents itself to the roentgenologist, that is the one which has gone on until mental changes have taken place. These cases are practically always fatal, no matter what treatment is administered. They are in the last stages of dissolution at the time they present themselves for treatment and tax the skill of the medical man and roentgenologist to the utmost.

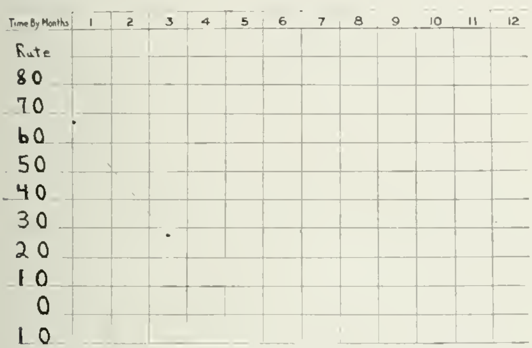

Chart 3. Mrs. H. Basal metabolic estimation before and after treatment; the first test showing a plus 66 per cent, the second test at the end of three months showing a plus 26 per cent and a third test at the end of eight months showing minus 4 per cent The patient has remained well up to the present time

Not only the routine physical examination as mentioned above should be made, but the investigation of all parts of the body for focal infections is very important. Since 90 per cent of all foci of infection which produce metastases in the body are located above the clavicle, the tonsils, teeth and accessory nasal sinuses should be especially investigated. This is of prime importance; and our experience has been that unless we eradicate the foci of infection in patients suffering from toxic goiter, they will not get well.

Our experience has also shown that there is a very close relationship between the function of the thyroid gland and the function of the ovaries. In cases in which there is excessive menstruation without any demonstrable pathology and in which the thyroid is diseased, not only do we treat the thyroid but some treatment is given over the ovarian region, aiming to check the ovarian function. In several cases in which this combination has existed, we have, for our information, treated the thyroid alone for a time to see what the result would be. When the patient did not respond with the usual rapidity to the treatment, we treated the ovarian region, and then found a much quicker response.

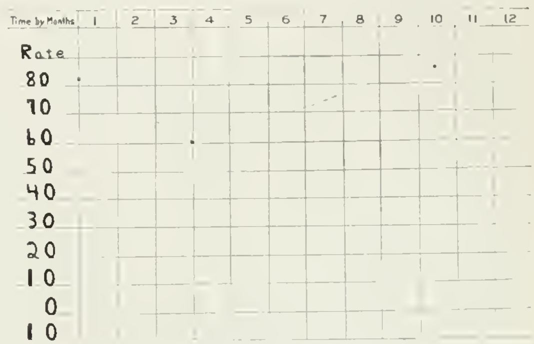

Chart 4. Mrs. L. A case of toxic thyroid showing the basal metabolism before treatment of plus 83 per cent, a second test at the end of three months of plus 60 per cent and a third test at the end of the tenth month showing a plus 85 per cent. An extreme case which has not had sufficient rest and has not responded well to treatment. The goiter was complicated by myocardial degeneration which made the case inoperable. She is still under observation.

In addition to all physical examinations, we especially urge the employment of the basal metabolic estimation. This should be done in all cases of goiter which present themselves for treatment. If carried out as a routine it will be found of great help in distinguishing between nervousness with focal infection and true toxic goiter. It is in this type of case that it has proved especially helpful in our hands in a diagnostic way. We would not be without its use to check the effect of treatment.

Dr. Holmes has shown us the extreme value of the basal metabolic test as a check on the effect of treatment. We cannot conceive, after a case has been worked out as here described, and the basal metabolic record shows that the metabolic rate is down to normal and remains there for a period of months, together with improvement in the general physical condition, how anyone could have any argument against the favorable influence of radiation on toxic thyroid. It has been mentioned by some that there will be a temporary increase in the basal metabolic rate for a short time after the first treatment. This occurs in the severely toxic cases, consequently we need to be a little cautious in the dosage administered in some of the cases. After this first increase in the basal metabolic rate in the severe cases, in the average case there will be a gradual decline of the basal metabolic rate until it reaches normal or slightly below. This decline covers a period ranging from three to twelve months. Clinical improvement will show earlier than the improvement in the basal metabolism; in fact, we personally feel that there should be clinical improvement in every case at the end of the four weeks when the patient returns for the second treatment. In cases which do not show this clinical improvement we feel that the treatment is going to be unsatisfactory and rather disappointing and prolonged.

Some men have mentioned that there was danger of producing myxedema by roentgenotherapy. There is no more danger of producing myxedema under proper technique than by surgery. The surgeon learned long ago that he could not remove the entire gland without getting into trouble. We should bear in mind that same knowledge and should not treat to destroy the whole gland. It is my custom, unless there is absolute need of treating the isthmus, to protect the isthmus during treatment so that it does not receive any radiation. This accomplishes two things: first, it avoids the danger of myxedema, and second, it protects the trachea and larynx from radiation. We have found that if we expose the trachea and larynx to heavy radiation, patients develop a temporary aphonia and in some cases of heavy radiation a permanent aphonia.

We have one patient who was so toxic that she was inoperable. She was referred to us for radiation treatment and improved very rapidly. After her recovery from the disease she still had quite a tumor in the neck, and because of her pride she went to the surgeon who had referred her to us for treatment and asked if he could not remove the tumor. This he did for cosmetic reasons. This patient suffered from myxedema, not from radiation treatment, but because, owing to the fibrous condition of the thyroid at the time of operation, it was completely removed, leaving insufficient thyroid tissue to maintain the balance of metabolism. We have had the privilege of making a microscopic section of this specimen, which proved beyond a doubt that radiation changed the parenchyma of the gland to fibrous and connective tissue.

Our routine when patients suffering from thyroid disease present themselves to us for treatment is as follows: First, a careful history is taken which includes all the family history, personal history, history of previous illness, previous operations and any other data which can be obtained. After this, a careful physical examination is made including blood-pressure, pulse, temperature and examination of the heart; then an *x*-ray examination is made of all the teeth and accessory sinuses and a fluoroscopic examination of the chest, together with plates in the oblique position, as recommended by Pfahler. After this is done a basal metabolic estimation is made; then *x*-ray or radium therapy is employed. It is our custom to use the *x*-ray in ambulatory patients, using a 10½ inch spark gap, 6 mm. of aluminum and one thickness of sole leather, 8 inch anode skin distance, 6 ma. of current for fifteen minutes over each area, treating three areas, one over each lobe and one over the thymus region. This dosage is repeated in four weeks and ordinarily three such doses are all the patient needs. We are very careful not to expose the trachea and larynx, unless absolutely compulsory, on account of the involvement of the isthmus.

It is our custom to employ radium therapy in cases requiring hospitalization. We do this because of the fact that we can employ radium while the patient is lying in bed, thus avoiding excitement and the physical exertion of being taken down to the x-ray room. We feel that the effect of x-ray and radium on the tissues of the thyroid gland and on the symptomatology of the patient is practically identical.

Advantages of Roentgenotherapy.—In advocating this type of treatment for toxic goiter we feel that it has certain advantages over other treatment. First, there is no surgical shock, consequently the mortality is very low; second, it is useful in surgical failures; third, it can be employed in inoperable cases. In comparing this method of treatment with the surgical method we must bear in mind that the basal metabolic rate returns to normal in about three weeks after an operation, while with roentgenotherapy the decline to normal is gradual, occupying from three to twelve months.

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DISCUSSION OF SYMPOSIUM ON THERAPY OF THE THYROID GLAND

PAPERS BY DRS. ALLISON,[1] HOLMES,[2] PFAHLER AND TYLER

Dr. Richards. I was very greatly interested in hearing the final résumé of a subject which has interested us considerably for the last six or seven years. There is nothing I can add to the discussion except to make the observation which one of our surgeons has several times noted in connection with adhesions following operation. We have had the usual criticism that long continued radiation causes adhesions which are detrimental in the operation, if that becomes necessary. One of our surgeons has made the observation that it permits him to do an almost bloodless operation and that he considers it not a great disadvantage but on the contrary occasionally a real advantage in that respect, and that the adhesions, as such, have not been a disadvantage. If I may be permitted to refer to our work, we published two years ago a series of 300 cases treated and since that time we have added about 150 other cases with, in general, the results which Dr. Holmes and the others have reported. During the last two years these were checked by metabolism tests almost invariably, and there is nothing to add in that respect except our conviction that the treatment offers in a large majority of cases quite as much as surgery, and sometimes much more. A number of cases were postoperative failures and we have been able to pull them around to a condition of apparent health. I would like to add two cases to those contained in Dr. Pfahler's paper of successful treatment of carcinoma of the thyroid. In both cases more than two years have now elapsed since the initial treatment; both were proved by operation; and both are now clinically well. The only other thing that occurs to me is that as roentgenologists we do not have the courage of our convictions. In my own work when my opinion goes up against the opinion of a surgeon, I am more likely to lose out than win out. I do not think it should be so. If we can substantiate our opinions with figures and with proof, I think we can offer to our patients quite as much as the average surgeon with much less risk.

Dr. Palmer. About two years ago I became very much interested in the thyroid question in association with the internist and surgeon. I would like to emphasize the value of the opinion of the surgeon, an opinion of one who is absolutely unbiased about this thyroid question, because I think his opinion is of great help in any of these cases.

[1] Allison, R. G. X-ray treatment of toxic goiter. Am. J. Roentgenol., Nov., 1921, viii, 635.

[2] Holmes, G. W. Some observations on the treatment of hyperthyroidism with x-rays. Am. J. Roentgenol., Dec., 1921, viii, 730.

We have been undecided as to the value of surgery in toxic adenomata. In cases in which it is impossible to bring them to the normal, or in cases in which the adenoma is giving pressure symptoms, we find it advisable to have the adenoma removed. We check these cases frequently by metabolism estimations and consider it of the utmost importance.

I would like to emphasize what Dr. Case said in regard to the dangers in some of these highly toxic cases. I believe each case should be carefully watched and studied before giving the first *x*-ray treatment and that no highly toxic nervous case should receive a full treatment without some preparation, such as the giving of morphia in the extreme cases. I have in mind a case that died in the hospital twenty-four hours after one *x*-ray treatment. Looking up the history of the case I found that there had been no metabolism estimation and that the patient had been given the treatment in a highly nervous condition, very high pulse rate with auricular fibrillation. It was the general opinion among those who saw the case that she died as the result of extreme toxemia following the treatment.

Dr. Case. It seems to me the time has arrived when we must consider the *x*-ray or radium treatment of hyperthyroid cases as well established and approved. I want to ask Dr. Holmes about adhesions following *x*-ray treatment of the thyroid. I have heard repeatedly that surgeons dislike very much to operate for goiter a patient who has had preliminary treatment with *x*-ray or radium on account of the numerous adhesions alleged to be present at the operation. In my own surgical experience I have not found adhesions to be present in any unusual amount in such cases; on the contrary one notices adhesions in thyroid operations more frequently after thyroiditis than after *x*-ray treatment. I would like to ask Dr. Holmes' experience with reference to this point.

I might also mention my experience at the Battle Creek Sanitarium in the treatment of toxic thyroid cases where the patient is so extremely nervous that a trip to the *x*-ray room would be very upsetting. We found it very helpful in those cases to use radium for the first application. It is not a bad idea to apply ice bags to the neck and throat of such cases; and it is very easy to slip a radium applicator in one of the ice bags and give the proper dose.

We are very fortunate in having as our metabolist Dr. Paul Roth, who worked with Dr. Benedict at Boston in developing the first apparatus for clinical metabolism estimations. We have utilized this method in checking up our cases since the earliest date when such a method was clinically available.

We must decide in a thyroid case whether we are going to use radiation or surgery. As Dr. Holmes said, it is not always possible to stick to our ground. If possible, we should never submit to *x*-ray or radium a case which may later need surgery for the reason that the combined procedure is far more likely to produce myxedema.

I would like to add to the list of thyroid cancer cases cited by Dr. Pfahler a patient with malignancy of the thyroid who received her first treatment from us in 1914. The patient is alive and well to date without any sign of recurrence or anything to suggest more than an ordinary goiter operation. An attempt was made to remove the thyroid. It was found to be malignant and the operation was given up when half accomplished and the patient sent to me for treatment. That was early in 1914 and to-day the patient is alive and well—free from any signs of recurrence.

Dr. Holmes. In regard to the question of adhesions, I think that in order properly to understand this condition we must consider very briefly the cause of adhesions. I do not think that this is well understood, but it is generally stated that following tissue destruction of any form new connective tissue will be produced. If this assumption is correct, some gland must be destroyed, and sufficient time must elapse for connective tissue to form before you have adhesions. We have been very fortunate to have associated with us in our work a clinician and surgeon who would cooperate. Our surgeon does not find any difficulty whatever if the operation is done within six months after starting treatment. The larger number of cases in which adhesions give trouble are those which have been inefficiently *x*-rayed over a long period of time—that is, years.

One of the arguments against the radiation of the thyroid is the length of the treatment, during which time the rapid heart continues. I think there is a very definite question as to whether or not the damage to the heart resulting from the stress of operation is not greater than that which would be brought about by the period of time before which the metabolism reaches normal.

Regarding the question of myxedema, we, as roentgenologists, are exactly in the same position as the surgeons were five or ten years ago. We do not know how much gland to destroy. Up to this year, I did not believe we could produce myxedema. I think that we shall be compelled to carry out some such technique as Dr. Tyler suggested. I believe that adenomatous cases develop myxedema more quickly than the exophthalmic type.

In connection with the treatment of malignant goiters, I have had the opportunity to treat six cases. One received as many as eighteen treatments over the thyroid gland. I had a metabolism done and it was normal. It would seem that it is very difficult to affect the normal thyroid. This is in line with the theory that cells undergoing some pathological change are more likely to be affected by radiation than the normal cells.

Dr. Pfahler (closing). I am very glad to learn of these additional cases that have been successfully treated. I am quite sure there must be a number of other men in the room who have had experience in this line. My impression is that carcinoma of the thyroid is more responsive to treatment than almost any other carcinoma, and I believe that we have not treated enough of these cases. I believe it is distinctly the best treatment we can use. I concur with the previous speakers that in very bad hospital cases of hyperthyroidism you can probably use radium to greater advantage than *x*-rays. In ordinary toxic goiter cases my technique differs a little from that which has been previously described. I use four portals of entry, dividing the thyroid in the median line, and again dividing each side with a line extending downward from the angle of the jaw to the middle of the clavicle. I treat the anterior two fields with the patient lying on the back and the posterior two fields with the patient lying on the abdomen—directing the rays downward and inward, protecting the larynx.

THREE CASES OF SARCOMA TREATED BY RADIATION*

BY D. Y. KEITH, M.D., AND J. P. KEITH, M.D.

LOUISVILLE, KENTUCKY

THE histories of the following cases are so unusual that a detailed report will prove of interest. You will note one case is well after five years; one after two years and one after fifteen months. Two had received all that surgery had to offer and the other was beyond surgical relief or aid.

CASE I

Personal History. Female, married, aged fifty-nine; married forty years; six children living; none dead. No history of tumors in any of her family.

Recent History. First noticed a small pigmented tumor in suprasternal notch in April, 1913. Sixteen months later this was removed and began to show evidence of return in about one year. It was again removed, but returned in about three months.

Diagnosis. Melanotic sarcoma.

She came to us on January 5, 1916, and we were told by her surgeon that it was impossible at the second operation to remove all the pigmentation because it was so far behind and so deep in the suprasternal notch, which was unusually deep, the patient on account of being thin weighing about 85 pounds.

At the time we first saw her a small black mass was present deep in the episternal depression, about the size of a navy bean. On palpation it felt spongy and appeared very much like jelly in consistency. Any attempt to remove or manipulate the small mass caused copious bleeding.

She was *x*-rayed anteriorly and posteriorly at monthly intervals for six months, receiving enough to give a first degree skin reaction on three occasions before any change in the tumor was noted. The tumor had completely regressed by June, 1916 (six months after treatment was instituted), and at present there is no evidence of return. A moderate telangiectasis is present over the site of the tumor, as the only reminder of her pigmented tumor.

She had received prophylactic or preventive doses at sixty to ninety day intervals since June, 1916, receiving seven in 1917; five in 1918; four in 1919, and four in 1920. She was last seen in December, 1920, though a letter was received from her on

* Read at the Second Annual Meeting of the Central Section of The American Roentgen Ray Society, St. Louis, Mo., Feb. 21, 1921.

February 15, 1921. There is no evidence of return or transplantation elsewhere.[1]

Technique. At the time the treatment was instituted she was given a 7 in. spark gap; 12 ma.; 8 in. skin distance; 3 mm. of aluminum filter, no leather, and six minutes, time. Three ports of entry anteriorly and two posteriorly were used.

During the last three years the technique has been 8 in. skin distance; 5 ma.; 9⅝ in. spark gap; ten minutes time with filters of one piece of photographic glass; 6 mm. of aluminum with a piece of sole leather lying upon the patient. Only an anterior and posterior port of entry have been used during this time.

CASE II

Female, married, aged fifty-two. Wife of a physician. Family and personal history negative.

Present History. First noticed a growth in the left side of the neck in August, 1911. Very small, perfectly free and movable, with no pain.

Operative History. On January 10, 1912, under local anesthesia tumor was removed for microscopical study. Pathological report was "round cell infiltration with a few giant cells." Diagnosis: Chronic adenitis, non-tubercular.

Second Operation. On October 1, 1912, under general anesthesia a small keloid scar was removed with a small nodule thought to be an enlarged cervical gland, which proved to be a blood clot.

Third Operation. On April 1, 1913, several enlarged glands were removed which were lying just over the carotid artery.

During the summer of 1914 a recurrence was noted, and on September 30, 1914, the enlarged nodules were again removed and submitted to a pathologist whose report follows:

"The specimen from the neck shows a malignant tumor rapidly growing. Further than this I do not like to go at present, but I am much interested in the future of this case. It has some indications of being a melanoblastoma (melanosarcoma). I want to make paraffin sections and do some differential stains to determine the nature of the pigment. If it is a melanoblastoma, I suppose it might be metastatic from a tumor in the central nervous system, which has not yet manifested itself.

"If it should prove fatal, I should like very much to have the opportunity of making a post-mortem examination."

Final report October 6, 1914. Diagnosis: Melanotic sarcoma.

Fifth Operation. In January, 1916, she was operated upon by Dr. Coley of New York, who removed all the enlarged nodules, the largest one being about the size of an English walnut and containing a small amount of fluid. A section of the carotid artery was removed with this mass of malignant nodules.

Treatment with Coley's fluid by Dr. Coley immediately after the operation was continued for more than one year under his directions, the treatments being given by her husband. The nausea and reaction were always severe, the patient finally refusing to continue the injection of toxins.

On January 25, 1918, another small nodule was removed about the size of a shelled peanut with the following pathological report:

Specimen consists of a tough mass of white and red tissue 45 × 22 × 12 mm. Section reveals several white glistening lymph nodes, cut surface of which is not remarkable. The largest is 22 × 17 mm. This node has in it a spherical mass 7 mm. in diameter which is harder than the remainder of the gland and irregularly speckled with white and gray.

Diagnosis. Melanotic sarcoma, metastatic.

She came to us on June 5, 1918, four months after last removal of a small nodule. On examination a well-elevated scar 3½ inches in length was seen on the left side of the neck anteriorly. The scar was about ½ inch in width and in the margins of the lower end were several small nodules, the size of shelled peanuts, fixed, with moderate tenderness on pressure.

Technique. 105 kv., equal to 9⅝ inches

[1] This patient was seen again on December 14, 1921 and is in good shape physically, though having suffered a hemiplegia in December from which she has completely recovered except the delicate movements of the hands'

spark gap; 8 inch skin distance; 5 ma. current; one photographic glass; 6 mm. aluminum and sole leather filters by the cross-fire method.

She was given divided doses every second day until full treatment was completed. The entire cervical area was covered anteriorly, laterally and posteriorly. Treatments were given at monthly intervals for one year. All the small nodules had disappeared within sixty days after treatment was instituted with marked thinning of the thick scar.

Thirty-three months have now elapsed since treatment was begun and twenty-one months since the last cycle was given.[2]

It is reasonable to believe that after so many recurrences with such marked relief from proper roentgenotherapy, relief and probably cure could be obtained in cases of this character without surgery. It is certain that if the growth could be inhibited it would be much easier for the patient.

These two cases of pigmented tumors are of great interest because of the long period of years over which they have extended, because both are at present free from evidence of recurrence and neither has ever been transplanted to other portions of the body. We are aware that you have seen many cases of this type that give very little if any response to radiation, either roentgen ray or radium.

Both these cases were given more than the erythema dose, which we feel has to be given in order to obtain a lethal dose for the structures beneath the skin. The deeper the nodules are beneath the skin the more absorption of the ray; hence, in order to obtain a lethal dose to the tumor mass as many ports of entry are used as it is possible to obtain.

CASE III.

Female, single, aged forty, white. Housekeeper.

Family History. Father living and in good health. Mother died of malignancy of axilla, developing from a small nevus. Has two brothers and four sisters living in good health. No history of tuberculosis or lues.

Previous History. Always healthy, of a robust physique and blonde complexion.

Present History. During August, 1919, patient says she experienced severe pains in the right arm after having used a sledge-hammer in breaking wood. Several days later the right pectoral muscle became swollen, infiltrated and very painful. She was treated for pneumonia, and after changing physicians two or three times she was referred to us for an opinion as to what she might expect from roentgenotherapy.

On examination we found a very robust patient; weight 160 pounds. She had lost 30 pounds during the past two months and had been taking opiates for the relief of pain. A mass, the size of an orange, was found in the upper half of the mammary gland, extending outward into the pectoral muscle with so much induration that it was impossible to determine whether the tumor was in the gland or in the pectoral muscle. The glandular enlargement in the axilla was marked. Edema of the entire arm was present but particularly marked in the hand. The movements of the shoulder and forearm were very much restricted, the least motion causing a great deal of pain.

Her physician and family were told that our opinion was that she had a sarcoma which, it was quite evident, was inoperable and that radiation offered her relief of pain for a short time and probably some reduction in the size of the tumor, and that with their consent we would use larger doses than was our custom, but no larger than we would use on any other patient with the same type of tumor.

Exposure over the anterior portion of the right chest, which included all the tumor mass, gave a skin reaction that was quite severe and caused us to reduce the dose on the posterior areas treated two days later.

Patient received treatment on the following dates: January 15, 17, 29, 31; February 17, 19; March 15, 18; May 3, 5, 24, 26; August 26, 28. She has been advised to see us at regular intervals of three months for the next two years.[3]

She was given a cycle of treatments on November 24–27, 1920, and at that time

[2] This patient is well and free from recurrence, January 10, 1922.

[3] This patient was in for prophylactic treatment November 2, 1921, and is well at the present time.

was completely free from any enlargement in the pectoral muscle. A symptomatic cure has been present for one year. She will be given radiation every three months for two years if she adheres to our advice. The pain was relieved within one week and has not returned. The edema in the hand and arm has completely disappeared, and there is no evidence at present of tumor in axilla, muscle or gland. When she returned in March, two months after the beginning of treatment, she insisted she was well, and it was only after a great deal of persuasion that she promised to return. She has completely regained her original weight (loss 30 pounds). There is no loss or restriction of motion in the arm or shoulder.

The points of interest in the technique in this small series is the difference in voltage which ranged from 7 to 9⅜ inch spark gap and in the filters: one patient received a filtration of 3 mm. aluminum, is well five years after beginning of treatment. The others received filters of one piece of photographic glass; 4½ and 6 mm. of aluminum with one thickness of sole leather with a spark gap of 9⅜ inches; voltage 105 kv. with no difference in the ultimate results. We believe there is one point to obtain in all cases; a full lethal dose for the malignant cells with as little injury to the skin points of entry as possible.

With the aid of radium needles to insert in local masses or recurrent nodules we are confident most types of malignancy can be handled with much less suffering to the patient, with more cures, than with radical surgery and inefficient radiation, as is usually the case when supervised by the surgeon.

The future in malignancy, we believe, will be in cosmetic surgery, *x*-ray externally, radium needles inserted in the drainage, lymph nodes or recurrent nodules, preferably supervised by the roentgenologist, as most of us have seen patients come back to us after radical surgical procedures where we had expected cosmetic surgery and find on examination that they are hopeless and much worse than if no surgery had been attempted.

Our experience with filters is that when erythema appears, it heals quicker with less annoying symptoms where heavy filtration has been used.

THE SUPERFICIAL REACTION OF RADIUM AS A GUIDE TO DOSAGE*

BY WILLIAM S. NEWCOMET, M.D.

PHILADELPHIA, PENNSYLVANIA

THERE seems to be a prevailing opinion in the medical profession that if a person possesses a given amount of radium it is possible to employ it for almost any lesion coming under observation. While this may be true to some degree, the best results will be obtained where the application of radium is made to fit the case, and not in accordance with the amount of the element the individual possesses. The more flexible the radium unit is, the better will be the results, and where it is only possible to obtain a limited amount of this element, several small units will be much more useful than one of larger size.

The acme of perfection would be reached if it were always possible to give the amount of radiation at one sitting that would completely heal the lesion treated. At the present time our dosage factor is so irregular that to carry out this procedure is almost impossible. In mentioning this fact, the cases of superficial epitheliomata must be excluded, as the majority of these heal easily under any form of radiation. Many have been observed that completely healed from a sub-erythema

* Read at the Sixth Annual Meeting of The American Radium Society, Boston, June 6–7, 1921.

dose. But where the disease has involved the deep structures, the treatment is always a most difficult and interesting problem. Many cases have been treated by radium where the dosage was not sufficient to produce the desired result. There would follow a local abatement in one area and a progression in another. Where this condition prevails it is best to stop all forms of radiation for several months and then make a new start. Such cases will respond better than those that have been previously subjected to excessive radiation, and where the tissues are breaking down from that cause, it is almost impossible to get a new start. Therefore, the application of a massive dose of radiation must always be given with the greatest care and only under circumstances where it is absolutely justifiable.

The reaction from radium has not been considered as dangerous as that of the *x*-ray, but it must not be forgotten that radium will give practically the same results under similiar circumstances. The radiation differs but the results produced are similiar and the modification is due, in a larger measure, to the difference of application rather than to the difference in radiation.

With the *x*-ray the standard is the "erythema dose," usually worked out by certain factors for distance from the anode and amount of current. In superficial conditions, the "erythema dose," although it does vary within limits, is a safe working basis due to the fact that the erythema produced is usually of a mild degree. But here we have the point of origin almost constant; the anode is always a given distance from the skin. With radium, however, the factors are different and the results upon the tissues depend upon the following conditions:

1. The amount of radium element or its equivalent.
2. The distribution of the radiating material.
3. Time of application, duration and intervals.
4. Distance from the part.
5. The style of container, filters, etc.

Any modification of these factors will produce entirely different results. If 100 mg. of radium element in a small glass tube contained within a silver tube about 1½ cm. long, 3 mm. in diameter, the thickness of the silver being about 1/10 mm., be applied for one hour; 50 mg.

Fig. 1. Shows results from 100 mg. for one hour, 50 mg. for two hours, 25 mg. for four hours. Radium element in a silver tube, filtered by two layers of gauze and one of thin rubber. Eight weeks after application. Most intense reaction was observed about three weeks after application.

applied for two hours; and 25 mg. applied for four hours, in capsules of the same character, all filtered by 1 mm. lead and a thin sheet of rubber, each separate application will amount to 100 mg. hours, and practically under the same conditions, yet the effect will be quite different so far as the reaction upon the skin is concerned and likewise its deep effect must also vary. The 25 mg. for four hours will give a more intense reaction over a larger field; in other words there will appear to be an accumulative effect. The erythema produced by the 100 mg. tube will be an oval area about 1½ by 2 cm., while the 25 mg. tube will produce an area of erythema of about 2½ by 3 cm. with an intense central reaction. The erythema usually appears and reaches the climax within a week; in ten days, there will be some vesication, followed by a superficial ulceration, which will heal in about six weeks to three months, leaving an area of less pigmentation which remains more or less indefinitely.

Fig. 2. Shows results from 100 mg. for one hour, 50 mg. for two hours, 25 mg. for four hours. Radium element in silver tube, filtered by 1 mm. lead and 1 layer of thin rubber, twenty-one days after application.

If the application is modified by placing 1 mm. of lead and 1 cm. of wood between the radiating material and the tissues, and the time increased, two hours for the 100 mg., four hours for the 50 mg., and eight hours for the 25 mg., a very wide difference will be noted. In about a week to ten days the area of erythema will appear to be at its height, the area being about 2×3 cm. where the 100 mg. had been applied; an area 3×4 cm. for the 50 mg. and 4×5 cm. for the 25 mg. tube. The local irritation will be far greater in the area where the small tube has been applied, while the erythema that develops by the 100 mg. application becomes quite dusky; usually there will be no ulceration; the 50 mg. tube produces in some instances a slight vesication and even a slight superficial ulceration at times; while the 25 mg. tube is followed by somewhat more severe local reaction in all trials and at times an ulceration almost of the first degree. While the dosage in each instance was 200 mg. hours filtered by 1 mm. lead and 1 cm. wood, yet the local reaction was far different. If the application be again modified by placing 2 cm. of wood between the radium and the skin, the 1 mm. lead filter and time being the same as in preceding series, it will be found that the reaction for the 100 mg. for two hours produces an erythema of less intensity but wider in area or about 3×4 cm. in diameter. The area of erythema for 50 mg. for four hours was about 5 cm. in diameter; while the 25 for eight hours was about 7 cm. in diameter with no vesication or ulceration. This illustrates the fallacy of expressing the dosage alone by milligram-hours.

In the first series the difference in the effect of the radium might be assigned to what may be termed an accumulative dosage; but the second and third series bring in another factor, that of distance, which appears to explain the rather wide difference in the reaction obtained from the *x*-ray. The further away the source of activity is from the area of application, the more uniform will be the surface radiation, while deep dosage suffers less variation in accordance with the law of dispersion. Therefore, if a beam of high *x*-ray is passed through a port of given size, the difference between the surface dosage and that 4 cm. below the skin will not be as great as where radium is applied directly to the skin. In the case of radium it can be easily seen that there is an enormous surface dosage, while 4 cm. below it is comparatively small. In the treatment of superficial conditions this factor is the most important one. The diseased condition receives an enormous dose while the sound tissues underlying the lesion receive comparatively little radiation.

If the lesion penetrates to some depth and a deeper radiation is required, then

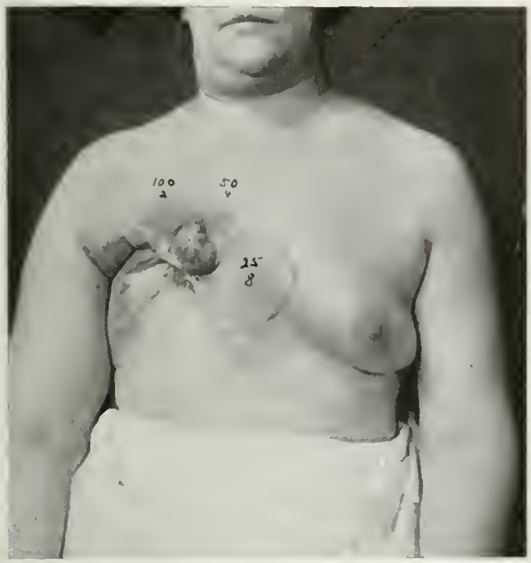

FIG. 3. Shows results from 100 mg. for two hoursl, 50 mg. for four hours, 25 mg. for eight hours. Radium element filtered by 1 mm. lead, 2 cm. wood. Three weeks after application.

the radium should be elevated and the time increased in proportion. But should this elevation be more than 1 or 2 cm. other factors must be considered. In those cases in which the cross-fire treatment is adopted the radium should be elevated 1 or 2 cm. from the skin; and while some authorities have expressed the belief that radium is not effective beyond 2 cm., yet in the number of cases of carcinomata of the larynx, the only ones living to-day without manifest evidence of disease were those treated by this method. Others, where there was a direct application to the larynx or by needles inserted into the growth, failed to respond.

Intense local reaction has been attributed to secondary radiation; but there is not the least doubt that most of this irritation is simply due to the relatively high surface dosage.

The small amount of damage done by the secondary radiation is scarcely negligible, and the judicious use of distance will to a great extent set aside all local surface irritation.

The distribution of the radiating material must also be taken into consideration. The effect of a large tube containing 50

FIG. 4. Result of one application 100 mg. Radium element in silver tube placed in the center of the opening, which was covered with a fungoid mass that nearly closed the opening. Previous *x*-ray and small applications of radium failed.

mg. of radium element mixed with a large bulk of non-radiating powder will produce an entirely different local effect compared with a small tube of highly concentrated element or a small tube of emanation. Therefore the factor of radiation must be worked out for each unit and the dosage arranged in accordance with the reaction produced. While we have a difference in the distribution of the radiating material, in reality the factor is only one of distance, and if the effects be compared they will be found to resemble each other more closely as the skin distance is increased.

Filtration is a most important consideration in the local application of radium. If the beta radiation is not removed, the surface radiation is so great that it will cause a superficial ulceration by a comparatively small dosage. To illustrate this fact, a number of tests were made: where one tube containing 50 mg. radium, the capsule being the same as previously described, was filtered by 1 mm. lead, another was filtered by a piece of soft wood of the same thickness. Applications were made for one hour and an hour and a half. Where the lead filter was used only a very faint erythema was produced, which reached its height at the end of ten days or two weeks. Where the wood filter was used the erythema was quite marked and a week later had formed a small ulcer about 1½ cm. in diameter, which required about six weeks to heal. The reaction resulting from low radiation of radium differs to a marked degree from that produced by the high or gamma radiation. The erythema is more superficial, is usually a bright red and can be removed by light pressure; while that of the gamma radiation is usually a dusky red, is deep and difficult to remove by pressure. Likewise the ulceration, if it should follow the beta radiation, is superficial, and will heal in a comparatively short time; while the gamma ulceration is deep and the time for healing is prolonged.

Usually in those cases where there is an ulcer covered by deep granulating or proliferating material about 1 or 2 cm. deep, if radium tubes are used in the treatment they need be only lightly filtered, and the tube placed directly upon the granulating mass, which in itself acts as a filter and allows the base to be radiated by the more penetrating rays. If the mass is covered by sound skin, then the choice will lie between the use of penetrating rays by cross-fire method, trying to avoid injury to the overlying parts, or by the use of needles placed directly in the mass. The election must be left to the discretion of the operator.

The element of time as a factor must be considered according to the area covered and also with areas in the immediate vicinity. There appeared to be little or no difference between areas exposed to 50 mg. radium element in a silver tube and the same quantity in a group of stock needles, when applied to the skin for one hour. Usually there was a marked erythema in ten days followed by a slight ulceration lasting about two months. The area was an oval about 1½ cm. in diameter; and it should be stated that the tubes were protected by two layers of gauze and a sheet of thin rubber tissue. If a lead filter be added 1 mm. thick, then 100 mg. can be applied for one hour, and usually only an erythema will result. The time and area must be considered when the cross-fire method is to be employed and the 2 cm. limit of useful radiation is not to be depended upon in making the calculations. If a mass with a base 5 cm. in diameter is to be treated, one application is made at the apex and seven about the base; probably there will be a very violent reaction at the apex of the mass due to the constant radiation from all sides and the supposed equal dose by the 2 cm. limit. The element of time in proportion to distance and space to be covered is always a problem. It may be worked out by "rule of thumb" yet it is always difficult of approximation.

A rather interesting and unexpected result was obtained in the treatment of a cystic goiter. The mass projected in front of the neck about 2½ cm. and was about 5 cm. in diameter; 100 mg. radium was applied filtered by 1 mm. lead and 1 cm. wood, for two hours, in four positions, two on the right side and two on the left side of the mass. Two weeks later there was a faint erythema over the whole mass, while at the end of two more weeks the area midway between the areas of application, about 1½ cm. in diameter, was covered by dry scales, which shaded off into a dusky red area. The site of the applications still showed a faint erythema. Two weeks later the whole process had disappeared leaving only a slight tanning of the skin.

This illustrates the usefulness of cross fire, and it would appear that the area so treated is affected to a greater extent than is usually supposed. It has been shown, as previously mentioned, that the effect of 100 mg. hours given 25 mg. for four hours is more intense and extends over a greater area than 100 mg. for one hour. In conjunction with the case just cited, would it not appear that cross-fire effect was somewhat above the usual calculated factor; time being the element that alters the result? The *x*-ray burn caused by the old low-powered gas tube depended to some degree upon this factor, while the time was relatively short compared with the application of radium; yet it must be admitted that modern technique has decidedly shortened the time of exposure.

The character of the tissue must always be considered, especially where the parts have been subjected to previous irritation from other causes, and some late reactions and ulcerations have been noticed from the application of irritants after radiation: iodine, mustard and excessive heat are common, and due regard must also be given to the tissues in the very old and very young. There seems to be a prevailing opinion that it is safe to make a second application after the lapse of three weeks. But in the light of some very late reactions that have occurred, it is difficult to come to an exact conclusion. In the folds of the axilla and groin the reaction is greater, possibly due to the mechanical irritation of sweating, rubbing or chafing.

The foregoing deductions apply to normal structures where more or less uniform results are produced, yet there is some variation in the degree of resistance; but when it comes to pathologic structures the variation is far wider than it is in normalcy. To illustrate this fact attention is directed to the ordinary wart that appears and disappears under circumstances that no one has as yet clearly defined. We have seen them resist the most approved methods and vanish like magic under the treatment of some charlatan. Yet these are peculiarities of pathologic tissues. Passing from warts to well-defined tumors, some of us have seen large tumors disappear or become quiescent under circumstances that could not be explained, while on the other hand, in spite of all that could be done many of these cases pass rapidly with literally no change in their course that might be attributed to treatment.

The small superficial epithelioma need no comment, except to state that any form of radiation properly applied will heal them promptly and with practically no scar. But when they have reached the deep structures or are of the glandular type, their treatment is often difficult and must be carried out with the greatest care. Under such circumstances, the radiation must reach the deeper structure without involving the surrounding normal tissue which by its destruction would produce a field for further irritation. To obviate the damage of normal tissues where large doses are required, the implantation of radium in the growth, where it is possible, appears to be the best procedure. In this way the growth is radiated to a greater extent while normal structures are decidedly less affected. Here again judgment must be exercised, for as much injury may be caused by the introduction of radium into the mass through the normal tissues as would be done by the rays passing through it. The surrounding structures must be always considered. An "application" that would be perfectly safe in one portion of the body would mean disaster to another. To illustrate this point we would call attention to the practice of placing a 100 mg. tube in the uterus for the treatment of carcinoma; yet when this same dose is applied in the rectum for the same condition, the result is usually quite the contrary, due to the difference in the character of the disease and the structure of the intestine. In the case of the uterus, the thick heavy tissue acts as a filter and keeps the normal structure at a safe distance.

Having called attention to a certain irregularity in the response of different tissues to radiation, the action upon several cases of sarcomata which were supposed to be enlarged glands might be mentioned. When radiation was applied they disappeared easily leaving absolutely no trace of them; their disappearance was unfortunate, for within a short space of time they had reappeared in other parts usually in the deeper structures with fatal results. Therefore when a nodule is treated, it matters not how sure we are of our diagnosis, it will not be amiss to regard it as a sarcoma until it is proven otherwise. By so doing we may save life.

This article does not pretend to enter into any scientific detail as to exact measurements, nor upon any microscopical study of tissues in various stages, but is based upon a large number of applications to prove some facts which were observed in the ordinary treatment of a large number of cases.

The statement of a well-known physicist that "if men would give their dosage in their work we might come to some conclusion" cannot be denied. The dosage factor must be worked out upon clinical lines and not in the laboratory. The wide variation of the effect of radiation upon diseased tissues is a variable factor and in ending, I wish to emphasize the importance, in reporting cases, of the details as to the amount of radium, its distribution, time of application and, if repeated, the different intervals with the filters and distance from the affected part. If radium is implanted the exact method should be described, not only the amount but its distribution; the reaction observed and the relation of the diseased to healthy parts and also the results obtained. And it must be remembered that each applicator has its own dosage.

DISCUSSION

Dr. Henry Schmitz. The paper impressed me for the reason that Dr. Newcomet dwells on the erythema dose. If we realized the importance of exactly determining the erythema dose we would all get busy as soon as we return home and try to get the proper erythema reaction. The question arises whether the faint reddish color is an erythema dose, or whether we should have this go on to scaling of the skin, with loss of hair, and after four or five or six weeks a deep tanning of the skin. We must of necessity have an absolute understanding of the extent of this reaction. After we have obtained this erythema skin dose (and we have an instrument for determining it which we use with an ionization that anyone can make) we can obtain good results. We could then by the discharge of this electroscope actually determine the amount it takes to produce the erythema skin dose. The skin dose is best compared to the old-fashioned sunburn. We get the intense reddening, even the intense sensation of burning in the skin, and in very sensitive persons there is even blistering, while in the ordinary individual within a week or ten days there is the well-known feeling of the sunburnt skin, the itching and burning, etc., depending upon the length of the exposure. This is the reaction we should obtain from the erythema skin dose. Different people have a different sensibility to rays and this differs practically 20 per cent either way. Some will stand 20 per cent more than others without any reaction, while in other cases you cannot under ordinary circumstances produce this effect, or if you do it is only with remarkable difficulty.

For illustration, in one case of skin cancer, we warned our patient beforehand that there might be a burn and this was done in the presence of other persons so that there could be no misunderstanding. We stated that ordinarily there was no trouble but that if the skin was oversensitive there might be a burn. In this individual we got an overdose of almost 5 per cent. She was a fair blonde, but nothing happened and she recovered nicely within a short time. In another patient whom we did not care to treat at all because the disease was so far advanced that we thought the case was entirely hopeless, the patient received an average dose and apparently stood it well. There was no skin reaction and no improvement in the local condition. She had a persistent leukopenia. She kept on bleeding and kept on going down. Finally, after about two months, we suggested another course of treatment and wished to do a transfusion for the leukopenia, for we were afraid to treat her. She went to the country for a rest and after about four to six weeks she returned with her blood picture normal. She then had the second treatment and following that she was normal, or at least greatly improved, but she had no reaction on the skin. If with the production of the erythema skin dose we had dared to use another treatment I am sure we would have had a burn in this case of the third degree any time within six months. So this patient must have had an undersensitiveness that amounted to 200 or 300 per cent.

The thing I derived from this paper was the determination of the biological skin dose which must be the unit of comparison for our work.

Dr. Rollin H. Stevens. I would like to say a word concerning the different strengths of radium. My experience has not been very large, but Dr. Pancoast mentioned angioma. For the last ten or eleven years I have been treating cavernous angiomata with small plaques, 1 to 2 mg. of radium distributed over about two and a half, and the other to 1 cm., with the 2 mm. plaque and two sheets of paper, and I get quite a marked erythema dose, one that will be red in about two weeks and that later will turn brown and peel, and in some sensitive places, like the face of a child, I have had some glistening. I apply it for seventeen hours. I have found that the application of these plaques has given me better results than the application of the 15 to 20 mg. plaques, and furthermore the scarring in the skin seems to be much less. I think the cosmetic results are much better. I have even treated large rhinophyma of the nose with these two plaques and have succeeded in reducing them almost entirely. I think we must use a good deal of judgment as to the strength of the radium we are going to use in the different diseases we are treating.

This treatment, of course, applies to the cavernous type of angioma only, not to the ordinary nevi.

Dr. C. J. Broeman. I wish to ask whether you ever use radium in tubes or needles in the treatment of superfluous hair, particularly in the so-called "bearded women" and on the upper lip where we know the electric needle is apt to leave some trace of scarring. I have treated several cases, using a deep filter, and in some cases I have been able to remove the hair without any bad after-results, sometimes without even an erythema dose.

Dr. Frederick Bryant. I would like to know what experience the Doctor has had in the treatment of lupus.

Dr. William S. Newcomet (closing the discussion). The statement that we can with perfect safety make a second application to a given lesion at the end of three weeks is not correct even when there is not the least sign of reaction. I think this has the approval of many medical men. Much depends upon how the first application has been, and we must look out for late reactions. I have seen reactions that were very pronounced six weeks or two months after the application of radium, when the skin appeared to be absolutely normal at the end of three weeks. Furthermore, it seems to be the opinion of many that a dosage of equal mg. hours will give the same effects with no difference as to how you distribute your radium.

I wish I could come to some conclusion as to what is the erythema dose for any given applicator at any given distance. It is by no means as constant as the *x*-ray factor. For our *x*-ray, though, the regularity of a good dose is fairly constant. We thought machines and the Coolidge tube gave us the regularity of the erythema, and I believe that some years ago someone made the statement that an *x*-ray burn was prima facie evidence of neglect. One can hardly agree with this rather strong statement, particularly when we can prove that the erythema dose is an undetermined factor.

In the treatment of angioma a number of cases have been complicated with superfluous hair; usually it is easily removed. Dr. Broeman has the right idea. If you can get rid of the hair without any marked reaction, you will have no scarring, and it is usually permanent. Excessive reaction, however, with ulceration from radium usually gives an area of decreased pigmentation surrounded by a line of increased pigment which may disappear in time depending upon the character of the skin and intensity of the burn, and the dose which will produce an erythema in one person may produce vesication in another. One must be very careful not to get an ulceration. The line between these skin reactions is a very narrow one, and peopel who desire to have hair removed do not desire a scar.

In regard to lupus vulgaris, Wichmann of Hamburg found that the majority suffered from recurrence. These cases usually respond very well to treatment, but the patients should be informed that it is likely to recur.

TREATMENT OF BRAIN TUMORS BY RADIATION*

BY HENRY K. PANCOAST, M.D.

Professor of Roentgenology, University of Pennsylvania

PHILADELPHIA, PENNSYLVANIA

Brain tumors are peculiarly adapted to treatment by radiation, for many reasons. A large proportion of them are made up of pathologically malignant cells and are, therefore, susceptible to the action of radium or roentgen rays. They are, as a rule, comparatively slow in growth and rarely metastasize, thus uniting two ideal conditions for such treatment, especially when it is considered that here, and in practically no other part of the body, it is safe and it is good surgical practice to remove a malignant growth in part only and leave its subsequent destruction to radiation. A localizable and accessible growth may be exposed and then be either left intact or partially or completely removed, and treated subsequently by radiation, by direct implantation of radium or by cross-firing through the skull by radium or roentgen rays, or both methods may be practiced. If a tumor cannot be localized, or it is inaccessible to the surgeon when localized, there is still left the possibility of obtaining fairly satisfactory results in some instances by cross-fire radiation from the outside alone.

The dangers attending the treatment may be considered under those of the surgical procedure, including a possible removal of the tumor; infection carried by the radium needles or implanted tubes or dependent upon leaving the wound open for the purpose of their removal; the effect upon the flap and subsequent healing as a result of external cross-fire radiation; and the effect of radium radiation directly upon normal brain tissue. Surgical dangers need not be considered here except for commenting that the very fact that radiation can be relied upon may in some instances render the operation less hazardous because complete removal of a growth may not be so essential if it is likely to be attended by added risk to the life of the patient.

The possibility of infection deserves careful consideration. Radium needles and capsules containing radium or its emanation for implantation can readily harbor dangerous infecting organisms for a long time and cannot be sterilized by heat when the radium or emanation tubes are in them. We advocate the immersion of needles or capsules and their threads in 40 per cent formalin for at least one half hour and then in 95 per cent alcohol for forty-five minutes, before they are used for implantation in the brain. More recently we have been sterilizing needles by careful boiling. In only one possible instance has an infection followed brain tumor implantation, and that was before the present method of sterilization was instituted. Infection due to leaving a part of the wound open for removal of implanted radium cannot be positively eliminated, but its avoidance must be a part of the surgical technique.

Cross-fire radiation through the scalp must usually include exposure of the surgical flap, as this is in the majority of instances the part of the surface of the head nearest to the growth. It is quite possible to jeopardize the integrity of the flap by such exposure if immediate radiation is applied. As rapid recurrence and metastasis are not likely, it is safe to postpone cross-fire radiation until healing is well under way. As the dosage given is a safe skin dose under ordinary conditions, necrosis of the flap is a remote possibility if the application is postponed for a short time. The presence of the hair must not be permitted to interfere with the application, nor should the strong possibility of its removal be allowed to weigh against the amount of treatment necessary. The patient should, of course, be warned of the likelihood of losing all or a part of the hair in the area exposed, especially in the part of the scalp included in the flap.

The possibility of dangerous effects from radiation of normal brain tissue demands

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separate and careful consideration. The technique of radium treatment of tumors must really be based largely upon the known ability of the normal brain structure to withstand definite amounts of radiation by both implantation and external cross-fire applications. Normal brain tissue is probably as resistant to destruction by radiation as any other tissues of the body, but the exact nature of the direct and indirect effects of destructive doses are serious and must be thoroughly realized and understood.

All cases treated by us have been on the service of Dr. Charles H. Frazier at the University Hospital, and all treatments have been carried out in cooperation with him. In the earlier cases treated in 1914 and later, the technique was carried out more or less at random, without the least accurate knowledge of the effect of radiation upon normal brain tissue. Implantation dosage was based entirely upon a knowledge of the approximate dosage required to destroy a similar growth of the same dimensions elsewhere, modified by an intuitive apprehension of possible danger from brain destruction and a desire to minimize destruction of normal tissue. The limit for cross-fire radiation was skin tolerance. It soon became apparent that more accurate knowledge was essential, based upon animal experimentation rather than upon clinical experience.

During the session of 1919–20, experimental work upon the brains of dogs was turned over to three senior undergraduates in the Medical School of the University of Pennsylvania—Drs. Williamson, Brown and Butler. The results of their work have been published.[1] The salient features of their experimental work were briefly as follows: A 50 mg. tube of radium element in a platinum capsule of 0.4 mm. thickness was laid directly upon the dural surfaces of the brains of dogs near the motor cortex—in the parietotemporal region—for varying periods up to a dosage of 900 mg. hours without untoward effects and without paralysis. At the end of one month, each dog was killed and the exposed area of brain examined macroscopically and microscopically. Microscopic sections of the brains exposed to 900 mg. hours' radiation showed three zones of reaction surrounding the position of the tube. In the central zone, 5 mm. wide, the brain tissue was completely destroyed; 2 mm. further out there was a hemorrhagic area with extravasation; and 1 mm. further was a zone of inflammatory reaction. The flap was not destroyed. One 900 mg. hour dog was kept alive for nine months and was then killed, and the brain showed an area of cicatrization 15 mm. in diameter with a central crater containing what was probably a clot. These experiments showed that it was practically safe to give a dose of 900 mg. hours with well filtered radium on the surface of the brain. Advantage was subsequently taken of this knowledge in the treatment of a case of extensive epithelioma of the external ear, canal, middle ear and mastoid in which direct applications were made to the involved tegmen of the attic and antrum. The experiments of Bagg with implanted unfiltered radium emanation would lead us to believe that such a dose without filtration would be dangerous.

Further experiments were required to determine the maximum tolerance to surface applications and to implantation into the brain, whereby the entire output of radiation would be exerted upon the brain tissue. In surface applications probably little more than half the radiation acts upon the brain. Sudden death had followed direct implantation in two cases of brain tumor, but not necessarily the result of the radiation. One of these was an hypophyseal tumor.

During the past year, at the request of Dr. Frazier and myself, my associate, Dr. Pendergrass and three senior undergraduate students, Messrs. Hayman, Houser and Rambo, have carried out a series of experimental applications ostensibly for the purpose of determining the maximum safe surface dose and implantation dose in dogs' brains and the surface dose upon the spinal cord. We will quote the results of their experiments only as they apply to the points under discussion. The combined results of their work have brought out many points of value and

[1] C. S. Williamson, R. O. Brown and J. W. Butler. A Study of the effects of radium on normal brain tissue. *Surg., Gynec. & Obst.*, Sept., 1920, xxxi, 239.

intense interest, and will shortly be published by them.

The smallest surface dose given was 1,000 mg. hours with 0.4 platinum filtration over the same area. The dog was killed on the fourteenth day, prematurely. The next higher dose was 1,150 mg. hours, and the dog was killed on the forty-ninth day and had shown no untoward results. The next higher dose was 1,400 mg. hours, and that dog developed a progressive paralysis and died in four weeks. The largest dose was 2,600 mg. hours, followed by death on the sixth day. Between these death doses there was found to be almost a direct relation between the dose and the time of death, which could be practically prognosticated by the intensity of dosage. The cause of death and the interesting antemortem phenomena will be fully discussed by the authors in their report.

Upon the basis of these experiments the human brain surface dose of fairly well filtered radium when concentrated over a comparatively small area should not exceed a figure between 1,150 and 1,400 mg. hours, when healthy brain tissue is exposed directly and had better be well below 1,400 mg. hours. Because of the comparatively small surface of the dog brain it is difficult or impossible to determine whether or not a larger dose can be given with safety if spread over a larger area. It probably could be, especially if a decidedly destructive dose was not delivered at any one point. This assumption finds credence in the fact that much larger doses are given over a large part of the head by external cross-fire radiation, and each area receives less than a destructive dose to the skin. No one expects to expose any one limited area of healthy brain surface of the human to such a dose as 1,400 mg. hours, but these danger figures are of value when one computes what dosage normal brain tissue is likely to receive in a limited area during the treatment of a brain tumor with a certain implantation dose.

As would be expected, the safe dose from *implantation* is much smaller than the safe surface dose. Implantation of filtered radium in dogs' brains from 900 mg. hours down to 360 mg. hours all resulted in death, with apparently the same manifestations in each instance, but not resulting from any local infection. The therapeutic dose from implantation must be comparatively small, therefore, when actual destruction of normal brain tissue is likely to result. The well filtered dose can probably be higher than the unfiltered dose, and tumors act as filters in protecting the normal tissue. Implantation of needles around the periphery of a tumor is probably more dangerous than central implantation. In every instance Dr. Frazier has employed central implantation. We have given as high as 1,445 mg. hours by implantation in a large cerebellar tumor without untoward results, and the patient is still alive seven years after the application. In another case, a 900 mg. hour dose was applied in a cavity the size of an egg following the removal of a cerebellar tumor. Implantation doses of from 900 to 1,050 mg. hours were applied in six other cases, and none of them died as a result of the applications with the possible exception of one who died fifteen days after an implantation dose of 1,000 mg. hours. It is more likely, however, that death was not the direct result of the radium application. Nearly all of these cases received supplemental external cross-fire radiation.

No experiments have been carried out to determine the effect of external cross-fire radiation upon dogs' brains for the reasons, first, that no actual comparisons can be made with safe skin doses because of the vast difference in size between the human and the canine head, and, secondly, because we believe external cross-fire radiation to be a comparatively safe procedure if the patient is carefully watched. In several instances nausea has necessitated intermissions in the applications. We have repeatedly given 3,000 to 5,000 mg. hour applications spread over a considerable area of the scalp with no bad results, and up to this point, at least, the only danger to be avoided, aside from nausea and collapse, which can be guarded against, is injury to the skin. Because of the frequency of nausea and possibility of collapse we prefer to proceed slowly with smaller amounts of radium—100 to 150 mg.

The technique employed in the treatment of brain tumors must be based upon such important factors as the following:

1. The dose must be as safe a one as our clinical and experimental experience teaches us is possible, yet sufficient to accomplish the desired result.

2. Implantation is contraindicated when all the tumor is removed unless a large cavity persists and the radium can be packed in the center of the cavity.

3. If the growth is partly removed or not removed, the implantation dose must depend upon the size of the tumor to be treated and its nature, but with due regard to any possible destructive effect upon normal brain tissue. It may be safe to destroy normal tissue in some parts of the body, but in the brain the amount of destruction permissible is distinctly limited, not so much on account of loss of brain tissue as because certain serious constitutional effects may result.

4. For implantation, the size of the tumor must be known in order to reach all parts with some effect but at the same time protect normal tissue.

5. A knowledge of the pathological nature of the growth is essential.

6. Until we know from experience the relative amount of dosage required for the destruction of brain tumors as compared to that required to destroy tumors of the same nature and size elsewhere in the body, provided the tumor is not one peculiar to the brain, our dosage must be approximately the same for the one as for the other.

7. As the implantation dose necessary to destroy the growth will rarely if ever be a safe one, implantation alone will usually or always be insufficient and must be supplemented by cross-fire radiation from the outside, especially if we expect to control the actively growing peripheral cells.

8. Cross-fire radiation can be repeated with slightly reduced dosage over each area as soon as the skin reaction subsides.

To a certain extent, the treatment of each case is a law unto itself, but cases can be so grouped that a general technique can be prescribed for each group, as follows:

1. *Tumors accessible to the surgeon and presumably completely removed.* Implantation is contraindicated unless a large cavity persists and the radium can be packed in the center of the cavity. Otherwise, if any treatment is regarded as necessary, it must be carried out entirely by external cross-fire radiation. This may be accomplished by roentgen rays if so desired, but we prefer the use of radium, well screened and at comparatively close range. The exact technique is not of so much importance. The one we have employed is to map out the close-cropped scalp into squares of 1¼ inch dimensions. The radium is placed in a cubical lead box of the same internal dimensions, with the open end covered by 2 mm. aluminum and 5 ply thick rubber-dam filter. The radium is about 4 mm. from the skin surface when the box is applied to the scalp with a special holder. With 110 mg. of radium this box can be left over each square one hour, and a marked but safe reaction will be produced. Thirty to fifty squares are thus treated, depending upon the requirements. The external applications may be repeated with slightly reduced dose to each area as soon as the skin reaction subsides.

2. *Tumors accessible to the surgeon and partly removed.* The question of implantation depends upon the size of the growth remaining, its nature, and location favorable to the removal of the needles or capsules. If implantation is practiced, it should be as nearly as possible in the center of the tumor area and entirely within the tumor. The dose will depend upon the size of the tumor, but will usually be less than is required completely to destroy it. Implantation should be supplemented by external cross-fire radiation, or the latter alone may be all that is possible.

3. *Tumors accessible but not removed.* The same remarks apply.

4. *Tumors not localized or not found at operation.* Depend upon general external cross-fire radiation.

5. *Pituitary growths.* At the present time we do not advocate implantation into pituitary growths exposed by the transsphenoidal route. Radium, carefully screened, may be applied to the nasopharynx and this application supplemented

by external cross-fire radiation by roentgen rays or radium. The nasopharynx will easily stand 500 to 600 mg. hours. This form of postoperative treatment is well worth trying after sphenoidal decompression. In one instance hypopituitary symptoms developed after a single application.

Of all the thirty-two cases treated, those of most importance are the four treated in 1914. One had undoubted symptoms of brain tumor clinically and this was confirmed by x-ray examination, but the tumor could not be localized and almost the entire head was exposed to cross-fire radiation. After giving about as much treatment as we dared without apparent improvement, the parents refused permission for further applications. Soon afterwards the child improved and lived five years without further treatment. She died of influenza. The other three cases are still living.

One of these cases was operated upon in 1914 by Dr. Frazier, and had about seven-eighths of a gliosarcoma removed from the left cerebellar region. She was then treated by cross-fire x-ray over a period of three months and again by radium once a year subsequently. She came back with a recurrence in June, 1920, and could not walk alone. A 50 mg. capsule was implanted in the growth for eighteen hours, followed by rapid improvement of symptoms. In October there was an increase in the growth and cross-fire radium radiation was given, followed in a month by another implantation of 50 mg. for eighteen hours, followed again by decided improvement. In April, 1921, another cross-fire application was made. She still has an ataxia, but no headache and is undoubtedly better.

Another of the three cases was operated upon by Dr. Frazier in 1914 and a large tumor exposed in the cerebellar region, supposedly glioma, and 85 mg. of radium implanted in the inoperable growth for 17 hours (1,445 mg. hours). Subsequent cross-fire radium radiation was given in 1915, 1916, and 1917. The case was decidedly improved although some ataxia remains and he never recovered his sight. An exploratory operation this summer revealed a large cyst occupying the seat of the original tumor. The pathological report on a section of this cyst wall showed no evidence of tumor formation, only a process of "chronic irritation."

The remaining case was operated on by Dr. Frazier in 1913 and 1914 (two stages) but no tumor was found in the cerebellar region. The prominent symptoms were

TABLE

SUMMARY OF CASES TREATED

Year first treated	Number cases treated	Cases living 1921	Years living after first treatment	Dead	Operations—Cases still living				Pathological report—Cases living				
					Tumor removed	Tumor partially removed	Tumor not removed	Tumor presumptive	Glioma	Endothelioma	Sarcoma	Pituitary not determined	Not determined
1914	4*	3*	7	1*	..	1	1	1*	1	0	1	..	1
1915	4	0	..	4	..	..	..	..	..	..	..	..	..
1916	3	0	..	3	..	..	..	..	..	..	..	..	..
1917	4	2	4	2	..	..	1	1	1	..	..	..	1
1918	4	3	3	1	2	..	..	..	2	1	..	..	..
1919	1	1	2	0	..	1	..	..	..	..	..	1	..
1920	10	7	1	3	..	2	5	1	2	2	..	3	..
1921	2	2	..	0	..	2	..	..	..	0	1	..	1
Totals	32	18	..	14	2	6	7	3	6	3	2	4	3

* One case treated a few months; further treatment refused; lived 5 years.

headache, vomiting, almost total blindness, and the patient could not walk without assistance. She was somewhat improved after operation. Radiation by cross-fire radium applications has been given a number of times. At the present time, she goes to school, can read easily and walks alone with only a slightly ataxic gait.

We believe that radiation had a decidedly beneficial effect upon all four of these cases and that the subsequent histories of many of the cases treated in later years will show similar results. We acknowledge the possibility of over-enthusiasm, but we feel sufficiently encouraged to advocate the treatment of a large number of cases by many individuals, and further animal experimentation, in an attempt to prove to the satisfaction of others that radiation is of distinct value and to improve the technique of the application.

We are now treating a case of endothelioma (pathological report) which originated apparently in the pituitary region and later grew down into the sphenoid sinuses and into the nasopharynx. The effect of treatment upon this tumor, if any, can be observed, and will be watched with much interest.

DISCUSSION

Dr. James T. Case. I would like to show some slides of a patient who in January, 1920, came to the Battle Creek Sanitarium almost totally blind. *X*-ray examination showed a very much enlarged sella. The roentgenogram of the sella and the graphic showing the visual field I will present on the screen. He was subjected to operation by Dr. B. N. Colver who removed, through the transnasal route, fragments of a tumor which proved to be adenoma. The patient's visual field was practically normal within two weeks; but as time went by his visual field gradually began to contract again. The surgeon realized that he had taken out only a small portion of the tumor. By May of this year the patient's visual field was again contracted as much as before the operation.

The question of using deeply penetrating *x*-rays came up, and we decided to subject this man to radiation with voltage of 180,000 and upwards. This decision was not reached, however, until the end of July by which time the visual fields were as shown in the slide before you. We accordingly treated him through five areas—rather small areas, the portals of entry being 4 × 4 cm. The line of attack was carefully calculated after studying the skull and the radiogram. Within one month the widening of the visual field was so pronounced as to be startling. We hope for a permanent improvement of the visual field in this man.

THE TREATMENT OF PRIMARY CARCINOMA OF THE VAGINA WITH RADIUM*

BY LEDA J. STACY, M.D.

Section on Medicine, Mayo Clinic

ROCHESTER, MINNESOTA

I AM presenting this paper for the purpose of calling the attention of radiologists to the treatment by radium of primary carcinoma of the vagina, and with the hope of stimulating more frequent reports of such cases giving the methods of treatment and the ultimate results obtained. I have found only three cases reported in the American literature.

Ward, in 1908, reported a case in which the disease had extended, and a rectovaginal fistula had formed two months after the application of the radium. Levin and Griffith both reported cases in 1914; their reports were made three months after the completion of the treatment, and both local and general improvement was marked.

Primary carcinoma of the vagina is comparatively rare. Williams states that less than 1 per cent of all cancers in women are of vaginal origin. The lesion usually occurs between the ages of thirty and forty. Williams reported the case of the youngest patient on record, a girl of seventeen. He believes that the often quoted cases of Guersant and of Johannovsky in which the patients were three and one-half years and nine years respectively, were of sarcoma and not of carcinoma. In our series of 21 cases, the youngest patient was twenty-eight. Three patients (14.28 per cent) were under thirty-five, the average age was 50.14 years.

Apparently trauma is not an etiologic factor in these cases, otherwise carcinoma would occur more frequently, since the vagina is subjected to many injuries from childbirth, prolapsus uteri, and the wearing of pessaries. Seventy-six and nineteen hundredths per cent of our patients had had children. None of them had prolapsus of the uterus.

All observers report that the growth occurs most frequently in the upper posterior portion of the vagina. In our series 42.8 per cent occurred on the posterior surface; 28.5 per cent on the anterior, and in 23.7 per cent there was involvement of most of the vaginal mucous membrane.

The course of the disease is very rapid. The average length of life following the first symptoms has been estimated sixteen and one-half months, the longest twenty-five to twenty-six months, and the shortest eight months. The rapid course and early glandular involvement are due to the free lymphatic supply of the vaginal mucous membrane.

Three groups of lymphatics drain into the pelvic glands from the vagina. A superior group arises from the upper third of the vagina and passes in front of the ureter, is joined by vessels from the cervix, and empties in the middle chain of the external iliac glands. The middle group comes from the middle third of the vagina and terminates in the hypogastric gland situated at the origin of the vaginal artery. The inferior group drains the lower third of the rectovaginal septum, travels along between the rectum and the sacro-recto-genital aponeurosis, and terminates in the gland of the promontory of the sacrum. The lymphatics of the vagina anastomose with those from the cervix, the vulva, and the rectum (Poirier, Cunéo and Delamere). This lymphatic supply explains the disappointing results in the surgical treatment of cancer in this location and also the subsequent glandular involvement when the local growth has been cured by radium. Metastasis to distant organs, however, is rare.

The symptoms of carcinoma of the vagina do not differ from those of carcinoma of the cervix. In our cases bloody discharge, leukorrhea, and in 52.63 per cent malodorous discharge, were noted. Pain

* Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6–7, 1921.

is not an early symptom and occurred in only 57.14 per cent. It is described usually as a low backache, or as inguinal.

Of the 21 patients with primary carcinoma of the vagina treated at the Mayo Clinic from July, 1915, to January, 1921, information concerning 14 has been obtained recently in answer to questionnaires. Seven of the 14 are living. One has lived three years and nine months, one two years and nine months, one two years and one month, one one year and two months, two six months, and one five months. Of those who died, one died two years and four months after treatment, one died one year and three months after treatment, one died one year after treatment, two died eleven months after treatment, and two died seven months after treatment.

SUMMARY OF CASE HISTORIES OF THE SEVEN LIVING PATIENTS

CASE I. Mrs. J. A., aged fifty-eight, had passed the menopause eight years before. For two years she had had a watery irritating vaginal discharge, recently tinged with blood, some pelvic discomfort and bearing-down pain. Examination showed a small papular roughness of the vaginal mucous membrane, slightly indurated and bleeding, on the left anterior wall of the vagina just within the introitus. No glands were palpable. Fifty mg. of radium salt were applied for six hours, directly against the ulcerated area. A specimen of the lesion removed one month later was reported to be inflammatory. The patient reported three years and nine months after treatment. She had recently lost 35 pounds in weight, but had no pelvic pain nor vaginal discharge.

CASE II. Mrs. H. G. F., aged eighty. Three months before the patient had noticed a growth in the posterior vulva, and occasional bleeding. A cauliflower growth, superficial, with very little induration, involved the posterior vaginal orifice and extended onto the perineum. The inguinal glands were not palpable. Two applications were made of the 25 mg. plaque for fourteen hours each, with 2 mm. brass and one-half inch gauze screening, and 2,000 mg. hours over the inguinal glands. Two months later 50 mg. radium salt were given for ten hours and twenty hours respectively over the posterior vulva and perineum. The patient reported two years and nine months later. Her general health was good and there was no evidence of local trouble and no discharge.

CASE III. Mrs. J. J. B., aged fifty, menstruated irregularly, and had had pain in the back and hips, and occasionally intermenstrual bleeding for two or three months. She had lost slightly in weight. The posterior vaginal wall was indurated, nodular and with some ulceration extending to within half an inch of the introitus. The cervix was atrophied. No glands were palpated. Four vaginal treatments of 50 mg. hours of radium salt for fourteen hours, screening with one-half inch gauze and 2 mm. brass, and posteriorly by 2 mm. lead, and two rectal applications of 50 mg. hours for two hours, at intervals of from three to four days were given. *X*-ray exposures were made over the abdomen and back. The patient returned two months later. She had gained in weight and strength, and was free from pain and discharge. Examination showed two indurated and nodular areas, one in the posterior vault of the vagina and one just within the introitus. There was no evidence of glandular involvement. Two applications of radium to the vagina, two to the rectum, and *x*-ray treatment were given. The patient returned five months later still in good health and free from discharge. The vaginal mucous membrane was smooth, with slight induration in the anterior vaginal wall. The left inguinal gland measured 2 cm. by 1.5 cm. Another course of treatment was given as before, and also radium exposure over the inguinal glands. The patient was last seen in August, 1920. She complained of pain in the back and hips and down the right leg, and recently occasional slight amounts of dark blood passed by rectum; defecation was not painful. She had the same clear odorless vaginal discharge; she had not lost weight. The vaginal mucous membrane was smooth, the vagina slightly contracted. The left inguinal glands were enlarged and a few small glands were palpable by rectal examination. The rectal mucous membrane was smooth. The patient was given one vaginal treatment of 700 mg. hours (50 mg. radium salt for fourteen hours), and 2,752 mg. hours over the left inguinal region. Two years and one month after the first examination the patient reported a poor general condition.

CASE IV. Mrs. W. M. S., aged sixty-two, had passed the menopause ten years before. For five months she had had a slight blood-streaked vaginal discharge, recently with a slight odor. She had lost but little in weight. An indurated nodular growth was found involving the vault of the vagina. Three cervical applications of 50 mg. radium salt for fourteen hours were given, one vaginal application of 68 mg. for ten hours and two rectal applications of 100 mg. hours each. Three months later three vaginal treatments of 700 mg. hours each and two rectal treatments of 200 mg. hours each were given. Six months later two vaginal treatments of 700 mg. hours each were given. The patient returned in six months, one year and two months after the first treatment, reporting a gain in weight and in strength, and practically no discharge. She was doing her own housework. The vaginal mucous membrane was found to be thickened and there was a small soft nodule on the posterior wall of the vagina. The vagina was shortened and the cervix flush with the vault. The left broad ligament was slightly thickened. A proctoscopic examination showed a slight ulcerated area on the anterior rectal wall. The patient was given *x*-ray treatment to the abdomen and back, but no more radium treatment.

CASE V. Mrs. C. E. R., aged thirty-six, had menstruated regularly. For four months she had noted an occasional bloody discharge and pain in the vagina radiating into the back. Her general health was good. An epithelioma 5 cm. in diameter was found on the posterior wall of the vagina. The cervix was free from involvement. No glands were palpable and the rectal examination was negative. The pathologist reported epithelioma, grade 3. Five exposures of 50 mg. radium salt for fourteen hours each, at from three to five day intervals, and *x*-ray treatment over the abdomen and back were given. The patient returned six months later. She had gained in weight, had very slight, if any, vaginal discharge, and no pain. She had had two menstrual periods since treatment. The vaginal mucous membrane was smooth and not indurated; the cervix was free from involvement, and the uterus moveable. Examination of the rectum was negative. The patient was given *x*-ray treatments over the abdomen and back, but no further radium. She was advised to report in four months.

CASE VI. Mrs. A. F. C., aged sixty-nine, had passed the menopause twenty-two years before. For three months she had had a bloody vaginal discharge, and had lost slightly in weight. On the posterior wall of the vagina was a proliferating tumor about 2.5 cm. long. No glands were palpable. The pathologist reported epithelioma, grade 4. Three vaginal exposures of 50 mg. for fourteen hours, and *x*-ray over the abdomen and back were given. A physician who examined her recently found no evidence of malignancy and reported her general health good six months after the treatment.

CASE VII. Mrs. C. R. S., aged sixty-three, had passed the menopause seven years before. For six weeks she had noticed mucous vaginal discharge, but no bleeding. A proliferating growth 2 cm. to 3 cm. in diameter was found on the posterior wall of the vagina; it was superficial, and no glands were palpable. The pathologist reported squamous cell epithelioma, grade 3. The patient was given one application of 50 mg. radium salt for fourteen hours in a wax mould, and two days later emanation needles were buried to approximate 518 mc. hours. Four days later the growth was excised with a portion of the posterior vaginal wall. Twelve days later two more treatments of 50 mg. for fourteen hours were applied. The patient was recently examined five months after the first treatment, by a physician who reported the local and general condition to be good.

SUMMARY OF CASE HISTORIES OF THE SEVEN PATIENTS NOW DEAD

CASE VIII. Mrs. M. O., aged forty-three, had fallen astride a bathtub five months before, and since then had bled irregularly and had noticed a swelling in the vagina. Examination revealed a cauliflower growth involving the anterior and the right vaginal wall. The uterus was movable. A total of 1,750 mg. hours radium into the vagina in three treatments, and two rectal treatments of 100 mg. hours each were given. The patient returned three months later stating that all discharge had ceased two weeks after the treatment, but a small new growth had appeared just within the vulva. Two vaginal treatments of 700 mg. hours each were given. When she reported one month later the vaginal mucous membrane was smooth and there were no adhesions. No induration was detected by rectal examination. Two months later there was found a small ulcerated area on the anterior vaginal wall and this was exposed to 600 mg. hours radium salt. The patient was not seen again until one year and three months after the first examination and eight months after the last radium treatment. There was no evidence of malignancy at this time and a diagnosis was made of a clinical cure. About six months later, however, she developed retroperitoneal tumors and died apparently of abdominal carcinoma, two years and four months after the first treatment.

Case IX. Mrs. A. H. P., aged forty-one, had had a pus-like discharge for seven months, and soreness around the vulva at intervals. Examination showed an ulcerating growth posterior to the urethra, about 3 cm. in size. She was given 600 mg. hours over the growth, and returned in two months. At this time there was merely an area of induration at the site of the growth, and induration of the labia, but the inguinal glands on both sides were enlarged. She was again given two treatments of 500 mg. hours each and *x*-ray treatment over the glands. Three months later when she returned for examination there was rather a deep ulceration but it did not involve the urethra and the glands were still large and tender. Another series of 1,000 mg. hours radium salt was given as before, and *x*-ray treatment. The patient died one year and three months after the first treatment.

Case X. Miss A. K., aged forty-four, gave a history of intermenstrual bleeding for from seven to eight months, and examination showed a carcinoma involving nearly all of the vaginal mucous membrane, associated with thickening in the broad ligaments. She was given three series of 20,000 and 21,000 and 22,000 mg. hours of radium salt respectively at three month intervals. There was local improvement but metastatic extension to the iliac glands, and the patient died one year after the first treatment.

Case XI. Mrs. C. F., aged twenty-nine, had a large proliferating and ulcerating mass involving most of the posterior vaginal wall. This patient received 2,100 mg. hours by vagina (50 mg. for fourteen hours each for three applications) and 200 mg. hours by rectum. She improved after the first treatment, and three months later received a second series similar to the first. In two months, and again in three months she had severe hemorrhages, and died eleven months after the first treatment.

Case XII. Mrs. R. McT., aged fifty-eight, gave a history of vaginal bleeding for one year. She had a polypoid mass 2.5 cm. long just within the orifice of the vagina, on the right and posterior surface, and nodules on both lateral walls; the inguinal glands were enlarged. She was given 1,200 mg. hours into the vagina. Improvement following treatment was only temporary and she died eleven months later.

Case XIII. Miss M. Van O., aged twenty-eight, had had a watery discharge from the vagina for five months and pain in that region for three months. The entire lateral and posterior walls of the vagina were involved. The inguinal glands were not palpated. Three vaginal treatments of 700 mg. hours each and two rectal treatments 100 mg. hours each, were given. The patient returned three months later. She had had three hemorrhages two weeks before. The entire mucous membrane of the vagina was nodular and bled easily. An examination by rectum revealed marked thickening in both broad ligaments. Another series of treatments was given consisting of 728 mg. hours into the cervix, 300 mg. hours into the rectum and 1,400 mg. hours into the vagina. The patient died in three months, seven months after the first treatment.

Case XIV. Mrs. E. L., aged thirty-two, had had a watery discharge of foul odor from the vagina for two months and pain for one month. Her menstrual periods had been regular. Examination revealed a large fungating growth on the left posterior surface of the vagina. The posterior lip of the cervix was granular, the inguinal glands were not palpated. Three vaginal treatments were given of 50 mg. radium salt for fourteen hours each and two rectal treatments of 50 mg. radium salt for two hours each. The patient died seven months later.

All the patients in this group were given *x*-ray treatments over the abdomen and back in conjunction with the local radium applications. As the technique of radium treatment improves the results will improve, particularly in the recent cases in which the emanation needles are buried in the growth, or in which much larger doses of radium salt are given. The increasing efficiency of the *x*-ray treatment is also an important factor. In our cases the local condition has been comparatively successfully controlled, but extension into the glands has not been prevented. We have no doubt been over-apprehensive of the development of vesicovaginal fistulas, and might have given heavier doses. Vesicovaginal fistulas and rectovaginal fistulas occurred in one case, one year after the beginning of the application of radium, following the third series of treatments.

SUMMARY

1. Primary carcinoma of the vagina is comparatively rare.
2. The symptoms are similar to those of carcinoma of the cervix.
3. The disease extends early to the iliac glands; it rarely extends to other organs.
4. Radium and *x*-ray treatments offer better chances for a cure than surgery, and as the technique improves a larger number of permanent cures should be effected.
5. Better results are obtained and there is less danger of formation of fistula if the initial treatment by radium is heavy and not repeated, *x*-ray exposures to abdomen and back being, however, continued.

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A NEW TYPE OF APPLICATOR FOR USE WITH RADIUM EMANATION*

BY DOUGLAS QUICK, M.D., AND F. M. JOHNSON, M.B.
Attending Surgeon, Memorial Hospital — Clinical Assistant, Memorial Hospital
NEW YORK CITY

FOR a considerable time we have recognized that certain types of lesions could be treated much more easily and more accurately if it were possible actually to hold the radium in place by hand while the treatment was being given.

To meet this demand the following simple method has been devised, and after a trial of several months has proven of inestimable value in our work. It is offered for the benefit of those who use radium emanation and are thereby permitted to have a varying supply of applicators with varying amounts of radioactive substance in them.

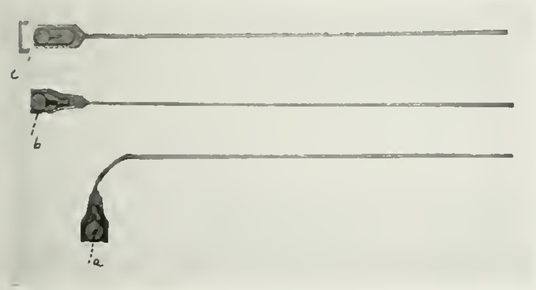

FIG. 1. (*a*) Shows bulb of radium emanation in curved container for larynx or other similar use. (*b*) Bulb in straight applicator. (*c*) Brass filter which may be placed over emanation bulb.

The entire output of emanation for twenty-four hours—about 600 mc.—is collected in a small, thin glass bulb 5 mm. in diameter (Fig. 1 A). The size and shape of this may be varied to suit individual needs.

This bulb is then sealed with paraffin in the end of a steel cone just large enough to receive it and permit of complete inclusion (Fig. 1 B). The steel cone has attached at its apex a pliable metal rod about 45 cm. in length which permits the operator to keep a reasonable distance from the emanation. The pliable material permits bending to facilitate applications in various locations. It will be seen that the bulb of radium emanation occupies the same position in the cone that a clapper does in a bell. At the base of the cone it is exposed and unfiltered, while in all other directions it is filtered by the steel jacket.

FIG. 2. Lead-lined board to protect operator.

In order to lend further filtration for

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certain cases another cone made of 2 mm. of brass with a 1 mm. brass cap to fit over the base of the cone has been constructed (Fig. 1 C).

While the distance afforded by the long metal handle is considerable protection to the operator, it is not sufficient for all practical purposes. To add to the safety there has been constructed a screen lined by 6 mm. of lead, with a glass window for observation, and perforations at various levels to permit passage of the applicator handle (Fig. 2).

The very large number of malignant skin lesions, usually basal cell epitheliomas, require the use of considerable filtered radium for their treatment and a dangerous amount of exposure on the part of the operator.

Many of these are very superficial and a centimeter or less in diameter. In the treatment of such lesions this bulb has proved very valuable. It can be held in place readily for the short period necessary (Fig. 3). An exposure of two minutes with 600 mc. of emanation is sufficient to clear up entirely a rodent ulcer 8 to 10 mm. in diameter. Since the radiation is from a flattened spherical surface, it is better adapted to these small lesions than a tube of radium which gives an oval field of radiation. Being unfiltered, both beta and

Fig. 3. Treating skin lesion.

gamma radiation is utilized, resulting in a saving of radioactivity, and, since the radiation is softer, the reaction is not so deep, and healing is much more prompt.

We have found it advantageous to accumulate these small lesions for a fixed treatment period once in three weeks. Then with a strong, freshly collected bulb of emanation, as many as 40 or 50 cases may be disposed of in an afternoon. This relieves congestion in the service, and saves radium, time and exposure on the part of the operator.

Fig. 4. Treating lesion in larynx.

When not in use in this manner the bulb may be put in a metal sphere or tube and used elsewhere as any other radium emanation tube or applicator.

We have found this method of special value in treating lesions in delicate locations. About the edges of the eyelids, at the inner canthus, or on the conjunctiva, where accuracy of application is the all-important feature, it has facilitated our work very materially. One case of epithelioma of the cornea, a lesion 10×12 mm. in size, has been entirely cleared up by an exposure of 648 mc. minutes—162 mc. of emanation applied over one area for two minutes and over two other areas for one minute each.

The filtered bulb shown in Figure 1*c* was constructed primarily for the treatment of a pigmented sarcoma of the iris where deeper penetration was desired and precision in application was of utmost importance.

For the treatment of papillomas of the larynx or unilateral superficial laryngeal carcinoma, it affords a means of very accurate approximation of the radium while it also protects to a considerable extent the opposite normal cord. Figure 4 shows such an application being made by the indirect method.

We have also utilized this method in the radiation of leukoplakia patches of the buccal and lingual mucosa where a very superficial effect is desired.

A COMPARISON OF RADIATION DOSAGES ATTAINABLE BY USE OF RADIUM ON AND WITHIN TUMORS*

BY CHARLES H. VIOL, PH.D.

PITTSBURGH, PENNSYLVANIA

THE past several years have witnessed considerable change and improvement in the technique of radiotherapy with corresponding indications of better results following treatment in some conditions where the prognosis formerly was very poor. We have also heard a great deal about the experiments and the newer x-ray technique which the Germans have devised.

One of the most interesting points brought out by the experiments of Friedrich and Kroenig, as given in their text on the "Physical and Biological Bases of Radiotherapy," was the observation that the x-ray dose at the depth of 10 cm. in tissues is three to four times greater than the dose which is to be expected if the calculation takes into account only the effects of absorption and distance. This greater dose is accounted for as due to secondary radiation from the tissue and scattered primary radiation.

The same sort of a phenomenon has been observed by Friedrich and Glasser[1] for the gamma rays of the radioactive substance, save that here at 10 cm. distance through tissue, the increase is only in the order of 60 per cent instead of 200 to 300 per cent as was the case with the x-ray dose.

Interesting as these results are and important as it is that they be extended, it nevertheless remains a fact that the clinical results must measure the value of any method and any technique.

The nature of things requires that deep x-ray treatments be given by firing massive doses of the rays through a portal, usually a normal skin area, towards the point to be influenced; and the limiting factor in x-ray dosage has usually been the limit of tolerance of the skin. The use of harder rays has improved results, but the use of massive doses of x-ray through normal tissues gives rise to bad systemic effects, and later there is the great likelihood of development of troublesome fibrous tissue.

Compared with the x-ray, radium by reason of its compactness offers more, since the radium applicator may be brought into contact with the foreign growth even when this is deeply seated.

In the first development of radium technique most of the massive doses were applied by bringing the radium in contact with the exterior of the growth, and depending on the penetration of the rays and exterior cross fire to produce a sufficient effect on the most inaccessible outlying cells.

Radium emanation has been used implanted in tumors since Joly and Stevenson[2] in Dublin in 1914 published the report on using tiny emanation tubes in hypodermic needles, which were thrust through the growth. Duane suggested the implantation of the bare glass emanation tubes; and within the last few years this method has been much used following the large use made of the method and the encouraging reports made on its employment by the late Dr. Janeway and his associates at the Memorial Hospital in New York.

As an approximation of the radium emanation, metal needles containing radium salt have also been employed for insertion into growths. The value of the radium salt makes it necessary to protect the material adequately; hence metal radium needles have a bulk which is even greater than would be necessary if the needle were simply to serve as a container that did not have to withstand considerable mechanical forces, not to mention the abuse which is frequently put upon such forms of applicators in forcing them into dense, fibrous growths.

Reports from those using such metal radium needles would indicate that they

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are satisfactory as the equivalent of the emanation seeds in most instances; therefore the small radium-user need not be deprived of the advantages which the emanation-user enjoys.

The immediate problem in the radiotherapeutic treatment of a localized malignant growth is to secure an adequate or lethal dose of rays in the most outlying cells, since a failure to accomplish this result leaves the patient in much the same predicament that results when the surgeon cannot excise all of the malignancy.

The intensity of the rays from a small source varies inversely as the square of the distance from the source, when absorption is neglected. Since gamma rays of radium are so penetrating that the fall in their intensity due to absorption in tissues is markedly offset by the effect of scattered and secondary rays in the tissue, absorption may then be neglected. If the distance from the radium to the most outlying cells is set as 1, then the intensity of the rays is $\frac{1}{(1)^2} = 1$ on those cells. If now by insertion into the tumor mass the distance between the radium and the most outlying cells is reduced to ½, the intensity of the rays becomes $\frac{1}{(\frac{1}{2})^2} = 4$.

It follows then that with the same amount of radium inserted for the same length of time, the ray dose applied to the most outlying cells will be increased fourfold.

It is the utilization of this principle by multiplying the number of points from which the rays emerge, which gives the possibility of most nearly approximating homogeneous radiation, and of securing the most intense effects of the radiation within the tumor and thereby avoiding the great waste of rays that results when external cross fire is used, together with the possible undesirable effects of these wasted rays in normal tissues adjacent to the neoplasm. A little thought will show that upwards of three fourths of the rays from a tube laid over a growth will fail to strike the growth, and if there are normal tissues lying near the radium applicator, as for example the mucosa, etc., in the mouth, then there is every likelihood of a bad burn in these tissues by reason of the intense action of the wasted radiation.

The future developments in radium technique which promise most, are those which will seek to place the radioactive substance throughout the mass of neoplastic tissues; and it is only in such manner that radiotherapy combined with other suitable methods can hope to control or destroy some of the malignant growths, such as cancer in the bladder, prostate, stomach, etc., where at present the prognosis is far from favorable.

Another point which I would like to mention before closing, is that brought out in a paper by Friedrich and Bender[3] regarding the possibility of enhancing the action of *x*- and gamma-rays by the action of radiators, such, for example, as implanted metal needles, injected colloidal metals, etc., or injected salts like potassium iodide. The opinion has been generally held that the use of such means would result in the absorption of more rays, and, rather illogically, it has seemed to me, more action by the rays in the tissue cells. The results of Friedrich and Bender indicate that not only is the intensity of the rays not increased, but in most of their experiments, due to the radiator cutting out scattered radiation, the radiation intensity is actually less in the tissue than when no radiator is used. The clinical results, where various injections, etc., have been made in an effort to enhance the absorption of the rays and so increase their action on the tissues, have so far not indicated any advantages for this method, and, in view of Friedrich and Bender's experimental results, the promise of this method does not seem great.

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THE EFFICIENCY OF THE BUCKY-DIAPHRAGM PRINCIPLE*

BY R. B. WILSEY

Communication No. 129 from the
Research Laboratory of the Eastman Kodak Company
ROCHESTER, NEW YORK

In the course of a general study of the scattering of x-rays under the conditions of deep roentgenography, a considerable amount of data has been secured showing the large influence of scattered radiation upon roentgenographic quality. In roentgenographing through water layers varying in depth from 4 to 10 inches, the scattered radiation affecting the film was found to be from two and a half to eleven times as intense as the primary radiation.[1] The relative intensity of scattered and primary radiation was but little affected by the tube voltage, the use of filters between scattering material and the film, or the use of intensifying screens.[2]

The scattered radiation reaching the film apparently differs so little in quality from the primary radiation that the only effective method of reducing its relative intensity is by means of diaphragms, which either limit the scattered radiation by restricting the volume of material rayed, or, as in the case of the Bucky-diaphragm principle, prevent the scattered radiation once formed from reaching the film. Experiments by the first-named method, that of using cones or diaphragms between the x-ray tube and the scattering material, have shown that a greater improvement is possible in contrast and definition by a reduction of scattered radiation than by any other form of roentgenographic technique. Better contrast and definition mean more detail, and therefore more information upon which to base a diagnosis. Evidently a satisfactory solution of the problem of scattered radiation will give a greater improvement in roentgenographic quality than any other technical advance in prospect at the present time.

The reduction of the intensity of scattered radiation by limiting the volume of the material rayed has only a limited application in practice on account of the small size of the roentgenographs possible by this method. The Bucky diaphragm is free from this objection, and the modification developed by Dr. Potter[3] also makes it possible to avoid the shadows of the diaphragm grids, a fault which made the original form of the Bucky diaphragm impractical. The Potter-Bucky diaphragm appears to be the only method now practicable for removing scattered radiation over the whole area of a large roentgenograph. It was therefore considered highly desirable to investigate by quantitative methods the efficiency and possibilities of this apparatus and the effects of various factors entering into the design of the diaphragm grid.

In this study two types of experiments were carried out, one consisting of measurements of the relative intensities of diffuse and focal radiation and the other experiments upon definition. The term diffuse radiation is used here to include both scattered radiation and primary radiation from other parts of the tube than the focal spot, while focal radiation refers to primary radiation coming from the focal spot.

THE EXPERIMENTAL METHOD

The Potter-Bucky diaphragm consists essentially of a series of metal strips whose horizontal directions are parallel and whose planes (projected) pass through the focal spot of the tube. A suitable mechanism moves the grid during the exposure in such a way as to prevent the shadows of the lead strips from showing in the roentgenograph. The space between each pair of metal strips forms a slit through which may pass the primary focal rays and scattered rays within a limited angle; scattered rays coming from beyond this angle are largely absorbed by the metal strips. The conditions in each slit are duplicated in every other; hence if the effectiveness of a single slit in reducing

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scattered radiation be determined, the result holds for the whole diaphragm. The advantage of using a single slit in this investigation is that its dimensions can be varied easily as desired, whereas a complete grid would be rather troublesome to alter in studying the effects of any changes in its form and dimensions.

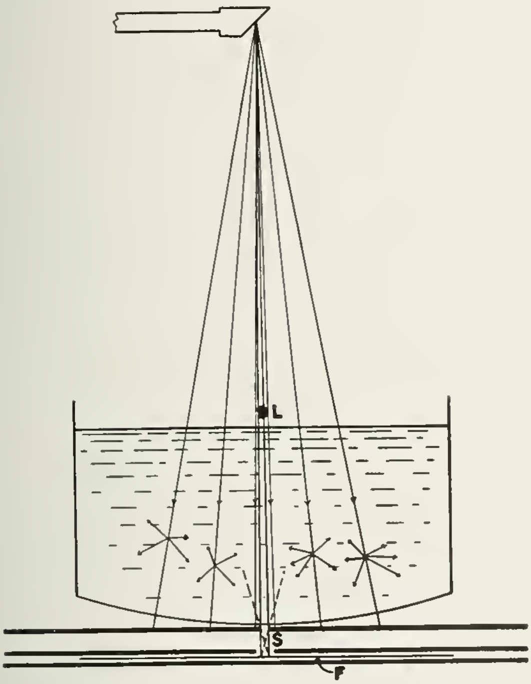

Fig. 1 A. Diagram illustrating experimental method; a disc of lead, L, is suspended over the tank of water and intercepts a small portion of the primary rays falling upon the film F through the slit S. The dotted lines show the angle within which scattered radiation may fall upon the film.

The effective depth of such a single slit is the distance from its upper edge to the photographic surface as illustrated in Figure 1A. Such is not the case in a complete Bucky grid, as shown in Figure 1B, where the effective depth of the slit is the depth of the lead strips. If in the latter case the film were brought up into contact with the lower edge of the grid, the effectiveness of the grid in removing scattered radiation would not be changed; the conditions in each slit would then be independent of those of every other slit and would be identical with the single slit arrangement as used in the present investigation.

When the film itself is at the same level as the bottom of the slit, the definition will be slightly better than in the case where the film is below this level. Consequently in definition experiments with the single slit arrangement the results will be slightly more favorable than would be obtained with a complete grid as operated in practical roentgenography, assuming equal slit width and slit depth

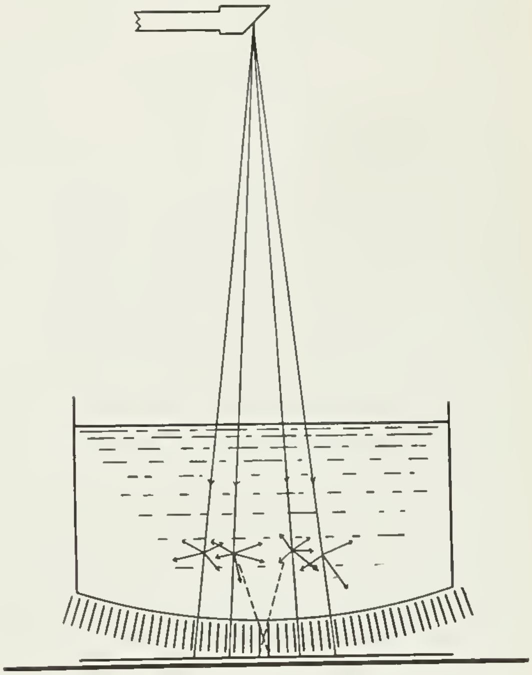

Fig. 1 B. Illustrating a complete Potter-Bucky grid for comparison with the single slit method of Fig. 1 A.

in the two cases. It will be apparent later that the definition obtained with a single slit should be identical with that given by a complete grid, provided that in these two cases there is the same distance between the scattering material and the film, and the same *ratio* of slit width to slit depth.

Water contained in an aluminum tank 12 inches square was used as the scattering material. The bottom of the tank was of $\frac{1}{32}$ inch aluminum and was curved in the form of a cylindrical surface having a radius of curvature of 25 inches. The lead slit was formed by the beveled edges of two lead plates, each $\frac{1}{8}$ inch thick and mounted on flat steel plates of the same thickness. The slit was 14 inches long and was located centrally under the tank. When necessary, another pair of lead plates was situated immediately over the film holder to limit the area of film that could be exposed at one time. A small disk of lead, L, one quarter inch in diameter and 1/16 inch thick was placed edge upward over the surface of the water in line with the slit and the focal spot (Fig. 1A). This intercepted a small portion of the primary rays and allowed only diffuse radiation to fall within its shadow on the film. Three such disks were suspended over the water at such distances that their shadows on the film were about two inches

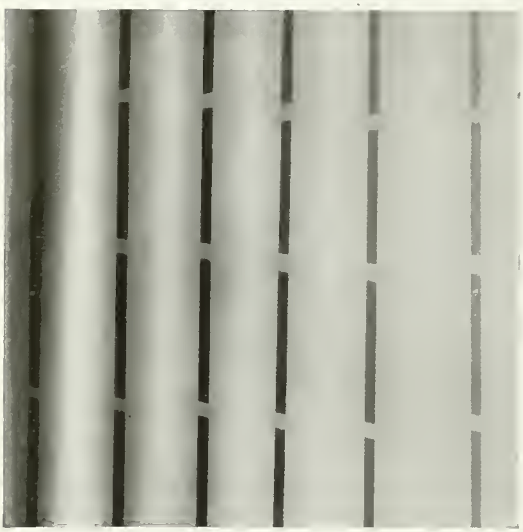

Fig. 2. Reproduction of a film obtained for determination of ratio of diffuse to total radiation.

apart; the *x*-ray image of each slit therefore contained three small areas affected by diffuse radiation only, while all other portions of the image received both the diffuse and the focal radiation. A series of varying exposures through the slit were made upon an 8 × 10 sheet of duplitized film. Figure 2 shows a reproduction of such a film. A microphotometer was used to measure the densities on the film, and curves were plotted of the photometer reading against the exposure, both for the total radiation and for the purely diffuse radiation. From these curves were read the exposures required to produce equal densities by the diffuse and by the total radiation. The reciprocal of the ratio of these exposures gave the ratio of the intensities of the two radiations. This ratio was determined for four or five density values on the curves for each film, and the final value for D/T, the ratio of the diffuse to the total radiation, was taken as the mean from four or more films. The details of this photographic method of evaluating relative *x*-ray intensities are the same as those described more fully in a previous paper.[1]

All the determinations of the ratio D/T were made using a 6 inch depth of water, measured in the center or deepest portion of the tank. The target-slit distance was 25 inches, the tube voltage 60 kv. (sphere gap calibration), and the tube current 4 ma. A radiator type Coolidge tube was used throughout the experiments. The films were developed in a tank of Elon-hydroquinone developer, and were kept in constant irregular motion to insure uniformity of development over the whole area of the film.

THE EFFECT OF THE BUCKY DIAPHRAGM UPON THE INTENSITIES OF SCATTERED RADIATION

The first experiments were performed to determine the effect of the distance between scattering material and slit upon the proportion of scattered radiation reaching the film. It has been claimed that theoretically the Bucky diaphragm principle should show a maximum of efficiency in removing scattered radiation when the subject roentenographed is at some distance from the grid.[4]

To test this conclusion, the ratio of diffuse to total radiation was measured with the tank of water at various distances up to one inch from the slit. The slit was 0.13 inch wide and 0.65 inch deep, giving a ratio of width to depth of 0.2. The values of D/T obtained at various distances between tank and slit are given in Table I.

TABLE I

EFFECT OF DISTANCE BETWEEN SCATTERING MATERIAL AND SLIT UPON PROPORTION OF DIFFUSE RADIATION REACHING THE FILM. SLIT WIDTH 0.13 INCH; DEPTH 0.65 INCH

Distance between Tank and Slit in Inches	*Ratio Diffuse to Total Radiation*
	D/T
0	0.40
0.25	0.39
0.50	0.40
0.78	0.41
1 06	0.42

The variations in D/T are seen to be quite small, negligible for practical purposes, and are of the same order of magnitude as the experimental errors. These data indicate no particular choice for the distance between slit and scattering material; for the subsequent experiments a distance of 1/16 inch was arbitrarily determined upon for the distance between the slit and the bottom of the tank.

The next experiments were carried out to determine the effects of slit width and slit depth upon the ratio of diffuse to total radiation. Three depths of slit were used, 0.37 inch, 0.65 inch, and 1.00 inch, and the slit widths varied from 0.044 to 0.43 inch. The values of D/T for the various conditions are recorded in the fourth column of Table II. Column 5 of this table gives the values of D/F, the ratio of diffuse to focal radiation, computed from the values of D/T by the relation

$$\frac{D}{F} = \frac{D/T}{1 - D/T}$$

With no diaphragm or slit limiting the scattered radiation, the value of D/T was found to be 0.83 and the value of D/F, 4.9.

TABLE II

Width of Slit, Ws	*Depth of Slit, Ds*	*Ratio of Width to Depth of Slit Ws/Ds*	*Ratio of Diffuse to Total Radiation D/T*	*Ratio of Diffuse to Focal Radiation D/F*
0.044	....	0.119	0.29	0.41
0.085	0.37	0.230	0.43	0.76
0.130	....	0.351	0.52	1.08
0.043	....	0.066	0.18	0.22
0.085	....	0.131	0.32	0.47
0.130	0.65	0.200	0.40	0.67
0.172	....	0.264	0.45	0.82
0.213	....	0.328	0.52	1.08
0.298	....	0.458	0.55	1.22
0.085	....	0.085	0.22	0.28
0.130	....	0.130	0.28	0.39
0.213	1.00	0.213	0.43	0.75
0.298	....	0.298	0.46	0.85
0.346	....	0.346	0.51	1.04
0.432	....	0.432	0.55	1.22

In Figure 3 the values of D/T are plotted against Ws and in Figure 4 D/F is plotted against Ws/Ds. The solid circles represent the values obtained with a slit depth of 0.37 inch, the crosses are for the slit depth of 0.65 inch and the hollow circles for the slit depth of 1.00 inch. It will be noted that the points for all these slit depths follow the same curve; in other words, the intensity of the scattered radiation is determined

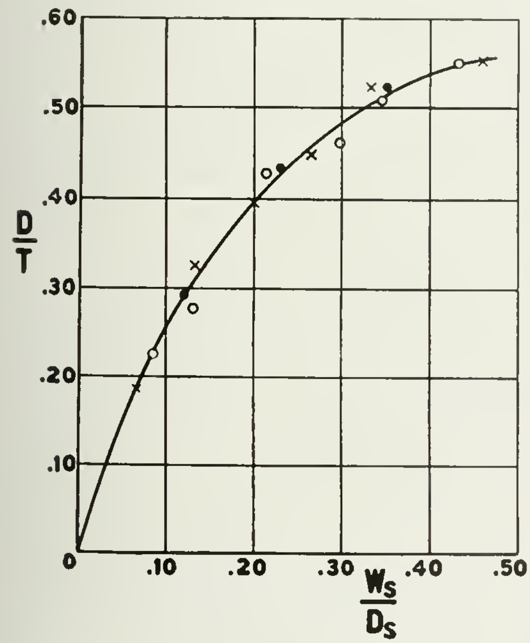

Fig. 3. Curve showing ratio of diffuse to total radiation as a function of the ratio of slit width to slit depth.

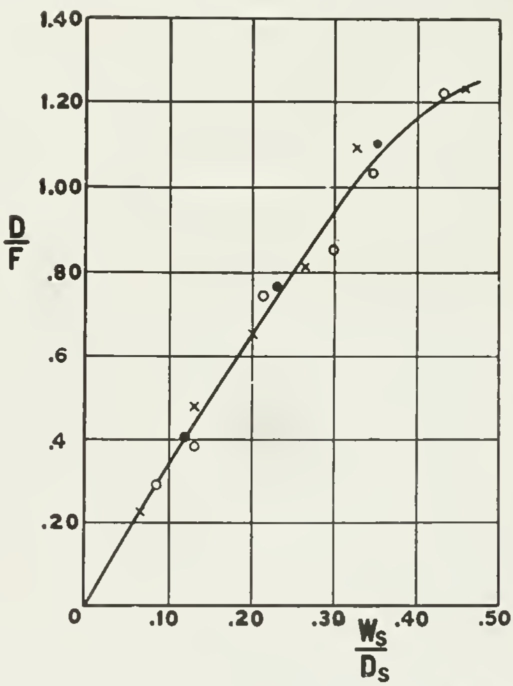

Fig. 4. Curve showing ratio of diffuse to focal radiation as a function of the ratio of slit width to slit depth.

by the ratio of slit width to slit depth but does not depend upon the actual size of the slit.

The curve in Figure 4 is nearly a straight line over most of its length, showing that the intensity of the diffuse radiation over a considerable range is practically proportional to Ws/Ds, that is, it is directly proportional to the slit width and inversely proportional to the slit depth.

Figure 5 shows the exposure factor plotted as a function of the ratio of slit width to slit depth. The exposure factor is the number by which the normal exposure must be multiplied to obtain the proper exposure when the diaphragm removes some of the scattered radiation. The method of computing the exposure factor has been previously described.[1]

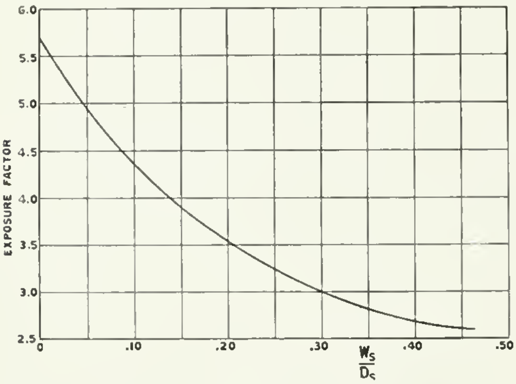

Fig. 5. Curve showing exposure factor as a function of the ratio of slit width to slit depth.

The *efficiency* of the Bucky diaphragm is defined as the fraction of the diffuse radiation which has been removed, as measured by the photographic surface. A diaphragm that removed all the diffuse radiation would be 100 per cent efficient. In roentgenographing through six inches of water with nothing to reduce the intensity of the diffuse radiation, the diffuse radiation is 4.9 times as intense as the focal radiation. If a diaphragm reduces the diffuse radiation to an intensity 0.49 times that of the focal radiation, whose intensity has not been changed thereby, then the diffuse radiation is 10 per cent of its former value, 90 per cent has been removed, and we may therefore state that the efficiency of the diaphragm is 0.90. In roentgenographing through six inches of water the efficiency is given by the equation,

$$E = \frac{4.9 - D/F}{4.9}$$

Figure 6 shows the efficiency plotted against ratio of slit width to slit depth.

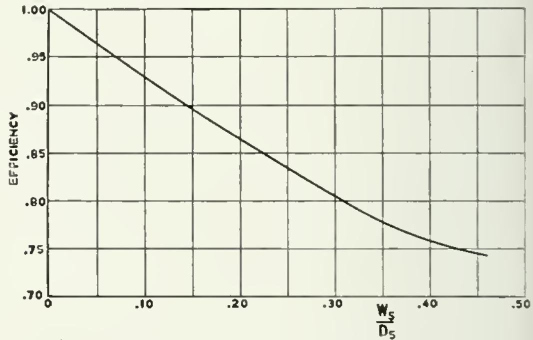

Fig. 6. Curve showing efficiency plotted against the ratio of slit width to slit depth.

In Table III are tabulated the values of D/T, D/F, exposure factor, and efficiency for several selected values of Ws/Ds; these values are taken from the curves of Figures 3 to 6. These values illustrate the high efficiency of the Bucky diaphragm; for instance a diaphragm for which Ws/Ds equals 0.30 removes 80 per cent of the diffuse radiation when Ws/Ds is 0.20, the efficiency is 86 per cent. Such ratios of slit width to slit depth are practicable, and they approximate the values used in the present commercial models of the Potter-Bucky diaphragm. Although such slit ratios allow considerable room for improvement, it is probably not advisable to use ratios much smaller than these in practice.

In a complete Bucky grid, the exposure factors given above must be increased to allow for the absorption of the filling material between the lead strips and for the area taken up by the thickness of the strips; the effect of these will depend upon the design of the grid and may increase the exposure as much as 20 or 30 per cent.

It is of interest to compare the effectiveness of the Bucky diaphragm principle with the method of reducing scattered radiation by circular diaphragms placed between the tube and the scattering material. This is done in the last column of Table III, which gives for each value of Ws/Ds the image size produced by a circular diaphragm having the same efficiency as the Bucky diaphragm principle; these image size values were taken from the curves obtained in a former investigation.[1] The table shows, for example, that a circular diaphragm allowing an image diameter of only 1.5 inches has the same efficiency in removing scattered radiation as a Bucky diaphragm with a slit ratio of 0.2.

TABLE III

Ratio Width to Depth of Slit Ws/Ds	*Ratio Diffuse to Total Radiation D/T*	*Ratio Diffuse to Focal Radiation D/F*	*Exposure Factor*	*Efficiency*	*Image Diameter for Equal Efficiency by Circular Diaphragm (inches)*
0.10	0.25	0.34	4.4	0.93	0.8
0.15	0.33	0.50	3.9	0.90	1.1
0.167	0.35	0.55	3.8	0.89	1.3
0.20	0.39	0.65	3.5	0.86	1.5
0.25	0.44	0.80	3.2	0.83	1.8
0.30	0.48	0.94	3.0	0.80	2.2
0.33	0.51	1.02	2.9	0.79	2.3
0.40	0.54	1.16	2.7	0.76	2.6

In making a complete Bucky grid, it has been found convenient to hold the lead strips in place by strips of wood; the question arises as to the effect of the wood filler upon the efficiency of the diaphragm and whether it is worth while to try to avoid the use of such a filler. The effect of the wood strips was measured for three sizes of the slit. The strips were made of beech wood; each one lacked 1/16 inch of being as deep as the slit in which its effect was measured; this difference in depth was necessary to allow for the thickness of the cardboard cover of the film holder. The results of these experiments are recorded in Table IV; the fourth column of this table gives the value of D/T observed with the wood strip filling the slit; the fifth column gives the value of D/T for the empty slit as read from the curve of Figure 3. The wood strips are seen to have only a small effect upon the proportion of diffuse radiation affecting the film; the largest effect observed is scarcely greater than the possible experimental error of its determination.

TABLE IV

EFFECT OF WOOD FILLER IN BUCKY GRID

Slit Width Ws	*Slit Depth Ds*	*Ws/Ds*	*D/T with Wood Filler*	*D/T for Empty Slit*
0.083	0.37	0.22	0.43	0.42
0.13	0.65	0.20	0.42	0.39
0.20	0.65	0.31	0.52	0.40

EXPERIMENTS ON DEFINITION

The effect of the Bucky diaphragm principle upon roentgenographic definition was studied with the aid of a set of copper wire gauzes, varying from 110 to 280 meshes per inch. They had been gold-plated to increase their absorption of *x*-rays. These meshes were mounted together between cardboard in a single row so that the whole set could be roentgenographed through the slit at one time. For each set of conditions, this definition test object was roentgenographed in two positions, one directly in contact with the slit, and the other immersed in the water at a distance of 1 1/8 inches above the slit. The exposures were adjusted to produce approximately the same density on the film in all the tests. The resulting roentgenographs were examined with a pocket magnifier giving a ten times magnification. The definition in any case was indicated by the finest mesh which could be resolved and was expressed in terms of meshes per inch. This definition test object gives a purely arbitrary scale of definition values, but it is very useful and convenient for comparing the definition obtainable under various conditions. The observations on the definition obtained with various dimensions of the slit are recorded in Table V. In column 4 is given the distance between the scattering material and the film; this is obtained by adding to the slit depth 0.06 inch, the distance of the tank above the slit. Where

TABLE V

EFFECT OF DIMENSIONS OF SLIT UPON DEFINITION

Slit Width in Inches Ws	*Slit Depth in Inches Ds*	*Ws/Ds*	*Distance between Film and Scattering Material*	*Definition: Test[1] Object on Slit*	*Definition: Test Object 1 1/8 Inches Above Slits*
	0.20	0.22	0.26	>280	140
0.044	0.37	0.12	0.43	>280	135
	0.65	0.068	0.71	245	120
	1.00	0.044	1.06	195	110
	0.20	0.42	0.26	>280	135
0.085	0.37	0.23	0.43	>280	130
	0.65	0.13	0.71	240	115
	1.00	0.085	1.06	185	<110
	0.20	0.65	0.26	280	130
0.130	0.37	0.35	0.43	>280	125
	0.65	0.20	0.71	235	115
	1.00	0.13	1.06	180	<110
	0.37	0.465	0.43	280	125
0.172	0.65	0.265	0.71	230	115
	0.65	0.328	0.71	225	110
0.213	1.00	0.213	1.06	195	...
	0.65	0.458	0.71	215	110
0.298	1.00	0.298	1.06	170	...
0.432	1.00	0.432	1.06	165	...

the definition comes outside the limits of the test object, it is designated as >280 (greater than 280) or <110 (less than 110). The conditions are the same as before; the tube was operated at 60 kv., roentgenographing through a 6 inch depth of water with a target slit distance of 25 inches. The films were given a standard development of five minutes in a tank Elon-hydroquinone developer at 65 degrees F.

The remarkable fact shown by these data is the loss in definition as the slit is deepened without changing its width. Increasing the depth of the slit diminishes the intensity of diffuse radiation in nearly the same proportion, thereby improving the roentgenographic contrast, but the definition is poorer than before. The definition diminishes gradually with an increase in the width of the slit. As regards definition, therefore, the controlling factor is the distance of the film from the object roentgenographed; to get the best definition the slit should be as shallow as possible while at the same time a fairly efficient ratio of slit width to slit depth is maintained

In a practical Bucky grid the lead strips should not be brought too close together, or the thickness of the strips will form too large a proportion of the total area of the grid and absorb a large part of the focal rays. If now the grid is made shallow in order to obtain the best possible definition, the ratio of slit width to slit depth will be somewhat larger than that consistent with the highest efficiency in removing scattered radiation; thus some gain in contrast must be sacrificed in order to improve the definition. It is believed this is the better procedure, however, to make definition the first consideration. Any slit ratio within the range investigated will remove most of the scattered radiation and considerably enhance the contrast, and this combined with the best attainable definition should give the maximum efficiency in the depiction of fine detail.

The factors in grid design which govern definition are the ratio of slit width to slit depth and the distance between the subject roentgenographed and the film, the latter factor being of the greater importance. In using Table V to estimate the definition given by any Potter-Bucky diaphragm, only these two factors (given in columns 3 and 4) should be employed as specifying the essential characteristics of the grid.

It is evident that in a complete working Bucky diaphragm there should be no waste space between the top cover and the grid or between the grid and the film. In order to obtain the same fine definition over the whole area of the roentgenograph the cassette should conform to the curvature of the grid, thus bringing all parts of the film as close as possible to the subject. The curved cassette has been recommended by Dr. Van Allen[5] who finds that it reduces both the distortion and the fuzzy appearance (poor definition) which are characteristic of objects distant from the film.

Some tests were also made of the definition attainable by the ordinary technique with no reduction of the scattered radiation; and a few experiments were carried out to determine the definition obtained with a circular diaphragm placed above the scattering material as compared with the definition given by the Bucky diaphragm; in these tests the film was placed directly beneath the tank; otherwise the conditions were the same as those employed in the tests of the Bucky diaphragm principle. The results of these tests are given in Table VI.

TABLE VI

EFFECT OF CIRCULAR DIAPHRAGM ABOVE SCATTERING MATERIAL IN IMPROVING DEFINITION

	Definition	
Image Diameter in Inches	*Test Object on Film Holder*	*Test Object 1⅛ Inches Above Film*
25	225	120
4.5	280	140
3 0	>280	145

Upon comparing the data of Table V with those of Table VI it will be noted that in every case where the film is 1.06 inches below the scattering material, the definition is poorer than that obtained by the ordinary technique with no precautions against scattered radiation. Such a diaphragm is of no benefit in roentgenographing through a layer six inches in depth; the thickness would have to be somewhat greater than six inches to make the use of the diaphragm advantageous. With the film 0.71 inch below the scattering material, a slit ratio (Ws/Ds) of 0.26 gave a definition nearly equivalent to that of the ordinary technique. Such a diaphragm would be advantageous in roentgenographing through a thickness of six inches on account of the improvement in contrast, even though it gave no improvement in definition. Smaller slit ratios at the 0.71 inch distance (between scattering material and film) gave somewhat better definition than the ordinary technique. In every case where the film was less than 0.43 inch below the scattering material, better definition was obtained than by the ordinary technique, considerable improvement being produced by the smallest slits.

It will also be noted that a circular diaphragm limiting the image diameter to 3 inches gives slightly better definition than was obtained with the smallest slit used. It is evident that on account of the distance between the subject roentgenographed and the film, the Bucky-diaphragm principle is not as effective in improving definition as in improving contrast; but by reducing the thickness of the grid so that the distance between subject and film can be made as small as possible, the Bucky diaphragm can be made to produce a considerable improvement in definition as well as a marked increase in contrast.

A few simple tests were made to determine whether a crossed grid of the original Bucky type would give any radical improvement over the slit type devised by Potter. A single element of such a grid was duplicated by blocking up most of the slit with strips of lead, leaving only a small square hole for the passage of *x*-rays. The definitions obtained in these experiments are recorded in Table VII.

TABLE VII

Dimensions of Grid Unit	*Definition* Test Object on Slit	*Definition* Test Object 1⅛ Inches Above Slit
0.05 inch square by 0.20 inch deep	>280	145
0.08 inch square by 0.37 inch deep	>280	140

The definition obtained in these tests is only slightly better than that obtained with a long slit of equal depth and approximately equal width. In view of the mechanical difficulties of making a crossed grid of the original Bucky type (resembling a honeycomb) so designed and moved that it would not show shadows of the grid, it seems that the slight advantage to be gained is scarcely worth the cost. The most promising and practical procedure would be to push the Potter type of grid to the limit of its effectiveness.

A few experiments in definition were made with a 4 inch thickness of water as the scattering material. With the film 0.43 inch below the tank of water, a slit ratio of 0.24 gave practically the same definition as the ordinary technique. Keeping the slit width the same (0.088 inch) the distance between scattering material and film was reduced to 0.26 inch; this produced an appreciable improvement in the definition; the slit ratio in this case was 0.44. A smaller slit ratio than this would doubtless be feasible in a thin Bucky grid, and it would improve both the definition and contrast in roentgenographs of thicknesses as small as 4 inches.

In studying the effect of the wood filler upon definition, the data shown in Table VIII were obtained. The wood was found to have only a slight effect; in the small slits which were found to give the best definition, the effect of the wood filler is practically negligible.

TABLE VIII

EFFECT OF WOOD FILLER UPON DEFINITION

Slit Width Ws	*Slit Depth Ds*	*Ws/Ds*	*Definition with Wood Filler* Test Object On Slit	*Definition with Wood Filler* Test Object 1⅛ in. Above Slit	*Definition without Filler* Test Object On Slit	*Definition without Filler* Test Object 1⅛ in. Above Slit
0.083	0.37	0.22	280	135	>280	135
0.15		0.41	280	125	>280	125
0.079	0.65	0.12	240	120	245	120
0.13		0.20	230	115	235	115
0.20		0.31	215	110	225	110
0.27		0.42	205	110	215	110

The thickness of the lead strips should be such as to absorb nearly all of the scattered rays incident upon them; the minimum thickness of lead required to do this has not been determined, but it is hoped that experiments to be carried out later will give some information on this point. The data of Richtmyer on absorption should be of considerable assistance in estimating the proper thickness of the lead strips.[6]

The increased exposure required by the Bucky diaphragm makes the use of intensifying screens necessary in most cases. In order to secure the fullest advantage of the improvement afforded by the diaphragm, the screens used with it should have the best possible definition, and the requisite precautions should be taken to insure good contact between the screens and the films.

In this study of the Bucky diaphragm principle, no attempt has been made to deal with the mechanical features of the Bucky diaphragm. A well designed mechanism for operating the diaphragm is as essential as an efficient grid for the production of satisfactory roentgenographs. There is opportunity for much ingenuity in devising a mechanism which gives a smooth uniform motion to the grid and which can be operated with a minimum of attention on the part of the roentgenologist or technician.

SUMMARY

Using a 6 inch depth of water as the scattering material, the efficiency of the Bucky diaphragm in removing scattered radiation has been measured for a variety of widths and depths of slit. The intensity of diffuse radiation was found to be a function of the ratio of slit width to slit depth, not depending upon the actual size of the slit. The Bucky diaphragm was found to be highly efficient, it being easily possible to remove more than 80 per cent of the scattered radiation. The wood filler used to support the lead strips has only a slight effect upon the efficiency of the diaphragm; for small sizes of slit its influence is practically negligible.

The definition obtainable with the Bucky diaphragm depends chiefly on the distance between the subject roentgenographed and the film; by making this distance sufficiently small the Bucky diaphragm can be made to give a considerable improvement in definition over the ordinary technique, and can be used with advantage in roentgenographing thicknesses as small as 4 inches.

The crossed grid of the original Bucky type (resembling a honey-comb) gives very little advantage over the Potter type of grid with the same depth of slit; it is concluded that the best practical improvement of the Bucky diaphragm lies in pushing the Potter type of grid to the limit of its effectiveness.

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DISCUSSION

Dr. A. H. Pirie. Mr. Wilsey mentioned that if you cut down the diaphragm and make a picture 3 inches in diameter you get as good results. Acting on that principle I used to take spines this way. I had a sliding diaphragm between the tube and the patient. It consisted of a sheet of lead with a transverse slit through which the rays passed. For taking spines I found it increased the detail very much. However, it increased the length of exposure so much that I gave it up. It improved the spine pictures very much ten years ago.

Mr. Wilsey. The chief value of the data I have shown lies in its quantitative character, which enables us to estimate more precisely how far in any one direction it is worth while to go in trying to improve the Bucky grid.

Regarding gallstone technique, I would hesitate to make any suggestions; not being a roentgenologist, I can investigate and report only upon the physical factors involved. When it comes to the practical application of this information, you have in your work motion of the patient and other factors which must be taken into account. The roentgenologist must take this information and apply it with his own special knowledge to determine what technique is likely to give the best results in any given case. I feel sure that if the diaphragm is altered in the way suggested by making the slit more shallow, the definition will be much improved.

Dr. Cole has done a great deal of work with the double slot method and undoubtedly it would have many advantages. By having a slot both above and below the patient, scattered radiation can fall only on that part of the film that is being exposed to the focal rays. This method would permit a very short distance between patient and film. Whether or not the double slot method is superior to the Bucky diaphragm, I have no measurements to determine. As Dr. Cole well knows, the chief difficulty with the method at the present time is the heavy continuous tube current required to make a full size roentgenograph.

I doubt if there is any appreciable advantage in using the combination of a cone above the patient with the Bucky diaphragm beneath. The advantage in using the cone by itself without the Bucky diaphragm lies in the short distance between the film and the patient.

SIGNAL LIGHT FOR BUCKY-POTTER DIAPHRAGM

BY JOHN H. LINDSEY, M.D.

FALL RIVER, MASSACHUSETTS

THE noise of an *x*-ray machine may obtund the sound of the signal bell of a Bucky-Potter diaphragm.

The suggestion having been made that a signal light was a practical attachment, the bell was disconnected and an electric lamp was placed on the wall of the *x*-ray room. This lamp was connected with a wall-socket and with the Bucky-Potter diaphragm in such a manner that the light would appear when the sliding grid made the contact. As a signal this arrangement was satisfactory, but difficulty was experienced in insulating the Bucky-Potter diaphragm. Moreover, the wall attachment is not readily portable.

Another device consisted in the attachment of a small electric lamp to the side of the Bucky-Potter diaphragm. Power for this lamp was furnished by two batteries which could be placed under the table or by the side of the table upon a convenient support. As a signal this arrangement also was satisfactory, but the batteries and wires proved clumsy and entangling.

As a third development a small tubular pocket flash-light was attached to the side of the Bucky-Potter diaphragm as shown in the illustration. This arrangement permits of better mechanical adjustment, but the device is very satisfactory as it is, and can be recommended as an efficient substitute for the bell.

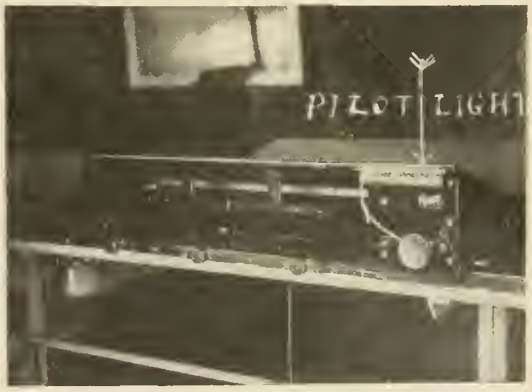

FIG. 1. Tubular pocket flash-light attached to Bucky-Potter Diaphragm.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

CENTRAL SECTION

Third Annual Meeting

The Third Annual Meeting of the Central Section of The American Roentgen Ray Society will be held at the Congress Hotel, Chicago, on February 22, 1922.

An interesting program of about twelve or fourteen papers will be offered. In the evening, a banquet will be held at the hotel, followed by a lantern slide exhibit.

Communications regarding the meeting may be addressed to the President, Dr. William M. Doughty, 628 Elm Street, Cincinnati, Ohio.

AMERICAN RADIUM SOCIETY

Notice of Annual Meeting

The Seventh Annual Meeting of the American Radium Society will be held at St. Louis, Missouri, on Monday and Tuesday, May 22nd and 23rd, 1922, immediately preceding the meeting of the American Medical Association. Those having new ideas or desiring to make presentations or to read a paper will please communicate at once with Dr. Henry K. Pancoast, Chairman of the Program Committee, Thirty-fourth and Spruce Streets, Philadelphia. A partial program has already been prepared, which promises much. Headquarters will be at the Planters Hotel where the meetings will also be held. Inasmuch as this hotel accommodates only 450 guests it would be wise to make reservations at once.

PACIFIC COAST MEETING

The Pacific Coast Roentgen Ray Society held its fifteenth semi-annual meeting in Phoenix, Arizona, on December 1st, 2nd and 3rd. The Society attempted an innovation at this meeting which proved to be successful to the highest degree. Arrangements were made to amalgamate their meeting with that of The Medical and Surgical Association of the Southwest, presenting a conjoined program. The Chairman of the Program Committee was Dr. W. Warner Watkins, of Phoenix, who is the President of the Pacific Coast Roentgen Ray Society. A creditable display of *x*-ray films in original form, in reduced form and in lantern slides, were placed on exhibition throughout the meeting and attracted wide attention, the exhibit being thrown open to the public during one evening.

Both organizations expressed themselves as highly pleased with the arrangement. The papers presented by the roentgenologists were all designed to appeal to clinicians, technical features being avoided and clinical points being emphasized. The papers read by members of the Roentgen Ray Society to the general meeting were as follows:

Fractured Vertebrae. Dr. W. B. Bowman, Los Angeles, read in the Symposium on Bone Lesions.

Roentgenology in Heart Diseases. Dr. Rolla Karshner, Los Angeles.

Aortic Lesions and Life Expectancy. Dr. Roy Payne, Portland. Symposium on Chest and Heart.

Non-Calculous Cholecystitis—a Plea for its Recognition and Surgical Treatment. Dr. W. P. Burnham, San Francisco.

Gastric Polyposis. Dr. Lloyd Bryan, San Francisco. Symposium on Abdominal Lesions.

Action of Radiation on Tonsillar and Hypertrophied Lymphoid Tissue. Dr. Albert Soiland, Los Angeles.

Non-malignant Conditions of the Uterus and Radiotherapy. Dr. John W. Cathcart, El Paso, Texas.

On Thursday night, the lantern slide show of the Society was given, introduced by a paper by Dr. Raymond Taylor of Los Angeles, on "Causes of Abdominal Pain, as found by Roentgen-Ray Examination."

Films or slides for exhibition were sent in by Dr. Willis H. Watson, of Portland, Ore., Dr. A. C. Siefert of Oakland, Calif., Dr. C. J. Johannesson, of Walla Walla, Wash., Dr. H. H. Heylmun, of Long Beach, Calif., Dr. Wm. H. Sargent, of Oakland, Calif. W. W. W.

CORRESPONDENCE

To the Editor:

In reading Dr. Pirie's article on the supernumerary bones, in the October issue, I was impressed with what he said in reference to the ossicle appearing in connection with the pedal scaphoid. My attention was first called to this supernumerary bone by Dr. A. J. Pacini, who had a print very closely resembling Dr. Pirie's Figure 12.

Some time later I came across a case showing this bone bilaterally. Having had access to the Surgeon General's library, I spent many hours searching the literature in the hope of finding a description of this rare bone. In this I believe I was partially rewarded. I found that Hyrtl[1] described a "trochlear process" on the posterior edge of the dorsal surface of the scaphoid at a point at which a line drawn bisecting the dorsal surface of the second metacarpal crosses the posterior edge of the scaphoid.

This, undoubtedly, is not the bone to which Dr. Pirie refers.

Pfitzner[2] describes an ossicle as a "supranaviculare (spurium?)" and says that it is situated on the posterior edge of the dorsal surface of the naviculare and articulates with the caput tali. In none of his writings does he illustrate this ossicle, but he does say that he considers it to be equivalent to Hyrtl's case. Pfitzner's description of his observation does not agree with the figure of Hyrtl's case. It may be that Pfitzner's case was also a "trochlear process," but he gives the impression that he really suspected the presence of a supernumerary ossicle which he called the "supranaviculare (spurium?)," probably adding "(spurium?)" to show his doubt.

Personally I believe that "supranaviculare" is a good descriptive name for this rare ossicle.

Respectfully,
Morris I. Bierman
Assistant Surgeon (Roentgenologist)
United States Public Health Service
Minneapolis, Minn.

[1] Hyrtl. Über die trochlearforsätze der menchlichen Knochen. *Denkschr. d. k. Akad. d. Wissensch. Math.-naturw. Klasse, Wien*, 1860, xviii, 141.

[2] Pfitzner. Die Variationen im Aufbau des Fuss-skeletts. *Morphol. Arb.*, 1896, vi, 245.

OBITUARY NOTICE

We announce with deep regret the death on January 5th of Dr. James Gerritt Van Zwaluwenburg, Professor of Roentgenology at the University of Michigan, for many years a member of The American Roentgen Ray Society, and past President of the Central Section. An obituary will appear in a forthcoming issue of the Journal.

A CORRECTION

In the article by Dr. Samuel Stern in the December issue of the Journal, entitled "Intensive X-Ray Therapy as Seen Practiced in the Clinics in Europe," on page 741, first column, the heading "Frankfort Frauen Clinic" should read "Freiburg Frauen Clinic."

BOOK REVIEWS

X-RAYS AND RADIUM IN THE TREATMENT OF DISEASES OF THE SKIN. By George Miller MacKee, M D., Assistant Professor of Dermatology and Syphilology, College of Physicians and Surgeons, Columbia University; Consulting Dermatologist and Syphilologist, St. Vincent's Hospital, New York. Contains 602 pages with 250 engravings and 22 charts. Price $9. Lea & Febiger, Philadelphia, 1921.

A modern book dealing with *x*-ray and radium therapy of diseases of the skin has been sorely needed for years. MacKee is the logical man to write one for he has had more experience with measured roentgen rays than any other man in America

The plan of the book has been carefully thought out. The first three hundred pages deal with history, physics, *x*-ray apparatus, dosage, filtered and unfiltered technique, the chemical, biochemical and biological effects of *x*-ray and radium, radiodermatitis, with idiosyncrasy and general therapeutics considered, while the last two hundred and fifty pages take up the various diseases in detail. In addition there is a chapter devoted to the medico-legal relations of radiation.

MacKee wisely believes that no one should employ either *x*-ray or radium without a thorough knowledge of the physics of this agent, and both a theoretical and practical knowledge of just what their action is.

The chapter upon general physics is excellent. Much space is devoted to all types of *x*-ray and radium apparatus. All methods of estimating dosage are dealt with in detail. The statement as to the value of various instruments and methods is cleancut and decisive.

The chapters dealing with the various diseases are, to the mind of the reviewer, very justly handled. MacKee does not recommend radiation where other methods give better results, and a wide dermatological training enables him to speak authoritatively upon this subject. For instance, he does not recommend radiation for squamous-celled cancer of the lips.

The illustrations are profuse, well chosen, and excellent. There is an admirable bibliography. Very few typographical errors have been noted.

It is possible that the men who are devoted to radium will feel that the *x*-ray is over-emphasized and radium slighted. But as a matter of fact no one should employ radium who is not thoroughly acquainted with the general subject of both roentgen rays and radium. In addition, the roentgen ray is so much more valuable to the dermatologist that it is justly entitled to more space.

One or two minor criticisms can be made. For instance, more advice might well be given in regard to the selection of equipment. In regard to *x*-ray equipment attention should be called to the fact that it is always wise to buy from a house which is prepared to render adequate service in the particular locality where the purchaser resides. It is a little difficult to see why "callositas" is used as a synonym for "verruca plantaris." In discussing leukoplakia mention is not made of the necessity of removing any irritating teeth.

In general it may be said that the book is safe, sane, conservative and complete. It is absolutely indispensable to every radiologist and dermatologist and should be in the hands of all men who see many skin affections. Let us hope that ere long we shall have an equally good work upon deep *x*-ray and radium therapy.

H. H. HAZEN.

TRANSLATIONS & ABSTRACTS

Moppert, G. G., (Geneva). Radioscopic Measurements Showing the Great Frequency of Spontaneous Biliary Reflex into the Stomach. (*Presse méd.*, May 25, 1921, xxix, 42.)

The author refers to the Einhorn thread test in gastric and duodenal ulcer. The measurements used by Einhorn were as follows: distance of cardia from dental arch, 40 cm.; lesser curvature 44 to 54 cm.; pylorus 56 to 58 cm., and duodenum 59 cm. The author in an article published last March showed that these reference figures are inaccurate. The thread is often stained by patients free from ulceration, while the pyloric distance shows considerable variation. The author has sought by means of the screen to show the actual distance of the pylorus from the dental arch. He uses Einhorn's thread and technique. When the capsule is withdrawn resistance is felt at the pylorus and at this juncture a mark is made on the thread at the level of the dental arch. The thread is then withdrawn entirely, and the distance read off and compared with that of the beginning of the bile stain. Of 128 threads examined 46 had never left the stomach, while 82 had entered the pylorus. The location of the latter was shown on the string in 32 cases. In these the figures varied extremely, from 47 to 77 cm. The measurements of Einhorn held good in about 35 per cent. If we compare the thread findings with the roentgenograms of the same subjects we shall find that this difference in measurements is in part due to factors readily intelligible. Thus in the short distances the stomach is presumably hypertonic and in the extra long distances hypo- or atonic. Distances midway between the two mean an orthotonic or normal stomach, which suggests that the measurements of Einhorn were made on normal subjects or rather on subjects with some hypotonia, for the orthotonic should show a length slightly under 56 to 58 cm. Hence the thread has a diagnostic value possibly greater than Einhorn had in mind in introducing it; since by it alone it should be possible to diagnosticate atony or hyperatony. The position of the bile stain coincides fairly well with that of the pylorus although in but 3 of 30 cases was the coincidence exact. The stain often began considerably above the pylorus, which illustrates the frequency of reflux through the pylorus, and in only one did it begin beneath the pylorus.

Concerning the numerous cases in which the string never traversed the pylorus, this was clearly due in a large proportion—(the author believes two-thirds)—to pylorospasm or organic stricture, which fact gives further diagnostic possibilities to the string test. But the string is not always held back by pyloric stenosis, for it was retained to some extent in a third of the cases in which the pylorus was patent as demonstrated on the screen. Tests by the author show that the site of the bile stain is not prejudiced by the possibility of capillary attraction exerted along the course of the thread. The weight of the evidence is that reflux of bile from the duodenum into the stomach is a common and spontaneous phenomenon.

Van Zwaluwenburg, J. G. and Grahfield, G. B. The Tonsillar Route of Infection in Pulmonary Tuberculosis. (*Am. Rev. Tuberc.*, March, 1921.)

The writers describe a shadow which they believe represents a thickening of the pleura over the apex of the lung, and studied its relationship to tonsillar and cervical gland tuberculosis. Ten per cent of all roentgen ray examinations of the chest coming to the University laboratory show such apical pleuritis. This shadow is seen in 93 per cent of the cases having tuberculous deposit in the faucial tonsils. This lesion probably occurs in a large number of cervical gland tuberculosis and is recognizable in 59 per cent, 71 per cent in this group showing either this lesion, or frank tuberculosis of the lung or both. Only 11 per cent of non-tubercular tonsil cases show an apical pleuritis. A common route of infection may be through the tonsil and the cervical lymphatics to the apical pleura and then to the lung.

Roy G. Giles.

Cole, H. N., Littman, S., and Sollmann, T. Study of Mercuric Injections by Means of the Roentgen Ray. (*J. Am. M. Assn.*, December 4, 1920, lxxv, 23.)

The authors of this article in a most able manner show rather definitely that the injection of mercuric substances into the muscles should be done with caution; and they prove that not only may this procedure become dangerous to the patient but that as a therapeutic means it often fails. They show by rather extensive experiments that absorption of insoluble mercuric preparations from intramuscular injections can be followed very satisfactorily by the roentgen ray shadows. This method cannot be applied to the soluble mercuric preparations. Study of clinical cases proves the following with regard to the time required for complete absorption.

Mercuric salicylate requires as a mean, 4 days, and as extremes from 4 to 10 days, for complete absorption by gluteal muscles. For complete absorption by lumbar muscles: mean, 8½ days; extremes from 2 to beyond 24 days.

Injections of calomel require for absorption as a mean, 15 days; extremes from 4 to 39 days. They state that gray oil was unabsorbed during their entire period of observation. It gave approximately a mean of 43 days; extremes from 16 to 125 days, which would indicate that gray oil injections are inefficient and dangerous and their use should be abandoned. They also state that calomel injections are dangerous.

Their conclusions in regard to mercuric salicylate injections are that when given especially into the gluteal muscles they show satisfactory absorption and present relatively little danger. They recently have seen a case of poisoning from gray oil injections four months after receiving the drug. This was proven by the *x*-ray examination which revealed a large mass of metallic mercuric globules.

W. W. Belden.

Clark, J. G., and Keene, F. E. Irradiation in Cancer of the Female Genito-Urinary Organs: Results in Three Hundred and Thirteen Cases. (*J. Am. M. Assn.*, August 20, 1921, lxxvii, 613.)

The writers report 313 cases treated prior to August, 1920, of whom 112 are living and 201 are dead. Of the living cases, 13 have had fistulas; 21 fistulas occurred among the 201 dead. Of the 201 dead, 60 remained free from local recurrence, death being caused by metastasis. Doubtless a larger number would have developed fistulas as a natural incident of bladder or rectal invasion, had they not been treated by radiation. The plan followed in general with at least 150 cases was the application of 100 mg. of radium screened with platinum and rubber for twenty-four hours, the healthy tissues being protected by lead. Most of the fistulas occurred in this group. The present technique does not include lead protection, protection being afforded to the neighboring tissues by means of gauze packing. Routine repetition of treatments is injudicious. The writers are inclined to limit radiation to those cases in which there is a visible or palpable localization of the gross changes. Advanced cases may be rendered worse by radium therapy, because the cells at the periphery of a widespread growth may be stimulated to activity. In cases in which a progressive favorable action is noted after six weeks, the patient is advised to return again in six weeks more. If a white hyaline cicatrix is seen covering the site of the ulcer, further action is delayed. In those cases in which no progress is noted one more application is made. If no progress be noted, further irradiation is abandoned.

The patient is given gas; if there is a cauliflower growth it is removed with the cautery. Fifty mg. of radium are introduced into the cervical canal, and a similar tube is held within the crater or against the vaginal portion of the cervix with fine catgut sutures. Needles may be inserted into the appropriate areas. The vagina is thoroughly packed with gauze.

In cancer of the fundus, operation is advised. "In cancer of the cervix, when in doubt always irradiate; in cancer of the fundus, when in doubt operate."

Ante-operative irradiation and post-radiation surgery are equally ill-advised. Irradiation soon after operation, or in fresh operative fields is dangerous.

Several statistical tables are set forth covering 313 cases. There were 214 cases of cervical carcinoma, of whom 56 are alive from one to seven years after treatment, 9 were untraced. 140 are dead (23 lived more than two years), and 8 are untraced. There were 23 cases of inoperable carcinoma of the fundus, of whom 12 are living one to six years after treatment, and 11 are dead. There were 2 cases of chorio-epithelioma, both alive six and seven years after treatment. Four cases of carcinoma of the cervical stump are alive, one and one-half to four years after treatment. Of 21 cases of recurrent carcinoma of the vagina after hysterectomy, 7 are living at periods of from one to five years after treatment, and 14 are dead.

L. S. Goin.

Schmitz, H. The Treatment of Cancer of the Uterus. (*J. Am. M. Assn.*, August 20, 1921, lxxvii, 608.)

The objects of this study are to discuss the prophylaxis of uterine cancer, to review briefly the diagnosis of carcinoma of the uterus, to group correctly the various stages of the disease, and to base the indications for a correct treatment on such a grouping.

Cases which are clearly localized after a physical examination are operable cases and are treated by abdominal pan-hysterectomy. Cases which appear to be doubtfully localized after a physical examination—borderline cases—and operable cases which are poor surgical risks owing to complicating constitutional disease, form the ideal group for radiation therapy. Cases in which a demonstrable invasion of the contiguous tissues and organs and regional lymph-nodes is found on physical examination are clearly inoperable and are subjected to intensive radiation. Hopeless and terminal cases are treated symptomatically.

The duration of an application of radium within the cervical canal depends upon the intensity of the radiation striking the rectal mucosa. This limits the extent of the action of radium in the pelvic cavity; the parts lying near the bony periphery do not receive an adequate dosage. This may be remedied by supplementing radium therapy by intense doses of *x*-ray. Surgery in connection with such treatment is not advisable, as these patients undergo a profound radiation toxemia, and succumb easily to sepsis and shock. The technique for combining *x*-rays and radium is outlined.

In the treatment of recurrences, the radiation must be as intense as though the uterus had not been removed, regardless of the consequences. The disease and not the patient must be treated. Pre-radiation curettage and cauterization or post-radiation panhysterectomy in the clearly inoperable cases render the patient's chances for even temporary improvement decidedly worse. An active immunization is produced by the action of radium on malignant cells, the cancer cells being stimulated to produce a specific antibody for other similar cells in the tissues of the patient being treated. Hence it is inadvisable to remove cells, the presence of which are necessary for the production of an antibody.

From April, 1914, to December 31, 1919, 168 cases of uterine cancer were treated with radiation. In some cases treatment was preceded by surgical procedures; as hysterectomy or cauterization, and in others radiation was followed by hysterectomy. Since 1918 radiation was used exclusively. The results show as apparent cure: 71.4 per cent operable cases; 54.5 per cent borderline cases; 27.9 per cent inoperable cases; 2.5 per cent terminal cases, and 2.2 per cent of recurrences.

L. S. G.

Duncan, R. D. Uterine Cancer: With Observations and Results of Treatment with Radium in More Than 300 Cases. (*J. Am. M. Assn.*, August 20, 1921, lxxvii, 604.)

The writer shows by a series of tables that the operative treatment of cancer of the uterus, even by the most skilled surgeon, is not satisfactory. Similar tables show encouraging results from radium therapy. The cases reported are not so numerous however, and the periods elapsing between treatment and report are variable.

The technique employed is the introduction of screened emanation tubes into the uterine cavity, supplemented, when necessary, by vaginal applicators, and in certain cases by burying needles or tubes in the tumor. The total dosage employed is from 4,000 to 6,000 millicuries hours, depending on the size and character of the uterus.

No toxemias have been noted. There has been little annoyance from bladder irritation, but in cases with involvement of the posterior vaginal wall a severe rectal tenesmus develops in ten days and continues for about two weeks.

The results consist in a gradual absorption of the cancer tissue, disappearance of the vaginal ulceration and new growth, and local healing of the cervix. The uterus reduces in size and becomes less fixed. Surgery following an apparent cure from radium is not only unnecessary but often disastrous.

The writer reports 236 cases treated with radium. An average of all cases shows 40.6 per cent clinically well. The results vary from 22 per cent clinically well after treatment for recurrent carcinoma to 86.6 per cent clinically well in the operable cases.

L. S. G.

Boggs, R. H. The Treatment of Tuberculous Adenitis by Roentgen Ray and Radium. (*Am. J. M. Sc.*, July, 1921, clxii, 90.)

Formerly roentgenotherapy was used in tuberculous adenitis to avoid deformity and scarring; now it is used on a definite therapeutic basis. Over 90 per cent of all tuberculous adenitis cases can be cured by roentgenotherapy. Tuberculous adenitis is no longer a surgical disease, it is merely a local manifestation of a general condition. Tonsils, if involved with tuberculosis, should not be removed until the cervical glands have been rayed to close off the lymph channels, especially in children under fifteen years of age.

The reasons given against surgical intervention are:

1. Children get well without it.
2. We have no certain method of diagnosis in early cases.
3. All affected glands cannot be removed.
4. Scars.
5. Recurrences.

Since the disease can be removed more successfully by roentgen ray or radium with no danger of spreading the disease, without scarring and without sacrificing tissue, complete extirpation of the tuberculous glands should never be performed until the disease is well localized Immediate opening of a tuberculous abscess is even counseled against, as being liable to disseminate the infection; close off the lymph channels just with radiation. Ultimate healing will be hastened. The lymph glands are the lines of the first defense. Overcoming this barrier, the bones are next involved and finally the lungs are affected. Left untreated and unaided in the fight, tuberculous adenitis may progress to more serious involvement. In conclusion:

1. Radium and the *x*-ray will cure more cases of tuberculous adenitis than any other method. Roentgenotherapy alone will cure over 90 per cent of these cases.

2. Surgical treatment is always contraindicated in every case of tuberculous adenitis.

3. Those who still hold to radical operation will find the responsibility hard to shoulder with the ever increasing recognition of the fact that tuberculous adenitis can be cured without it.

4. Hard fibrous nodules following roentgenotherapy seldom contain any tuberculous foci, but it may be permissible to remove these nodules through a small incision the same as with a foreign body.

5. It is to be remembered that large cervical glands may be due to sarcoma, Hodgkin's disease, leukemia, etc., and that roentgenotherapy is still the best form of treatment for multiple glandular tumors, but the end results are not the same as when the enlargement is due to tuberculosis.

6. In the treatment of tuberculous adenitis in the future, when a more systematic raying is employed and when the cases are referred earlier, this method of treatment will be universally accepted.

L. R. Sante.

Sachs, E. The Diagnosis and Treatment of Brain Tumors. (*J. Missouri M. Assn.*, July, 1921, xvii, 217.)

Attention is called to the marked progress in the diagnosis and treatment of brain tumors in the past decade. The localizing symptoms of brain tumors in different localities is taken up. Concerning the *x*-ray in diagnosis of brain tumor the writer says:

"Another method that I feel should be made use of in every case is the *x*-ray. There are only a limited number of cases in which it is of real value, but one never can know beforehand when the diagnosis may be strikingly confirmed by the *x*-ray. I have stereoscopic plates taken in every case and study the plates myself with the roentgenologist. A special technique is necessary, for the position of the patient's head on the plate is of great importance. The plate may reveal the following points:

1. General signs of increased pressure. The appearance of a so-called pressure skull is characteristic. The areas of convolutional atrophy are due to thinned bone at the site of the convolutions.

2. The sutures may be separated in children or young adults.

3. The conformation of the dorsum sellae may be significant; when there is general increased pressure the dorsum sellae may be thinned and pressed forward, while in lesions originating in the sella turcica—pituitary tumors—the dorsum is pushed backward. In very advanced cases the dorsum may be completely destroyed. A large deformed sella is, of course, noted in cases of pituitary tumor, though this is not always the case, for the tumor may lie above the pituitary fossa.

4. In tumors in the cerebello-pontine region, particularly acoustic nerve tumors, comparative studies of stereo-plates of the right and left sides may reveal an enlarged internal auditory meatus. These plates are the most difficult of all to take and require a most painstaking technique.

5. In a few cases there may be a shadow due to calcified deposits in the tumor. When this is found it is of great value and importance.

Concerning the treatment of brain tumors, other than operative, roentgenotherapy is mentioned as holding forth considerable hope.

The writer feels that it is too early to express a final opinion on this subject, but it seems from the cases thus far reported that the application of radium or the *x*-ray, after a tumor removal through a decompression opening, helps to inhibit the growth and possibly to destroy the remaining vestiges of a tumor that has been removed.

L. R. S.

Gellhorn, G. Roentgenotherapy in Non-Malignant Diseases. (*J. Missouri M. Assn.*, July, 1921, xvii, 220.)

The question of the real therapeutic value of *x*-rays and radium in gynecologic diseases is no longer open for argument; it merely remains to enumerate the non-malignant conditions (to which this paper is limited) in which it is of distinct benefit.

Chronic metritis, especially prevalent in women near the menopause, causes severe protracted hemorrhages which often resist every other method of treatment. All observers agree that these hemorrhages can be checked with absolute certainty. In 95 per cent the recovery was complete; of the remaining 5 per cent recurrences occurred in about 3 per cent, but with a repetition of radiotherapy only 2 per cent finally failed to respond. It should be borne in mind that hemorrhages at this age are very often due to carcinoma of the uterus and this condition should be definitely excluded in all cases before undertaking such palliative therapy. Operation alone is justifiable in carcinoma.

The second principal field for therapy is in the treatment of fibroid. Even in the hands of excellent surgeons there is still a mortality of 3 to 5 per cent. Roentgenotherapy has no mortality. The word "cure" means something different in the two methods; by operative cure we mean the removal of the fibroid and survival of the patient; by a roentgenotherapeutic cure we aim only at a clinical cure—the object desired being obtained if the menorrhagia caused by the fibroid ceases, or the fibroid disappears. Recent monographs by Gauss and Friedrich state that in 2,982 cases of fibroid treated with rays there were 95.6 per cent cures and 4.4 per cent failures. In 944 fibroids treated with radium there were 94.4 per cent cures and 5.6 per cent failures.

To accomplish these results the technique must be according to the latest advances, and the therapeutist must not only be familiar with the theoretical and practical principles of roentgenotherapy, but he must have at his disposal a modern *x*-ray apparatus. It should be borne in mind that the effect of *x*-rays on fibroids as well as on climacteric hemorrhages is primarily exerted upon the ovaries. A bloodless castration is thereby produced. *X*-ray or radium should be applied soon after the menstruation. Roentgenotherapy should not be applied in cases of fibroid which extend above the umbilicus. Large pedunculated fibroids are also unsuitable for radiation. Gauss and Friedrich estimate that 70 to 80 per cent of irradiated fibroids shrink in size, one-third disappear entirely. Roentgenotherapy should be applied only in cases in which there is no doubt as to the diagnosis.

L. R. S.

Jackson, C. The Symptomatology and Diagnosis of Foreign Bodies in the Air and Food Passages; Based upon a Study of 789 Cases. (*Am. J. M. Sc.*, May, 1921, clxi, 625–661.)

An elaborate symptomatology of foreign bodies in the respiratory tract is given. The *x*-ray is hardly necessary or useful in examination of the larynx, the direct examination always being more certain and practically conclusive. Aside from direct examination, the *x*-ray is of great value in examination for the detection of foreign bodies in the trachea and bronchi, and their differentiation from esophageal foreign bodies. Disc-shaped foreign bodies seen in the *x*-ray in the sagittal plane, if lying flat in the postero-anterior view, must be in the esophagus; if seen on the edge in the postero-anterior view the trachea is the site of lodgment. This is on account of the anatomical construction of the trachea with a free space in the cartilaginous rings posteriorly, and likewise because the foreign body must necessarily enter the trachea through the glottis which is in a sagittal plane. The esophagus on the other hand, is a closed, flattened tube lying in a plane perpendicular to it. Roentgenoscopic mixtures can be seen to pass posterior to tracheal foreign bodies and to divide and go around esophageal bodies. Opaque foreign bodies can be easily localized in the bronchi and lungs. Both lateral and posteroanterior plates must be taken to avoid missing any shadow which might overlap the spine or bony structure. Likewise a very thin or flat foreign body might cast an inappreciable shadow in one position and in another view at right angles to it, give quite a distinct shadow.

For distinguishing non-opaque foreign bodies certain roentgenographic findings are mentioned:

1. Increased transparency on the obstructed side of the chest.
2. Displacement of the heart toward the uninvolved side.
3. Downward displacement of the diaphragm and a marked limitation of its motion on the obstructed side.

In short, an acute monolateral obstructive emphysema.

To localize a branch bronchus invaded by a small foreign body the bronchoscopic insufflation of dry bismuth subcarbonate is used. No ill effect has been noted from this method.

Roentgenograms should be made to localize the foreign body before removal and again after removal to discover the possible presence of a second foreign body. Instances are cited where failure to do this would have led to disastrous results.

Where non-opaque foreign bodies are present in the esophagus the administration of opaque media may be used, or a barium-filled capsule may be given. This lodges at the site of the foreign body, slowly dissolving and liberating the barium which surrounds the body. All cases where long standing, obscure chest conditions are present, especially where no tubercle bacilli can be found in the sputum, should be given the benefit of roentgenographic examination for foreign bodies. A negative diagnosis should not be made except on plates of the very best quality and after fluoroscopic and several plate examinations. All cases, even when foreign bodies can be clearly seen, should be given a thorough physical examination so that the knowledge gained thereby may be utilized in the localization of non-opaque foreign bodies at some future date.

J. E. SUNDER.

CHARLIER. Radiotherapy of Neuritis. (*J. de Méd. de Par.* May 30, 1921, xl, 15).

Since so-called neuritis and allied conditions are a rich field, the possibility of successful treatment by irradiation presents much interest. The idea is by no means new, for in 1908 this treatment was recommended under certain conditions by Babinski and Delherm. The author states in advance that the best results are obtained in paroxysmal neuralgia or neuritis, when the paroxysms succeed one another rapidly. One had better make use of weak doses several times weekly, for moderate and strong radiation may at first aggravate the pain and the small dose may give an equally good result. The author's technique is best shown by repetition of case histories. Thus a woman of fifty-three was first seen in 1908 with a history of neuralgiform crises for the previous three months in the cervicodorsal area. The right shoulder, right side of the neck and upper part of the back were the regions involved. The patient had been treated without benefit by the constant current. The entire region was rayed with 5 H, 1 mm. aluminum filter, at weekly sessions. After five or six sessions the patient appeared to be cured. In a second case of the same sort, treated in 1920, in a woman of thirty-four, 2 H were used, at three séances, filtration aluminum 3 mm., at intervals of two to three days. In this patient the part rayed was the spine—the four first cervical vertebrae. A recurrence was treated with 1 H, 2 doses, and the patient has since been free from attacks. In a severe case of sciatica of long duration—over twenty years—with five separate protracted experiences, the third, fourth and fifth lumbar vertebrae and sacrum were rayed, initial dose 2 H, later ½ H and 1 H. After ten séances the patient recovered completely.

FAURE-BEAULIEU and BECLERE. Rectal Insufflation with Carbonic Acid Gas in Radiologic Exploration of the Liver and Spleen. (*Bull. et mém. Soc. méd d. hôp. de Paris*, February 3, 1921.)

For a number of years various attempts have been made to increase the visibility of the abdominal viscera with special reference to the liver and spleen. In areophagus subjects the contours of these two viscera are notably clarified. The artifice of generating air in the stomach by drinking fluids which effervesce on mixing has not proved meritorious and the insufflation of air into the colon was found to be superior to the preceding, but had one notable disadvantage, which was the tendency of the injected air to remain in the colon, especially in subjects with peritoneal adhesions, organic stenoses, spastic contraction, etc., of the bowel. Artificial pneumoperitoneum is also open to objections such as disturbances of the static relations of the viscera which have exceptionally proved serious. In insufflation the custom has been to employ either atmospheric air or oxygen, neither of which gases is readily absorbed. The author has substituted carbonic acid as having greater absorbability by the intestine. One should secure a tube of compressed carbonic acid of the ordinary commercial type. This may be connected with an oxygen gas bag which serves as a reservoir and from which the carbonic acid is conveyed into the rectum under screen control. It is not necessary to evacuate the colon in advance of the insufflation. The examination must be made rapidly before much of the gas can be absorbed. Cases are narrated which bring out the great advantages of the method.

Jas. G. Van Zwaluwenburg

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HIGH VOLTAGE X-RAY WORK*

BY W. D. COOLIDGE, PH. D. AND W. K. KEARSLEY, JR.

Research Laboratory, General Electric Company
SCHENECTADY, NEW YORK

CONTENTS

A. Introduction

It seems desirable, for experimental purposes at least, that one should be able to produce *x*-rays of shorter wave-length than those which have heretofore been available. This involves the operation of *x*-ray tubes at very high voltages.

The following is a description of a preliminary survey which we have made up to a voltage of 300,000 (max.). Much of the work has been carried out mainly for the purpose of finding the path of least resistance, as this is the path which should later lead to the successful use of still higher voltages.

It is for most purposes important to know both the intensity and the penetrating power of the radiation, for this reason, other things being equal, preference must be given to that method of production which best lends itself to quantitative control.

As there is an insistent and growing demand for short wave-length radiations

*Read at the Twenty-second Annual Meeting of The American Roentgen Ray Society, Washington, D C., Sept. 27–30, 1921.

in *x*-ray therapy, the conditions of many of the experiments have been chosen with the medical application in mind.

It is important, especially in the case of the medical application, to know how the measurement of the quantity and quality factors can best be effected, whether through direct measurement of *x*-ray intensity or through electrical measurements of the energy supplied to the tube. It is for this reason that so much attention has been given in the following to the relation between the *x*-ray output and the energy input of the tube. For it is relatively much easier to measure the factors of the energy input, and this is sufficient provided *x*-ray output is determined with sufficient accuracy by electrical input.

B. Design of High Voltage X-Ray Tube

In connection with a paper[1] read before this Society in 1915, a tube was shown which had been operated on an induction coil at the voltage corresponding to a 20 inch spark between points.

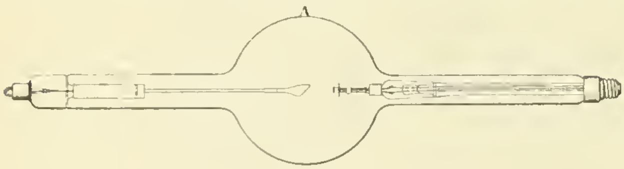

Fig. 1.

The experience gained from working with this and with later experimental models has led to the design shown in Figure 1.

General Description of Model Shown in Figure 1

The bulb is 8 inches in diameter and the overall length is 32 inches. As in the "Universal" type of tube, the anode is of solid tungsten with a molybdenum stem and is supported from almost the extreme end of the anode arm. The distance between the cathode and the anode has been increased from that of the "Universal" type of tube (1 inch) to 2 inches, to reduce the electrostatic pull on the filament and to decrease the tendency for the liberation of electrons from the edges of the focusing device.

[1] W. D. Coolidge, "Hard *X*-Rays," Am. J. Roentgenol., 1915.

Tubes of this design and of the regular "Universal" type have been used for all of the work described in this paper and will be referred to under the names of "High Voltage" and "Universal Type" tubes.

C. Description of an Experimental Interrupterless Machine for more than 300,000 Volts (Max.)

1. The Transformer

Two large transformers, originally intended for electrostatic precipitation work, have been used, with their high tension coils connected in series. The middle point is connected to earth. The low tension coils are connected in parallel.

2. The Mechanical Rectifier

This was of the Snook type and consisted of a wooden shaft, with four metal cross arms, driven by a synchronous motor.

A first model enabled us to go up to 280,000 volts maximum. As some of the *x*-ray tubes would stand more than this, a larger rectifier was built for higher voltage.

There had been one serious difficulty with the first rectifier, namely, that the insulating power of the shaft which was made of wood, had not been high enough. This was remedied in the second one by making the shaft of thin-walled paper-shellac tubing. This does not conduct current, does not warp and has been in every way satisfactory even when handling 300,000 volts during very humid summer weather.

The rectifier cross-arms are 35¼ inches long, and are spaced 33 inches apart. The total length of the rectifier is 12½ feet.

This rectifier has as yet not been operated above 300,000 volts maximum, but is designed for more.

The collectors are large to avoid corona. They consist of brass tubing 3 inches in diameter and are fitted with hemispherical ends. The collectors subtend an angle of 42 degrees of arc.

The gyroscopic action of the cross-arms tends to straighten the shaft out at high speed. This makes it easy to build very large rectifiers of this type.

3. VOLTAGE CONTROL

About four-fifths of the line voltage is consumed in the control resistance. This increases the smoothness of operation of tubes and greatly reduces the danger attendant upon accidental contact with the high tension circuit.

4. VOLTAGE MEASUREMENT

Voltage is measured by means of a voltmeter connected across the low tension side of the *x*-ray transformer. This is calibrated by a sphere-gap connected in parallel with the tube. This gap has spherical electrodes 25 cm. in diameter and conforms fully with the specifications of the American Institute of Electrical Engineers.

5. CURRENT MEASUREMENT

Two milliamperemeters are always connected in series in the *x*-ray tube circuit. This rule was adopted after the following experience: A good milliamperemeter which had just been calibrated was used carefully for two or three days, at the end of which time it was found to be reading over 50 per cent too low. The zero had not changed and up to the time of recalibration there had been nothing to indicate the trouble. Subsequent examination showed that a portion of the resistance shunted around the moving coil had been short-circuited, owing doubtless to a high voltage surge. As there is no known method of providing absolute protection against such surges it would seem best for the therapeutic application of the *x*-rays, always to employ 2 milliamperemeters in the high tension circuit. The probability would be very strong against these two meters ever suffering to exactly the same extent at the same time.

6. CIRCUIT BREAKER

A quick-acting double-pole overload circuit breaker is connected in the primary circuit next to the line. If a current of not more than say 8 ma. is to be used in the tube, the breaker can be adjusted to open the circuit in case the load ever exceeds 10 ma. The presence of a circuit breaker set to open for such a low milliampereage in the high tension circuit, together with the large amount of ballast resistance in the low tension circuit, which prevents the attainment of high instantaneous current values in the high tension circuit, greatly reduces the electrical danger attendant upon the use of such a high voltage outfit.

The heating current for the cathode of the *x*-ray tube has been derived from a storage battery. Otherwise a stabilizer would have been required.

D. Description of a 200,000 Volt Constant-Potential Continuous-Current Machine

A constant-potential continuous-current machine for 200,000 volts is shown diagrammatically in Figure 2.

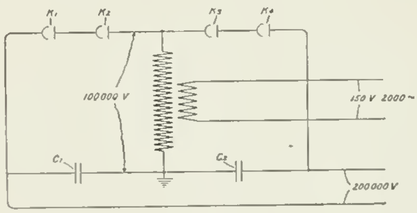

Fig. 2.

Alternating current of 2,000 cycles and 150 volts from a motor-generator set is fed to a special transformer where its voltage is raised to 100,000 (max.). By means of 4 kenotrons K_1, K_2, K_3, and K_4, this alternating current is allowed to flow alternately into two condensers C_1, and C_2. The two condensers are in series and the *x*-ray tube is operated directly from their outer terminals. Each of the condensers has a capacity of 0.001 microfarad. The outfit is seen to be somewhat similar to that described by Dr. Hull.[2]

The necessity for two kenotrons in series in each side of the circuit is due to the fact that the available kenotrons were suitable for only 100,000 volts each and each side of the circuit has to withstand 200,000 volts.

[2] Am. J. Roentgenol., 1915, pp. 153–155.

In general, the potential will not divide itself equally between kenotrons. This difficulty is remedied by putting capacity around the kenotron which is getting more than its share of the voltage. This is easily accomplished by first operating the outfit at a voltage which is just sufficient to cause distress in one of the kenotrons. This distress will be manifested by green fluorescence in the bulb. A small amount of capacity is then placed in parallel with this kenotron and this capacity is increased by the cut and dried method until the signs of distress disappear. The voltage of the outfit is then raised. A kenotron on the other side of the circuit may then show distress. It is relieved by connecting capacity in parallel with it. By continuing to raise voltage and adjust capacities, the terminal voltage may be safely brought to 200,000 with the kenotrons showing no distress.

Although some of the relief has been due to leakage as well as capacity, for a period of several months at least, it has not been necessary to readjust the condenser capacity around the kenotrons.

E. Measurement of High Tension Voltage

The measurement of high tension voltage by means of a voltmeter connected across the low tension winding of the transformer or induction coil, may be satisfactorily carried out under certain conditions.

In general, the primary voltage required to produce a given high tension voltage will depend on the milliamperage. It is then necessary to calibrate against the sphere-gap for the exact milliamperage which is to be employed.

This method becomes inaccurate and unsatisfactory in case the voltage varies too rapidly with the milliamperage.

This is illustrated by Table I, which gives voltage calibrations of four different outfits. For these calibrations the sphere-gap was kept set to spark over on 180 kv. (max.) and, for each tube load, in milliamperes, the voltage impressed upon the low tension winding of the transformer

Table I

CALIBRATION OF DIFFERENT OUTFITS AT 180 KV. (MAX.)

Ma.	I Experimental Interrupterless	II Induction Coil	III-A Transformer with Open Magnetic Circuit and Single Arm Switch	III-B Same Transformer as III-A but with 4-arm Rectifier
0	(100)	(100)	(100)	(100)
1	96.0	104.4	137.0	114.0
2	96.6	109.0	169.0	116.0
3	96.6	110.7	217.0	115.0
4	96.6	...	...	115.5
5	98.0	...	...	108.0

or induction coil was gradually raised until a spark jumped across the sphere-gap.

The data of Table I are plotted in Figure 3.

In the case of I, the experimental interrupterless machine (described in Section C), the primary voltage is seen to change very slowly with the load.

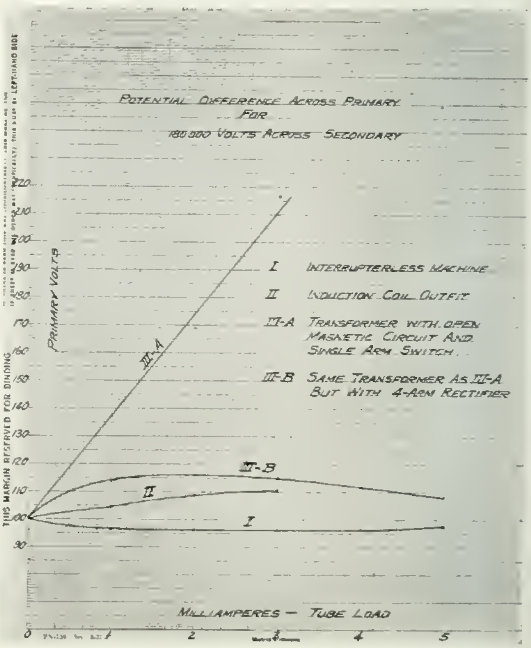

Fig. 3.

With II, the induction coil outfit, the

change is more pronounced, but is still not troublesome.

The outfit III-A, consists of a transformer with an open magnetic circuit, having high magnetic leakage, and a single arm high-tension switch which utilizes every other half wave. The primary voltage curve is seen to rise very rapidly with increasing milliampereage. It rises so rapidly in fact that, for 180,000 volts, the load could not conservatively be increased above 3 ma., because of the danger of breaking down the transformer from the high "inverse" voltage. The worst objection, however, to the use of an outfit having such a calibration curve as III-A lies in the fact that the steepness of the curve reduces the accuracy of measurement of the high tension voltage.

Furthermore, a change of a milliampere or even less in the corona loss would occasion a relatively large error in the voltage determination.

The outfit of the last column, III-B, is the same as III-A except that the single arm high tension switch has been replaced by a 4-arm rectifier. Both half-waves are in this way utilized and the resulting calibration curve is then entirely satisfactory.

F. Effect of Electrical Characteristics of High Tension Supply Circuit on *X*-Ray Output

For this study, the tube was rigidly mounted in front of a lead booth which shielded observer No. 1 and an ionization chamber (Fig. 4). The tube was connected to an overhead aerial system which was 27 feet long and extended into a second, adjoining room. A sphere gap was permanently connected across the aerials and two milliamperemeters were connected in series with the tube. The filament was lighted from a storage battery and the rheostat for controlling the filament current was operated by a cord extending into the lead booth.

It was then possible, at a moment's notice, to connect any one of the high tension generators, referred to in the following, to the aerial system and thence to the tube.

Voltage and milliamperage were both controlled by observer No. 1, while observer No. 2 measured *x*-ray intensity as indicated by ionization currents.

The lead booth was 1/4 inch thick on the front (the side facing the tube) and 1/8 inch thick on the remaining five sides. The door

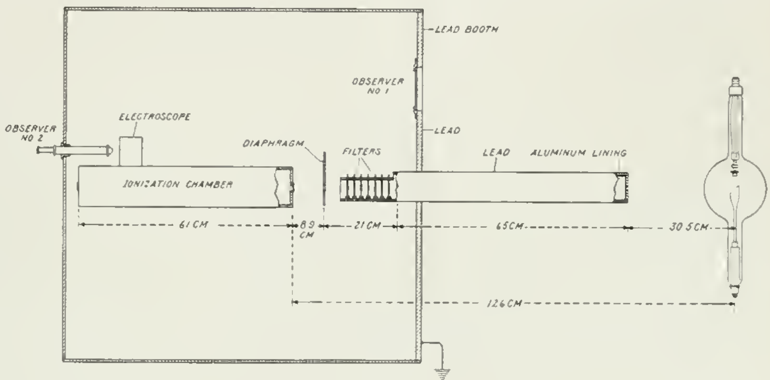

Fig. 4.

was at the back of the booth and was kept closed during the measurements.[3]

The system of diaphragms used to limit the *x*-ray beam was always such as to permit the rays from the entire head of the target to enter the ionization chamber, and care was taken to secure such alignment that none of the beam should touch either

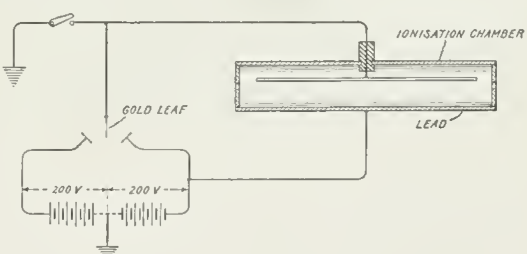

Fig. 5.

of the electrodes of the ionization chamber. The rays entered and emerged from the latter through thin mica windows.

Air at atmospheric pressure was always used in the ionization chamber.

[3] Experiment had shown that this was necessary for the adequate *x*-ray protection of the electroscope.

A Bumstead electroscope was used and was connected to the ionization chamber and dry battery as indicated diagrammatically in Figure 5.

The first experiments were made with an interrupterless machine operating at 127,000 volts (max.), as measured by the sphere-gap.

1. *Interrupterless Machine with Resistance vs. Auto-Transformer Control*

The absorption curves shown in Figure 6 were obtained from ionization chamber measurements, the tube being operated from a Snook direct-current interrupterless machine.

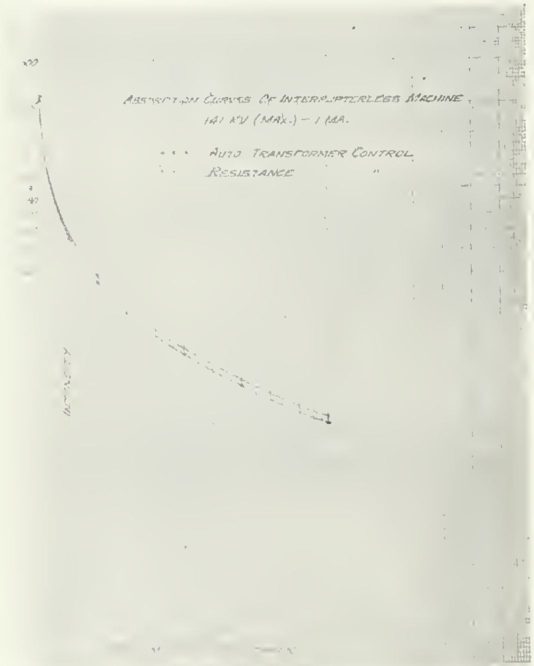

Fig. 6.

The data for these curves is given in Tables II and III.

With both resistance and autotransformer control the fine regulation of voltage was obtained by means of a special 1.5 ohm rheostat inserted in the primary circuit.

In the case of resistance control, the autotransformer was set for maximum voltage, so that as much as possible of the resistance of the control rheostat could be used. Under these conditions 35 per cent of the voltage obtained from the auto-transformer was consumed in the rheostat.[4]

Table II

AUTO-TRANSFORMER CONTROL
1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10$
0.0	4.9	204.0
0.1	17.8	56.2
0.2	27.4	36.5
0.3	36.2	27.62
0.5	54.2	18.50
0.7	72.6	13.79
1.0	102.8	9.73

Table III

RESISTANCE CONTROL
1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10$
0.0	4.7	213.0
0.1	17.3	57.8
0.2	25.4	39.3
0.3	34.3	29.1
0.5	51.0	19.6
0.7	69.1	14.5
1.0	98.6	10.15

Table IV shows the result of dividing the resistance-control by the corresponding auto-transformer control intensities.

Table IV

Mm. Copper	Intensity—Res. Cont. / Intensity—A. T. Cont.
0.0	1.04
0.1	1.03
0.2	1.08
0.3	1.05
0.5	1.06
0.7	1.05
1.0	1.04
Average	1.05

The intensity with resistance control is seen throughout the experiment to be higher than with auto-transformer control

[4] It is this fraction of the voltage wasted in the rheostat which determines the amount of ballasting action in the case of resistance control.

the difference amounting, on an average, to 5 per cent. This difference may be due to the greater tendency of the tube-load to distort the wave-form, in the direction of flattening the peak, in the case of resistance control. It is very small however, and amounts to but little more than the possible experimental error introduced through the measurement of the high tension voltage.

2. *Interrupterless Machine—Effect of Widely Different Amounts of Ballast Resistance*

The absorption curves of Figure 7 were obtained from ionization chamber meas-

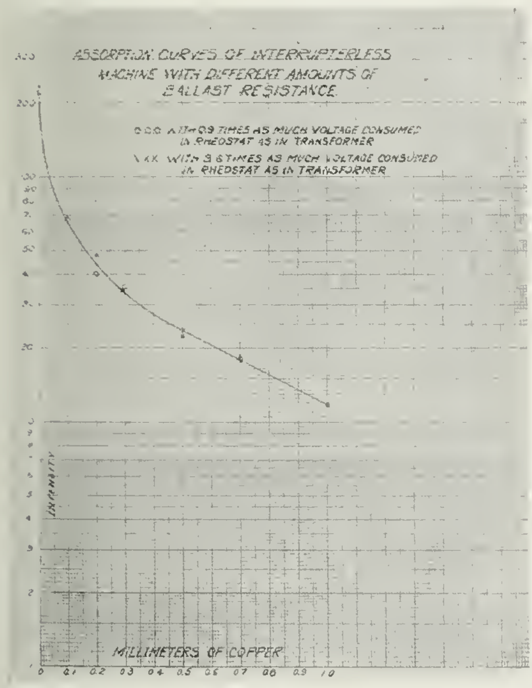

Fig. 7

urements, while the tube was operated from an earlier model, Waite & Bartlett interrupterless machine.

A special rheostat was used in the primary circuit and different primary connections were employed for the two curves. The data are given in Tables v and vi.

Inspection of Figure 7 shows that the graph best fitting the data of Table v coincides with that for the data of Table vi.

Table v

Primary connections 1 and 3, with 0.9 as much voltage consumed in the control rheostat as in the transformer primary

1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.0	4.5	222.0
0.1	15.0	66.5
0.2	24.8	40.3
0.3	28.2	35.4
0.5	42.4	23.6
0.7	56.9	17.6
1.0	85.2	11.7

Note. The intensity values of Tables v and vi are not directly comparable with those of Tables i and ii, as the constant of the electroscope may have changed. The slope of the absorption curves can, however, be compared. It is the same throughout, indicating the same quality of radiation from the two different machines.

Table vi

Primary connections 3 and 4, with 3.6 times as much voltage consumed in control rheostat as in transformer primary

1 Ma., 141 Kv. (Max.)

Mm. Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.0	4.3	233.0
0.1	14.7	68.0
0.2	20.9	47.8
0.3	29.4	34.0
0.5	44.8	22.3
0.7	55.4	18.1
1.0	84.6	11.8

This extremely wide range of ballasting effect shows then, no change in either the intensity or the kind of x-rays produced.

3. *Interrupterless Machine vs. Induction Coil*

For the first of these measurements a large Scheidel-Western induction coil, was employed. It was operated from a mercury turbine interrupter with hydrogen used as the dielectric.

For comparison with this coil, the Snook direct-current interrupterless machine, previously mentioned, was used with resistance control.

The maximum voltage was measured in both cases by a sphere-gap. In the case of the interrupterless machine the voltage was controlled by means of a voltmeter connected across the primary, and with the coil it was controlled by means of an Abraham-Villard high tension electrostatic voltmeter connected in parallel with the tube. The interrupterless machine was the large experimental one described in Section C.

The comparison was made at 1 ma. and 296,000 volts.

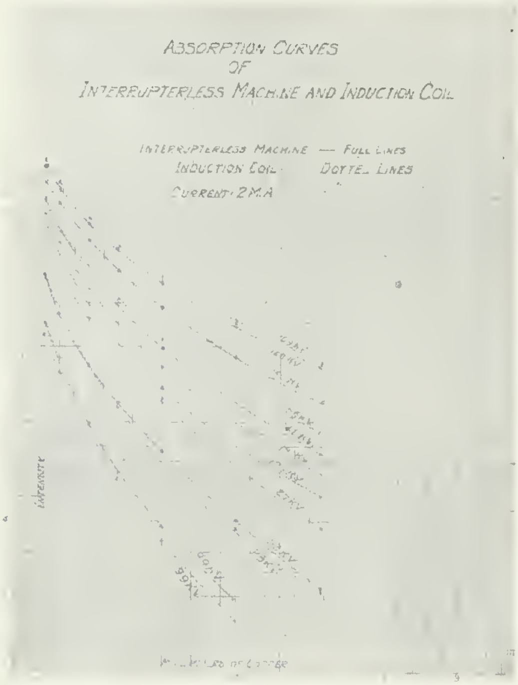

Fig. 8

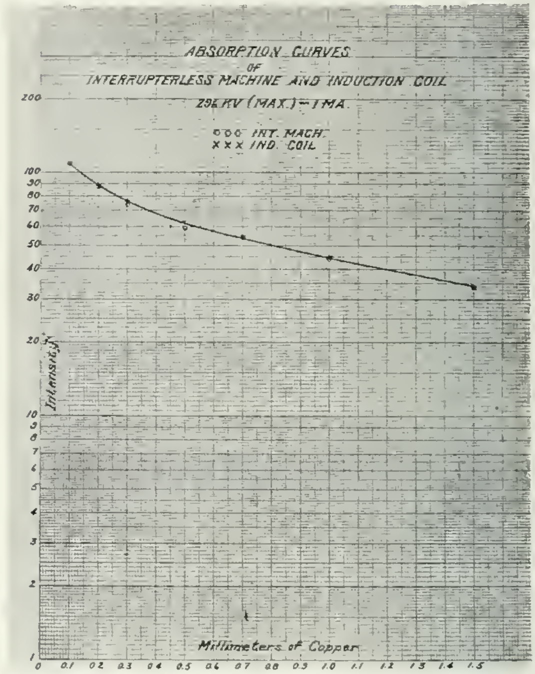

Fig. 9

The ionization currents for the different voltages, expressed in kilovolts (max.) and for different thicknesses of copper filter are given in Tables VII and VIII, and are plotted in Figure 8.

Table VII

IONIZATION CURRENTS

SNOOK D. C. INTERRUPTERLESS MACHINE—2 MA.

Millimeters of Copper	99 Kv.	113 Kv.	127 Kv.	141 Kv.	155 Kv.	169 Kv.
0.2	24.8	38.7	60.2	78.0	92.5	105.2
0.3	17.7	26.7	45.0	57.5	74.6	84.7
0.5	9.78	17.15	29.2	39.7	53.2	62.8
0.7	6.35	11.65	20.7	28.7	40.0	49.0
1.0	3.79	7.60	13.63	19.5	29.1	36.7
1.5	1.94	4.08	8.00	11.67	18.13	24.5
2.08	.....	2.14	4.97	7.80	12.35	16.7

A second comparison between induction coil and interrupterless machine was made later at higher voltage. In this case a different induction coil was used. The interrupterless machine was the large experimental one described in Section C.

The data are given in Tables IX and X and plotted in Figure 9.

Both sets of data are best represented by the same line, showing that, in so far as is indicated by this test, any existing difference in quality or intensity is less than the experimental error of the measurements.

4. *Interrupterless Machine vs. Constant-Potential Continuous-Current Machine*

The interrupterless machine was the large experimental model described in Section C.

The high tension voltage was measured by the sphere-gap. In both cases, resistance control was employed and the high tension voltage was kept constant by hand regulation of the low tension voltage, indicated by a voltmeter connected across the primary. That the high tension voltage remained constant was also indicated in the case of the high tension direct-current machine by an Abraham-Villard electrostatic voltmeter which was connected in parallel with the tube.

Table VIII

IONIZATION CURRENTS

SCHEIDEL-WESTERN INDUCTION COIL—2 MA.

Millimeters of Copper	99 Kv.	113 Kv.	127 Kv.	141 Kv.	155 Kv.	169 Kv.
0.2	22.4	39.7	54.0	68.0	76.8	113.7
0.3	15.77	27.0	48.6	52.0	56.9	93.4
0.5	8.45	17.64	25.5	34.0	42.0	66.5
0.7	5.96	11.35	17.9	25.0	31.2	51.4
1.0	3.38	6.65	12.5	16.7	20.8	38.8
1.5	1.60	3.79	6.58	12.0	14.2	25.9
2.08	.....	2.07	3.73	6.25	9.60	17.13

Table IX

INDUCTION COIL OUTFIT

1 Ma., 296 Kv. (Max.)

Millimeters of Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.1	9.1	109.9
0.2	10.8	90.0
0.3	12.9	77.5
0.5	15.7	63.8
0.7	18.2	55.0
1.0	22.2	45.1
1.5	29.6	33.8

Table X

EXPERIMENTAL INTERRUPTERLESS MACHINE

1 Ma., 296 Kv. (Max.)

Millimeters of Copper	Time (T) Seconds	Intensity $\frac{1}{T} \times 10^3$
0.1	9.1	110.0
0.2	11.3	88.6
0.3	13.2	75.8
0.5	16.9	59.2
0.7	18.1	55.3
1.0	22.6	44.3
1.5	29.3	34.1

The ionization currents for the two machines, at the voltages indicated, with the different thicknesses of copper filter, are given in Tables XI and XII.

Three series of measurements were made on the constant-potential continuous-current machine, operating at 200 kv. and 2 ma. The ionization currents are given in Table XI. The last column gives the average values of the three series.

Table XII gives the ionization currents obtained at different voltages with the interrupterless machine, which was also operated at 2 ma.

The results of Tables XI and XII are plotted in Figure 10, in which the dotted line shows the

Table XI

CONSTANT-POTENTIAL CONTINUOUS-CURRENT MACHINE

200,000 Volts., 2 Ma., Tube 143

Millimeters of Copper	Ionization Current			
	Series 1	Series 2	Series 3	Mean
0.0	154.0	149.5	156.1	153.2
0.1	70.2	71.5	73.7	71.8
0.3	42.6	42.5	45.9	43.7
0.5	33.4	35.1	34.9	34.8
0.7	26.3	27.7	28.2	27.4
1.0	21.6	22.6	22.0	22.1
2.0	12.5	13.3	13.2	13.0
4.0	5.61	6.39	6.30	6.10
6.0	2.87	3.45	3.40	3.24
8.0	2.02	2.11	1.61	1.91
10.0	1.34	1.33	1.05	1.24

Table XII

INTERRUPTERLESS MACHINE

2 Ma., Tube 143

Millimeters of Copper	Ionization Current			
	200 Kv.	212 Kv.	225 Kv.	237.5 Kv.
0.0	125.8	135.0	148.5	162.0
0.1	49.0	57.5	62.2	70.0
0.3	27.4	33.0	39.4	43.9
0.5	19.4	24.6	29.0	35.0
0.7	15.4	20.0	24.6	28.3
1.0	11.45	15.1	19.4	23.2
2.0	5.78	8.48	11.1	13.8
4.0	2.32	3.81	5.14	6.58
6.0	1.052	1.96	2.69	3.69
8.0	0.536	1.075	1.66	2.20
10.0	0.302	0.648	1.03	1.41

values obtained with the constant-potential continuous-current machine. The dotted line is seen to lie between the 225 kv. and 237.5 kv. curves for the interrupterless machine. Inspection also shows that it very closely parallels the 225 kv. curve. This is also brought out in Table XIII in which the fourth column gives the 200 kv., d.c. values divided by the corresponding 225 kv., a.c. values.

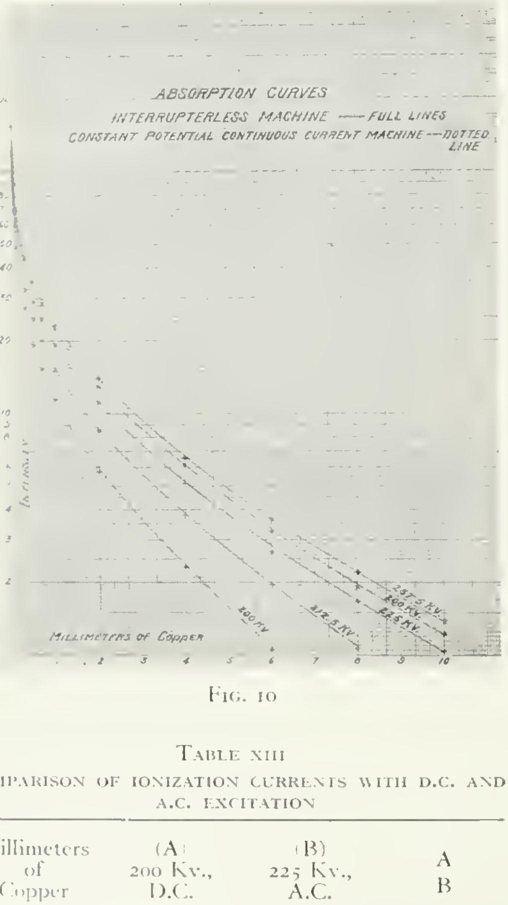

Fig. 10

Table XIII

COMPARISON OF IONIZATION CURRENTS WITH D.C. AND A.C. EXCITATION

Millimeters of Copper	(A) 200 Kv., D.C.	(B) 225 Kv., A.C.	$\frac{A}{B}$
0.0	153.2	148.5	1.031
0.1	71.8	62.2	1.155
0.3	43.7	39.4	1.109
0.5	34.8	29.0	1.200
0.7	27.4	24.6	1.114
1.0	22.1	19.4	1.172
2.0	13.0	11.1	1.187
4.0	6.10	5.14	1.204
6.0	3.24	2.69	1.150
8.0	1.91	1.66	1.205
10.0	1.24	1.03	1.205
Average			1.15

The last column of the above table shows no systematic variation with respect to the average value. The 200 kv., d.c. absorption curve can then be duplicated throughout its entire length by 225 kv., a.c. using 15 per cent more milliamperage (2.30 ma.) in the latter case.

Comparison of Percentage Depth-Intensity Values (Under 10 cm. of Water) Obtained with the Constant-Potential Continuous-Current and the Interrupterless Machines

It seemed possible that the voltage of alternating-current excitation equivalent to the 200 kv., d.c., might be somewhat different for equal percentage depth intensity in water than it was as determined by the absorption curves in copper.

To test this out the apparatus was arranged as in Figure 11. The water container consisted of a rectangular brass box 3 cm. wide, 5.5 cm. deep and 10 cm. long lined with aluminum. Thin mica windows were inserted in the two ends. The water-chamber was inserted through a side door in the lead tube and was always placed in the same position, against the end of the filter holder.

The data obtained with the interrupterless machine, operating at 2 ma. and different voltages, are given in Table XIV and plotted in Figure 12. Two different copper filters 0.5 mm. and 1.0 mm. thick were used.

The precision is not all that could be desired. The curves indicate clearly, however, that, up to 250,000 volts at least, the percentage depth-intensity continues to increase with voltage.

The penetration data for the constant-potential continuous-current machine, operating at 200 kv. are given in Table XV. If the percentage depth-intensity values are placed on the curves of Figure 12 it is seen that, with the 0.5 mm. copper filter, the equivalent alternating-current-voltage is 233.2 kv. and that with the 1.0 mm. filter it is 236.5 kv. The average of these is 235 kv.

From the absorption curves in copper the equivalent alternating-current voltage appears to be 225 kv. The difference in these results may be due to experimental error, or it may be due to the fact that the

TABLE XIV

PERCENTAGE DEPTH-INTENSITY UNDER 10 CM. OF WATER—INTERRUPTERLESS MACHINE—2 MA.

Kv.	0.5 Mm. Copper Filter: Time (Seconds): Without Water	0.5 Mm. Copper Filter: Time (Seconds): Under 10 Cm. Water	0.5 Mm. Copper Filter: Per Cent Depth-Intensity	1.0 Mm. Copper Filter: Time (Seconds): Without Water	1.0 Mm. Copper Filter: Time (Seconds): Under 10 Cm., Water	1.0 Mm. Copper Filter: Per Cent Depth-Intensity
200.0	17.3	117.4	14.70	29.2	183.7	15.74
	17.3	.....	.....	28.4	....	....
	17.2	.....	.....	29.0	.	....
	Mean.....17.27	.	....	28.87	.	
212.5	13.7	89.6	15.25	21.4	138.0	15.74
	13.7	..	....	21.8	..	.....
	13.6	.		22.0	.	..
	Mean.....13.67	....	...	21.73	.	.
225.0	11.8	73.3	15.73	18.0	107.3	16.71
	11.4	....	....	17.8	...	....
	11.4	..	..	18.0	.	.
	Mean.....11.53	....	..	17.93	..	
237.5	9.5	61.2	15.80	15.0	86.4	17.28
	9.8	...	..	15.0	....	.....
	9.7	.	..	14.8	.	..
	Mean..... 9.67	..	...	14.93	..	....
250.0	8.7	49.6	17.32	12.7	69.8	18.20
	8.4	...	....	12.6	.....	.....
	8.7	.	..	12.8	.	.
	Mean..... 8.60	....	.....	12.70	.....	..

TABLE XV

PERCENTAGE DEPTH-INTENSITY UNDER 10 CM. OF WATER—CONSTANT-POTENTIAL CONTINUOUS-CURRENT MACHINE—200 KV.—2 MA.

With 0.5 Mm. Copper Filter: Time (Sec.) Without Water	With 0.5 Mm. Copper Filter: Time (Sec.) Under 10 Cm. Water	With 0.5 Mm. Copper Filter: Percentage Depth-Intensity	With 1.0 Mm. Copper Filter: Time (Sec.) Without Water	With 1.0 Mm. Copper Filter: Time (Sec.) Under 10 Cm. Water	With 1.0 Mm. Copper Filter: Percentage Depth-Intensity
10.0	64.2	..	15.6	91.0	...
10.2	....		15.8	.	...
10.6	..		15.6	..	
10.2	66.6		15.8	92.8	.
10.8	....	..	15.6	.....	
10.7	.	.	16.1	..	
10.6	65.2	..	16.0	91.5	.
10.6	....	.	15.6	.....	
10.6	....	.	15.6	.....	
10.6	64.3	.	15.7	90.5	.
10.6	.....		15.4	.....	
10.6	.....		16.0	..	
Mean 10.51	65.08	16.17	15.73	91.45	17.22

composition of the beam of *x*-rays is not exactly the same in the two cases and that the ratios of scattering to absorption in the two media, copper and water, are different.

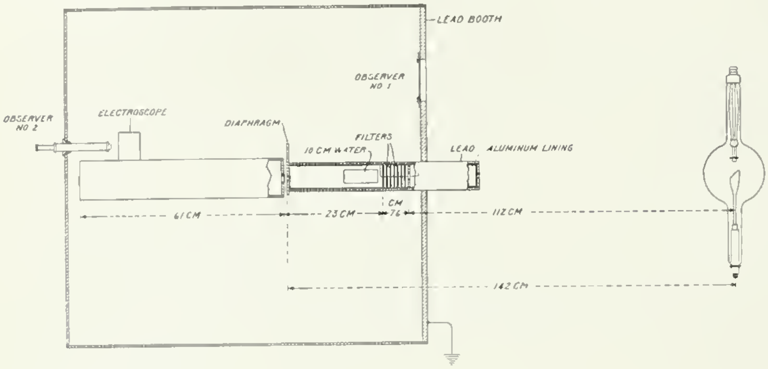

Fig. 11

G. Effect of Electrical Characteristics of High Tension Supply Circuit on Behavior of *X*-Ray Tube

1. *Interrupterless Machine, with Resistance vs. Auto-Transformer Control*

With high voltage operation on the interrupterless machine, resistance control is much easier on the tube than auto-transformer control. It is for this reason that resistance control has always been used for operating hot-cathode tubes on the pump during their evacuation. The resistance in the primary circuit serves as a dam to check the large flow of energy which would otherwise take place to the tube in case, for any reason, its conductivity is suddenly greatly increased. No such dam is present in the case of the auto-transformer control.

A tube whose vacuum has been seriously impaired by operation on a current source having unfavorable characteristics will often clear right up and run smoothly on an interrupterless machine with resistance control.

In addition to its ordinary ballasting action, resistance in the primary circuit also helps to dam out high frequency oscillations originating in the mechanical rectifier, or, in the case of too poor a vacuum, in the tube itself, or from other causes such as the sudden opening or closing of the primary circuit.

2. *High Voltage Transformer with No Auxiliary Rectifying Device*

Twelve new "Universal" type tubes were taken just as they came from the factory and were operated at 140,000 volts (max.) on an interrupterless machine with resistance control. They all ran smoothly. The rectifying switch was then stopped and the tubes were operated directly from the transformer on alternating current, care being taken to use a very low milliamperage so that the focal spot should not become too hot and that the "inverse" should not become appreciably higher than the "useful" voltage.

Under these conditions ten of these tubes ran nicely on alternating current. The other two suffered a rapid impairment of vacuum, as indicated by a vivid green

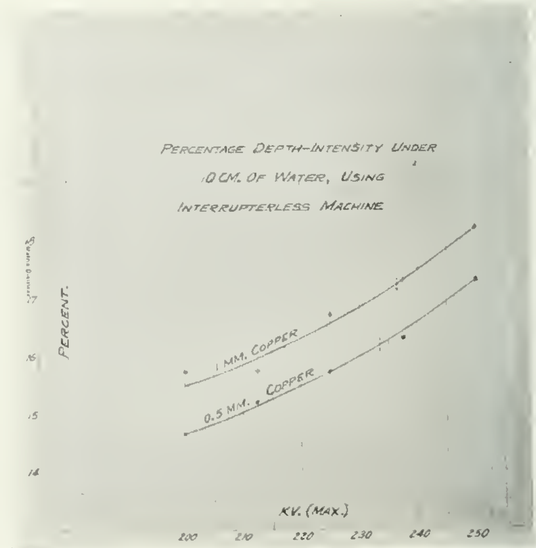

Fig. 12

fluorescence throughout the bulb, and with continued operation would certainly have punctured. Upon again operating these two tubes on the mechanical rectifier, the vacuum cleared right up and they ran as smoothly as before. This cycle of operations was repeated with both of these tubes with exactly the same result as before.

This and numerous other experiments which have been tried indicate that some "Universal" type tubes will operate at a higher voltage on rectified current than they will when they are forced to rectify their own current.

The operation of tubes directly from a transformer without auxiliary rectifying device is further complicated by the fact that for satisfactory operation, this method calls for auto-transformer rather than resistance control as otherwise the "inverse" voltage becomes appreciably higher than the "useful." We have already seen that the use of auto-transformer control is harder on tubes.

Later experiments have shown that "high voltage" tubes which may operate in an experimental way at as much as 300,000 volts with rectified current will, as a rule, not run smoothly at more than 200,000 volts when rectifying their own current. The tube rectifying its own current at 200,000 volts will, furthermore, not inspire the same feeling of confidence as when operating from rectified current at 300,000 volts.

3. *Induction Coil*

A given "high voltage" tube may stand as high voltage on the induction coil[5] as it does on the interrupterless machine, but, the chances are against it, as shown by the statistics of Table XVI.

Of the tubes which operate satisfactorily on the interrupterless machine at the voltage shown in the first column of Table XVI, the percentage which operate as high as this on the coil is given by the second column.

TABLE XVI

Voltage	Percentage
200,000	54
250,000	21
300,000	11

These results have been obtained with "high voltage" tubes as they come from the factory.

[5] Operated with a mercury-turbine interrupter with gas dielectric.

The behavior of a few of the individual tubes is indicated in Table XVII.

Experience has shown that the numbers in the table are really characteristic of the tubes and that the differences indicated are very consistent. It is quite striking to find some tubes operating smoothly at 300,000 volts on the interrupterless machine and carrying less than 140,000 volts on the coil.

The underlying causes call for further study.

TABLE XVII
MAXIMUM VOLTAGE FOR QUIET OPERATION

Tube	Interrupterless Machine	Induction Coil
A	300,000	225,000
B	300,000	140,000
C	300,000	140,000
D	300,000	140,000
E	300,000	250,000
F	295,000	140,000
G	300,000	210,000
H	300,000	250,000

4. *Constant-Potential Continuous-Current Machine*

Tubes operate very smoothly on the constant-potential continuous-current machine, described in Section D.

Fifteen tubes were tested on this machine with a current of 5 ma. and then on the interrupterless machine at currents of 2 and 5 ma. The maximum voltages at which the different tubes ran quietly are given in Table XVIII. A + sign after the

TABLE XVIII
MAXIMUM VOLTAGE FOR QUIET OPERATION

Tube No.	Constant-potential Continuous-current Machine 5 Ma.	Interrupterless Machine 2 Ma.	Interrupterless Machine 5 Ma.
268	200,000+	245,000+	....
247	200,000+	245,000+	....
140	200,000+	255,000	250,000
129	200,000+	280,000	250,000+
143	200,000+	255,000	225,000
130	200,000+	235,000	235,000
116	200,000+	255,000	225,000
137	200,000+	255,000+	210,000
125	200,000+	295,000	250,000
153	180,000	210,000	205,000
152	180,000	210,000	210,000
136	180,000−	255,000	180,000
157	150,000	220,000+	250,000
146	130,000−	210,000	180,000
141	115,000−	230,000	110,000

number indicates that the tube could have supported more voltage, and a — sign indicates that its behavior was not quite satisfactory at the given voltage.

Bearing in mind that, according to Part 4 of Section F, the constant-potential machine at 200,000 volts gives the same penetration through 10 cm. of water as the interrupterless machine at 235,000 volts, it may be said that, for the same end result, as measured in this way, the present tubes seem to operate as well on the constant-potential machine as on the interrupterless machine.

H. X-Ray Output of Different Tubes Operating Under the Same Electrical Condition

1. *Comparison of X-Ray Output of 20 "High Voltage" Tubes, Operating on the Interrupterless Machine at 200,000 Volts (Max.) and 2 Milliamperes*

Twenty high voltage tubes were taken just as they came from the factory and were in turn operated at a definite distance in front of an ionization chamber.

Care was taken to choose such a distance and such a diaphragm opening that radiations from the entire focal spot should reach the ionization chamber, even in the case of the largest focal spot and, in addition to this, that there should be sufficient margin to make the proper location of the tube an easy matter. The distance and diaphragm opening were also so chosen that no direct radiation should impinge upon either of the electrodes of the ionization chamber.

The ionization currents were measured with a gold-leaf electroscope and stopwatch, the timed excursion of the leaf always being the same.

The results are given in Table XIX. The times in the second column are obtained with no filter, those in the third column, A, with a filter consisting of 0.2 mm. of copper and those in the fourth column, B, with a copper filter 1 mm. thick. The last column gives the calculated ratio of A to B, which may be taken as a relative measure of the penetrating power of the radiations.

The averages of the various columns are found below and, on the last horizontal line, the average percentage deviation of the single observations from the mean.

Table XIX

200,000 volts (max.)—2 ma.

Tube No.	Time (Sec.) No Filter	A Time (Sec.) 0.2 mm. Copper	B Time (Sec.) 1.0 mm. Copper	A/B
132	8.8	42.4	113.1	0.375
161	14.8	44.0	113.7	0.387
146	10.3	43.1	114.8	0.375
130	10.1	42.8	115.0	0.372
129	10.7	42.4	113.8	0.373
125	10.7	43.3	112.8	0.384
140	12.3	42.0	113.1	0.371
137	9.0	42.4	111.4	0.381
136	11.0	43.4	112.7	0.385
147	7.9	42.3	111.9	0.378
131	10.8	43.9	112.3	0.392
152	11.0	42.4	111.7	0.380
123	10.8	42.0	110.3	0.381
153	9.7	43.4	114.7	0.378
148	9.7	42.3	111.6	0.378
111	10.0	43.3	115.6	0.375
118	9.0	42.6	110.7	0.384
116	9.7	42.3	111.3	0.380
155	13.6	42.8	108.2	0.392
157	10.7	42.4	109.9	0.386
Average	10.53	42.77	112.43	0.3803
a. d. %	9.6	1.25	1.33	1.29

Inspection of the results shows that if no filter is used different tubes vary appreciably in their x-ray output. This is to be accounted for by differences in the wall thickness of the different bulbs.

Where a filter equivalent to as much as 0.2 mm. of copper is used, the effect of variations in bulb thickness becomes negligible; the observed differences in the output of the various tubes is but little more than the experimental error of the observations. Under such a filter then, the quantity and penetrating power of the radiations coming from the twenty tubes showed an average variation from the mean of only a little more than 1 per cent.

It is also interesting to compare the extremes in the series. This is done in Table XX. Used without a filter, tubes 147 and 161 show a difference in ionization current of 87.5 per cent. With the filters, the extreme differences are relatively small.

Table xx
extremes in the set of 20 tubes

Tube No.	Time in Seconds		
	No Filter	0.2 mm. Copper	1.0 mm. Copper
147	7.9	....	.
161	14.8	.	...
161	....	41.81	...
140	....	39.50	....
111	....	.....	107.6
155	....	.....	104.4
Difference in %	87.5	5.5	3.1

2. *Comparsion of X-Ray Output of 7 "Broad" Focus "Universal" Type Tubes, Operating on Interrupterless Machine at 127,000 Volts (Max.) and 5 ma.*

The effect of varying bulb thickness should be greater at lower voltages and it seemed interesting to compare some "Universal" type tubes under the conditions in which they are used in therapy. As both "medium" and "broad" focus tubes have been employed, a set of each was studied.

A voltage of 127,000 volts (max.) was used, corresponding to about a 9 inch spark between the ordinary blunt points. This was obtained from the interrupterless machine described in Section C.

Aluminum filters of 3 and 6 mm. thickness were employed.

Table xxi
"broad" focus "universal" type tubes
127,000 volts (max.) 5 ma.

Tube No.	Time (Seconds)		
	No Filter	3 mm. Aluminum Filter	6 mm. Aluminum Filter
37402	7.75	33.4	62.4
22727	9.71	35.1	63.5
37396	7.60	33.2	61.6
37400	9.55	36.0	65.7
37452	8.33	34.5	63.2
37392	7.30	32.1	59.7
37393	7.25	32.3	60.8
Average.......	8.21	33.8	62.4
a. d. %........	10.2	3.55	2.35

The results are given in Tables xxi and xxii.

Table xxii
"medium" focus "universal" type tubes
127,000 volts (max.)—5 ma.

Tube No.	Time (Seconds)		
	No Filter	3 mm. Aluminum Filter	6 mm. Aluminum Filter
37391	7.05	33.1	61.3
37389	6.93	32.6	60.4
37390	8.08	34.2	59.2
22376	5.83	31.9	60.3
37387	7.50	32.8	62.0
37376	7.00	33.5	62.9
37394	8.25	34.9	64.7
36976	7.30	32.6	60.6
36977	7.65	35.1	65.1
36904	7.45	33.6	62.2
Average.......	7.40	33.4	61.9
a. d. %........	6.5	2.48	2.44

As was to be expected, the "Universal" type tubes, operated at this lower voltage, show greater differences among themselves than did the "High Voltage" tubes operated at 200,000 volts.

As before, the differences between tubes are much less when the intensity measurements are made under a filter.

The results indicate that, as a class, there is no difference in output between the "broad" and the "medium" focus tubes. For this reason they are all classed together for a study of the extremes. See Table xxiii.

Table xxiii
extremes in 17 tubes

Tube No.	Time (Seconds)		
	No Filter	3 mm. Aluminum	6 mm. Aluminum
22727	9.71	....	....
22376	5.83	....	....
37400	.....	36.0	....
22376	.....	31.9	....
37400	.....	....	65.7
37390	.....	....	59.2
Difference in %	66.5	12.9	11.0

I. Loss of X-Ray Intensity From a Heavy Tungsten Deposit on Bulb

When the focal spot of an x-ray tube is overloaded, metal vaporizes from it and condenses on the anterior hemisphere of the bulb. The question has often been raised as to whether such a tungsten deposit formed in this way can ever attain sufficient thickness to appreciably reduce the efficiency of the tube.

To investigate this matter the following experiment was tried: From the tubes which had been returned to the tube factory for repairs, the one was selected which showed the thickest tungsten deposit on the bulb. A piece of glass having an area of 9.6 square centimeters was then cut from the region showing the maximum thickness of deposit.

This piece of glass, with its tungsten deposit was then placed before the ionization chamber and, with an x-ray tube operating at 127,000 volts, and 5 ma., the time of discharge of the electroscope was determined with and without filters.

The piece of glass with its deposit was then weighed. After this the tungsten deposit was removed chemically and the piece was again weighed. The difference between the two weighings of course gives the weight of the tungsten layer and from the measured area of the surface in question and the known density of tungsten the thickness of the deposit was calculated.

The glass piece freed from its tungsten deposit was then again placed before the ionization chamber and the previous measurements repeated.

It was found that the glass alone reduced the x-ray intensity by the same amount as a filter of 1 mm. of aluminum.

The results are given in Table XXIV.

Table XXIV

Millimeters Aluminum Filter	Time (Sec.) Glass + Tungsten	Time (Sec.) After Removal of Tungsten Deposit	X-ray Intensity $\frac{1000}{T}$		Reduction %
			With Tungsten	Without Tungsten	
0	14.35	12.95	69.7	77.2	9.7
2	30.45	28.82	32.9	34.7	5.2
5	58.8	55.7	17.01	17.95	5.2

The last column of the table shows that when no external filter was used the tungsten deposit reduced the x-ray intensity, as measured by ionization current, by 9.7 per cent. It should be borne in mind, however, that the glass was itself equivalent to a 1 mm. aluminum filter. If the support glass could have been removed the percentage reduction in intensity due to the tungsten deposit alone would have been considerably greater.

The 2 mm. aluminum filter taken together with the piece of bulb glass was equivalent to 3 mm. of aluminum, and with this the tungsten deposit caused a reduction in intensity of 5.2 per cent. The 5 mm. of aluminum, together with the glass was equivalent to 6 mm. of aluminum and, with this filtration also the reduction of intensity due to the tungsten deposit was 5.2 per cent.

The data relating to the thickness of the tungsten deposit were as follows:

Area of deposit (sq. cm.)........	9.6
Weight of glass plus deposit (grams)..................	2.4817
Weight of glass................	2.4620
Weight of tungsten, by difference	0.0197
Specific gravity of W	19.3
Thickness, calculated (in mm.)..	0.00106

The experiment just described could have been tried in more simple and direct fashion by comparing the output of the blackened tube with that of a new tube, had it not been for two obstacles. In the first place the tube with its heavy metal deposit would not operate satisfactorily at a voltage as high as 127,000. In the second place, the target was deeply pitted and this, as will be shown in Section J, of itself exerts a much more marked effect on efficiency than does the metal deposit on the bulb.

The measured loss in efficiency due to the heavy deposit was relatively small, only 5.2 per cent under 3 mm. of aluminum, and it seems safe to predict that a "Universal" type of tube, operating at a voltage as high as 127,000 will never show even as much loss in efficiency as this, due to tungsten deposit, for it will doubtless puncture before any such thickness of deposit has been attained.

There is, furthermore, no reason why a broad focus tube used for therapeutic purposes should have any appreciable tungsten deposit on the bulb. Such a deposit would come only from abuse in diagnostic work and would never happen if the tube were used solely for therapy.

J. Loss of Efficiency from the Bad Pitting of a Target

X-rays are produced by the impact upon the target of cathode rays, the path of which, in the "Universal" and "Radiator" types of tube, lies essentially in the axis of the tube. Most work is done with the central beam of *x*-rays which is, in these tubes, essentially perpendicular to the cathode ray stream.

If the focal spot were to lie at the bottom of a deep cylindrical pit whose axis was parallel to the tube axis it is obvious that the passage of the cathode rays to the bottom of the pit would be unimpeded but that the *x*-rays emerging at right angles to this direction would have to pass through a considerable thickness of the target material.

In the case just considered, the resultant efficiency of *x*-ray production in the central beam, expressed in terms of that of a normal tube, might be extremely low.

Fig. 13

Although no two pitted targets will be alike, it seemed worth while to study the worst case of pitting which could be found. A selection was made from a lot of used tubes which had been returned to the factory. The tube in question had evidently been heavily overloaded in radiographic work. The condition of the focal spot may be seen from Figure 13. The main cavity was 2.5 mm. deep. The tungsten which had left the focal spot had been deposited on the bulb where it would, of course, exert a certain amount of filtering action. For this reason the target was removed from the old tube and put into a fresh bulb. It was, of course, necessary that the cathode should be so placed as to make the new focal spot register with the old one. By the method of trial and error this was finally accomplished.

The *x*-ray distribution in different directions from this tube is given in Parts 3 and 4 of Section K; its efficiency in two directions, in terms of a tube of like design having a smooth unpitted focal spot, is contained in Table xxv. The two tubes were operated at 127,000 volts (max.) and 3 ma., on the interrupterless machine.

Table xxv

Efficiency of tube with badly pitted target in terms of that of normal tube, both operating at 127,000 volts (max.) and 3 ma.

Filter, Millimeters of Aluminum	Efficiency in Per Cent	
	Central Beam	40° away from Central Beam, Towards Cathode
0	42	69
3	70	95
6	78	103

Too much attention should not be given to the value of efficiency where no filter was used, as no attempt was made to use bulbs of the same wall thickness.

It is pleasant to find that, even in this extremely bad case of pitting, the efficiency in the central beam is, with the 3 mm. filters, as high as 70 per cent. Where a tube having a large focal spot is used for therapy only, there will be no pitting of the focal spot and the effect of slight roughening and of thin cracks whose area is small compared with the total area of the focal spot, will obviously be very small.

The effect of pitting in lowering efficiency could be reduced by using rays coming from a direction other than that of the central beam, as, for example, in the other direction referred to in the table. This practice seems undesirable, however, as it tends to bring the cathode end of the tube too close to the patient.

K. Distribution of X-Ray Intensity in Different Directions from a 45-Degree Tungsten Target

If dosage is to be determined in therapy from the measurement of the current and voltage supplied to the tube, taken in conjunction with the factors of time, distance, filter thickness and port of entry, it becomes necessary to know something about the distribution of the *x*-ray intensity radiating in different directions from the focal spot.

It has been customary to work with the central beam of rays and there are good reasons for this practice, but, it is, of course, desirable to know, from actual experiment, how much difference in intensity will be caused by a given inaccuracy in the setting of the tube.

For the following measurements the apparatus was arranged as in Figure 11, with the exception that the water-cell shown there was, of course, not used. The tube was placed with the axis horizontal, and was so mounted that it could be rotated about its own axis and about a vertical axis passing through the center of the focal spot. The degree of rotation about each axis was indicated by a graduated circle.

The tube and its holding device were so adjusted, by sighting through the ionization chamber and diaphragm system, and by the help of a cathetometer, that the focal spot was properly located with respect to the ionization chamber and that the two axes of rotation passed through the center of the focal spot.

In all cases a solid tungsten target was used, having the shape and size employed in the "Universal" type of tube.

The diaphragm next to the tube was large enough to admit to the ionization chamber the radiation from the whole working face and nearly the whole head of the target. This means then that not only the rays from the focal spot but also the radiation from the balance of that side of the head of the target was included in the measurements. This was intentional, for this same condition pertains in the ordinary use of the tube.

The intensity was determined by measuring the charging rate of the Bumstead electroscope.

1. *Distribution Around Girdle of Tube, with 200,000 Volts (Max.), 2 Milliamperes and Interrupterless Machine*

Table XXVI gives the distribution of intensity around the girdle of a High Voltage tube (No. 154) operating on the interrupterless machine at 200,000 volts (max.) and 2 ma.

The interpretation of the first column in the table will be clear from the direction diagram in Figure 14. This shows an end view of the target. The focal spot is indicated by the small circular stippled area and the direction of the central ray is taken as zero degrees.

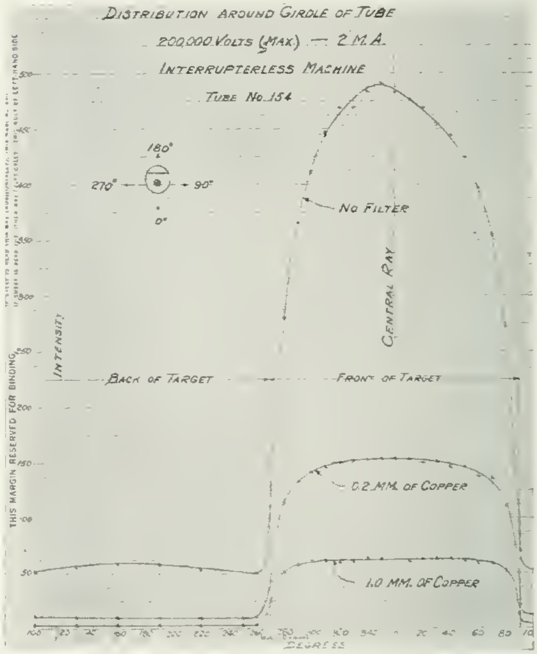

Fig. 14

The second, third and fourth columns give the *x*-ray intensity as measured by the ionization current with no filter, 0.2 mm. and 1.0 mm. of copper. The last column gives the quotients obtained by dividing the intensities under 1 mm. of copper by the corresponding values for 0.2 mm. of copper. The values of the last column may then be taken as a rough qualitative measure of the penetrating power of the radiations in the different directions. It is seen that the penetrating power of the radiations coming from the back of the target is less than that of those coming from the front. It is also seen that for the radiations coming from the front, the penetrating power increases as glancing incidence is approached on both sides of the central beam. This last

Table XXVI

DISTRIBUTION OF INTENSITY AROUND GIRDLE OF TUBE, WITH 200,000 VOLTS (MAX.), 2 MA. AND AN INTERRUPTERLESS MACHINE—TUBE 154

Direction (Degrees)	No Filter	A 0.2 Mm. Copper	B 1.0 Mm. Copper	B/A
90	71.9	23.7	14.08	0.595
80	273.0	111.8	52.7	0.471
70	355.0	135.8	59.3	0.437
60	397.0	137.9	60.2	0.437
50	424.0	147.0	62.5	0.425
40	444.0	147.0	62.8	0.427
30	455.0	151.1	63.6	0.419
20	469.0	150.1	62.6	0.417
10	476.0	154.1	61.6	0.400
0	483.0	154.1	62.6	0.405
350	490.0	154.1	62.8	0.407
340	483.0	152.3	63.9	0.419
330	469.0	152.3	60.8	0.399
320	469.0	150.1	60.2	0.401
310	447.0	146.0	62.2	0.426
300	412.0	142.0	61.5	0.433
290	365.0	135.8	57.3	0.422
280	280.0	115.8	52.4	0.453
270	110.6	43.4	25.6	0.590
260	49.7	10.20	3.08	0.302
250	51.0	9.29	3.12	0.336
220	54.3	10.52	3.11	0.295
190	58.8	11.31	3.15	0.278
160	59.9	11.21	3.33	0.297
130	56.9	11.01	3.07	0.278
100	52.2	11.13	3.55	0.318
90	77.0	18.12	.....	.....

Table XXVII

DISTRIBUTION OF INTENSITY IN PLANE CONTAINING TUBE AXIS AND PERPENDICULAR TO TARGET FACE—200,000 VOLTS (MAX.)—2 MA.—INTERRUPTERLESS MACHINE—TUBE 154

Direction (Degrees)	No Filter	A 0.2 Mm. Copper	B 1.0 Mm. Copper	B/A
−50	55.4	13.95	4.07	0.291
−40	166.1	83.9	41.6	0.499
−30	372.0	144.3	65.0	0.450
−20	452.0	155.0	66.7	0.431
−10	495.0	154.0	65.8	0.427
0	486.0	151.3	62.8	0.415
10	451.0	146.0	59.5	0.407
20	412.0	140.4	58.0	0.413
30	379.0	138.0	56.2	0.407
40	368.0	137.2	55.3	0.403
50	376.0	131.5	53.8	0.409
60	400.0	132.1	54.8	0.414
70	373.0	116.4	51.3	0.441
110	300.0	119.8	54.3	0.453
120	269.0	116.4	51.3	0.441
130	218.0	104.0	47.6	0.457
140	39.9	11.17	3.36	0.303
150	.....	10.64	2.81	0.264
160	44.7	10.32		
170	65.7	9.89		

effect is doubtless due to the fact that as glancing incidence is approached, the x-rays as they emerge from the target metal have to pass through a greater and greater thickness of tungsten which, of course, exerts a filtering action.

The x-ray intensity values are plotted in Figure 14.

It will be seen that, with no filter, the intensity is greatest in a direction close to that of the central ray.

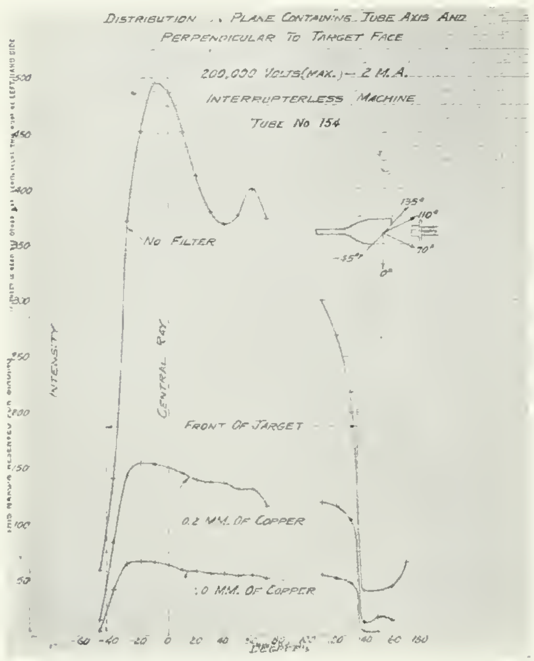

Fig. 15

The distribution curve is appreciably flattened by the use of the filters. On going, for example, from 350° to 320° the intensity falls off with no filter 5.1 per cent, with 0.2 mm. of copper 2.1 per cent and with 1 mm. of copper there is no measurable change.

At the back of the target the intensity reaches a maximum at a point close to 180° where it should be a maximum from geometrical considerations.

The maximum intensity from the back of the target with no filter is 12.2 per cent of the maximum from the front of the target; with 0.2 mm. of copper filter it is 7.4 per cent and with 1 mm. of copper filter it is 5.2 per cent. The average penetrating power of the radiations coming from the back of the target is then seen to be less than that of the radiations coming from the front.

2. *Distribution in Plane Containing Tube Axis and Perpendicular to Target Face, with 200,000 Volts (Max.), 2 ma., and Interrupterless Machine*

The data from this experiment, obtained by first placing the tube so that the central ray was passing into the ionization chamber and then rotating the tube about the

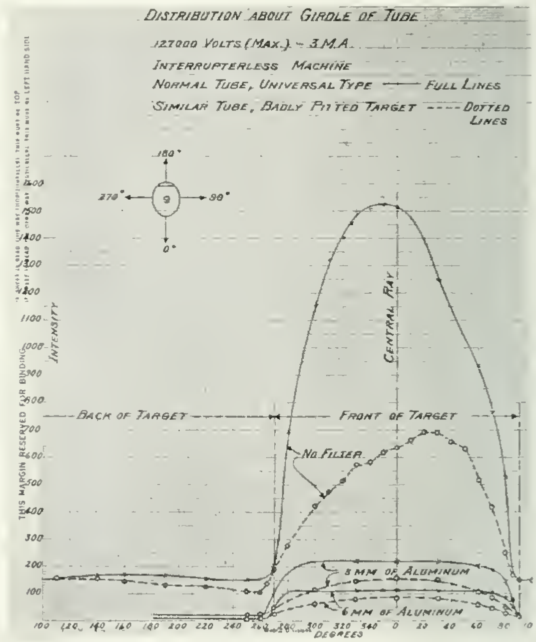

Fig. 16

vertical axis, are given in Table XXVII and plotted in Figure 15.

The significance of the numbers of the first column of the table will be made clear by reference to the direction diagram of Figure 15. The other columns have the same significance as the corresponding columns of the preceding table.

From 70 to 110 degrees there is a gap which cannot be filled in, owing to the presence of the cathode structure.

From the values of $\frac{B}{A}$ it is seen that the rays are least penetrating in a direction normal to the face of the target and that the penetrating power increases on both sides of this direction as glancing incidence is approached.

It will be noted that, with no filter, the intensity maximum in this plane lies about 10 degrees away from the central beam towards the heel of the target and, with 0.2 mm. and 1.0 mm. of copper filter, about 20° from the central beam.

The direction of maximum intensity appears then to make an acute angle with the cathode rays. This might be accounted for by the assumption of a Doppler effect. It seems more probable, however, that it is mainly due to the following circumstances: In the hot cathode type of tube and with a target having a 45° face, the cathode ray stream does not remain parallel to the axis of the tube but is electrostatically deflected towards the toe of the target. It may very well be then that the intensity maximum lies in a direction perpendicular to the cathode-rays at the point of their impact with the target face, as suggested by the simple theory of polarization without the Doppler effect.

As in the equatorial plane, the intensity curves are somewhat flattened by filtration.

3. *Distribution Around Girdle of Tube, with 127,000 Volts (Max.), 3 Milliamperes, and Interrupterless Machine, Using "Universal" Tube No. 22376 and a Similar Tube Having a Badly Pitted Target*

Tube 22376 was an ordinary "Universal" type of tube with a "medium" focus. The other tube was the one referred to in Section J. It was entirely similar in design but had the badly pitted target shown in Figure 13.

TABLE XXVIII

DISTRIBUTION AROUND GIRDLE OF TUBE, WITH 127,000 VOLTS (MAX.), 3 MA. AND INTERRUPTERLESS MACHINE

Direction (Degrees)	Tube 22376				Similar Tube Badly Pitted Target			
	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	B/A	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	B/A
0	1520.0	216.0	111.3	0.51	636.0	155.5	82.5	0.53
350	1526.0	.....	.....	..	618.0	.....	.....	....
340	1505.0	...	.....	..	582.0	.	..	...
330	1500.0	221.0	111.7	0.51	572.0	142.8	78.7	0.55
320	1401.0	....	.....	....	515.0	....	.....	....
310	1320.0	.	..	...	477.0			..
300	1153.0	217.0	111.0	0.51	422.0	114.0	61.0	0.53
280	690.0	....	.....	....	278.0	....	.....	....
270	209.0	101.3	55.8	0.55	191.7	48.3	25.7	0.53
265	.....	.....	10.46	....	134.8	.....	.....	....
260	160.0	23.1	10.30	0.45	105.7	20.8	10.30	0.50
250	155.0	22.3	....	....	107.4	19.4	9.45	0.50
220	157.0	.....	...	....	124.6	.....	.....	....
190	168.5	...		...	129.7	.	...	...
180	......	23.1	9.95	0.43	.....	.	...	...
170	.....	...	.	...	.	22.6	11.31	0.50
160	167.4	...		...	142.3	.....	.....	....
140	169.0	.		..	154.0	.....	...	....
110	152.0	.		..	154.0	....	...	....
100	151.5			.	148.7	...	....	....
90	148.3	21.5	10.23	0.48	148.7	21.8	10.86	0.50
85	.....	71.5	52.2	0.73	164.0	.....	.....	....
80	529.0	147.4	84.4	0.57	248.0	48.2	25.2	0.52
70	767.0	186.5	100.5	0.54	417.0	80.9	43.3	0.53
60	936.0	201.0	106.0	0.53	516.0	101.6	55.8	0.55
50	1046.0	.....	.....	....	630.0	.....	.....	....
40	1160.0	.....	.....	....	654.0	.....	...	....
30	1250.0	210.0	111.0	0.51	690.0	148.2	80.0	0.54
20	1329.0	.....	.....	....	690.0	.....	.....	....
10	1382.0	.....	.....	....	662.0	.....	.	....

The numerical results are given in Table XXVIII and are plotted in Figure 16.

The general conclusions to be drawn from the data on the normal tube are the same at 127,000 volts as they were at 200,000 volts.

With the normal tube, the maximum intensity from the back of the target with

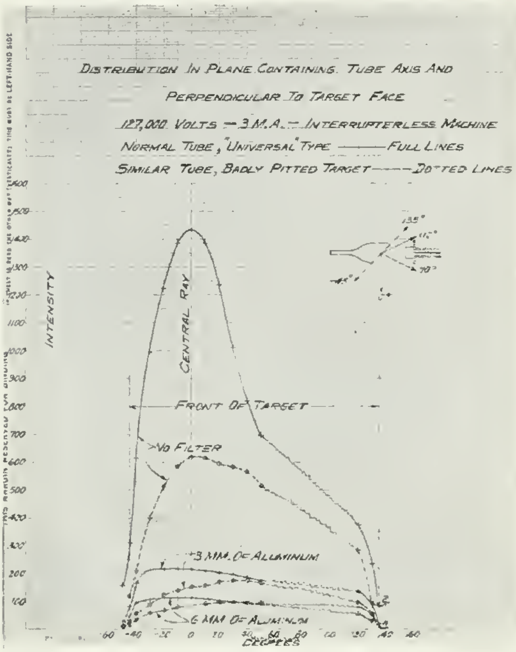

FIG. 17

no filter is 11.1 per cent of the maximum from the front of the target; with 3 mm. of aluminum filter it is 10.4 per cent and with 6 mm. of aluminum filter it is 9.0 per cent.

Apart from its effect of reducing intensity, bad pitting is clearly a disadvantage, for as the curves show, in the cases where filters were used, it greatly reduces the angle through which the intensity is essentially constant.

4. *Distribution in Plane Containing Tube Axis and Perpendicular to Target Face, with 117,000 Volts (Max.) 3 Milliamperes, and Interrupterless Machine, using "Universal" Tube No. 22,376 and a Similar Tube Having a Badly Pitted Target*

The results are given in Table XXIX and plotted in Figure 17.

In the case of the normal tube the intensity curves are markedly flattened by the use of the filters.

The intensity curves for the badly pitted target approach those of the normal tube as the direction approximates that of the cathode ray stream.

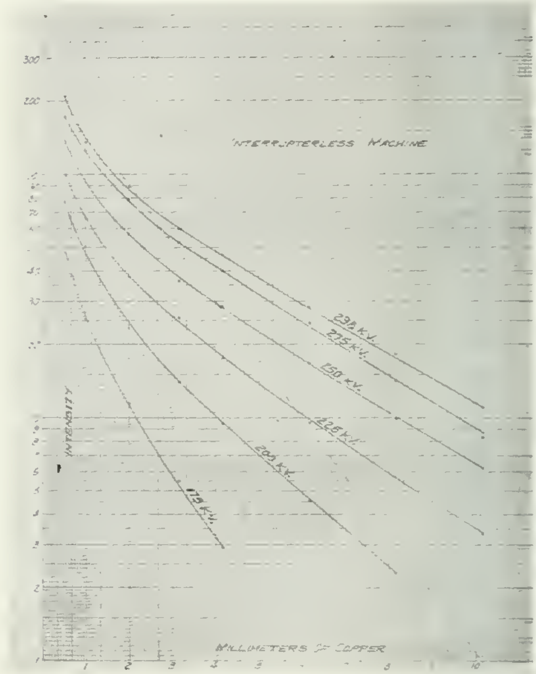

FIG. 18

L. ABSORPTION CURVES WITH COPPER FILTERS FOR VOLTAGES UP TO 298 KV. (MAX.)

The absorption data of Table XXX were obtained with high voltage tube V117, operating on the interrupterless machine described in Section B with a current of 2 ma. The apparatus was arranged as in Fig. 4. The ionization current was measured by means of a Bumstead electroscope and stop-watch and the x-ray intensity is assumed to be inversely proportional to the time, T, required for the image of the gold leaf to travel from 2 to 10 on the scale of the reading telescope. The time varied from 4 to 400 seconds.

The voltage is expressed in kilovolts (max.).

TABLE XXIX

DISTRIBUTION IN PLANE CONTAINING TUBE AXIS AND PERPENDICULAR TO TARGET FACE, 127,000 VOLTS (MAX.) 3 MA.—INTERRUPTERLESS MACHINE

Direction (Degrees)	Tube 22376				Similar Tube Badly Pitted Target			
	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	$\frac{B}{A}$	No Filter	A 3 Mm. Aluminum	B 6 Mm. Aluminum	$\frac{B}{A}$
0	1433 0	219.0	111.7	0.51	614 0	150 7	.....	...
−10	1388.0	217.0	111.4	0.51	582.0	138 8	75.1	0.54
−20	1223.0	216.0	112.7	0.52	511.0	122.0	64.8	0.53
−30	995.0	212.0	110.5	0.52	400.0	98.5	54.8	0.56
−40	615.0	164.2	95.0	0.58	210.0	52.7	30 0	0 57
−45	310.0	80.1	44.5	0.56	117.0	26.2	14 4	0.55
−50	154.0	27.6	12.90	0.47	.....	.....	10 47	....
10	1385.0	211.0	106.0	0.50	618.0	158.1	89 6	0 57
20	1235.0	204.0	102.0	0.50	596.0	170.4	94.7	0 56
30	1010.0	194.5	98.8	0.51	582.0	174.0	97.5	0.56
40	820 0	183.7	93.8	0.51	568.0	175.2	94.7	0.54
50	694.0	176.0	89 3	0.51	513.0	167 9	93 3	0.56
120	374.0	138.2	79 0	0.58	283.0	93 1	54.0	0.58
130	234.0	90.0	54.1	0.60	92.5	52 0	29 6	0.57
140	87.0	18.75	9.10	0.48	111.1	22 5	10.82	0.48
150	96.0	19.25	9.19	0.48	117.0	.....	.....	....

The data of Table XXX are plotted in Figure 18.

It is interesting to note that the portion of the curves lying to the right of the dotted line is essentially straight and that those straight portions are all essentially parallel to one another.

TABLE XXX

INTERRUPTERLESS MACHINE—TUBE V117—2 MA.

Millimeters of Copper	Intensity $= \frac{1}{T} \times 1000$					
	175 Kv.	200 Kv.	225 Kv.	250 Kv.	275 Kv.	298 Kv.
0.098	125.0	178.5	.....	.....	.....	.....
0.196	88.0	137.0	.....	.....	.....	.....
0.294	73.0	105.2	.....	.....	.....	.....
0.49	48.1	77.7	100.0	139.0	173.0	209.0
0.69	36.0	64.1	.....	.....	.....	.....
0.98	25.2	50.5	66.7	92.8	125.0	135.0
1.48	16.67	33.6	.....	.....	.....	.....
1.97	11.22	23.4	38.0	56.2	78.2	90.0
3.15	5.45	13.80	25.2	36.2	52.7	60.3
4.19	2.91	9.36	17.63	28.7	40.0	46.8
6.27	.....	4.57	9.52	16.6	24.6	28.5
8.35	.....	2.28	5.65	9.88	14.4	18.2
10.43	.....	.....	3.44	6.23	8.28	11.0

In a general way, the quality of the radiation is indicated by the slope of these absorption curves and, in so far as this is true, the curves show that increasing the thickness of the copper filter beyond a certain point does not essentially change the quality of the radiations. They also show that, with sufficient copper filtration the quality, as indicated in this manner, is essentially the same through the range from 225 to 298 kv. They show that the amount of filtration required to get to the straight portion of the curve decreases rapidly with the voltage. Where high intensity of penetrating radiation is desired, there is, in this last consideration, a strong argument in favor of the use of high voltage. With a 3 mm. copper filter at 298 kv., for example, the penetration, as indicated by the slope of the absorption curve is about the same as with a 6 mm. copper filter at 225 kv. Under these conditions the intensity is seven times as great at the higher voltage. As the milliamperage is the same in both cases, this seven fold increase in x-ray intensity has been obtained with an increase of only 32 per cent in the energy supplied to the tube.

The lowest value of the average linear absorption coefficient indicated is 2.31.

This, according to the work of Richtmyer[6], would correspond to a wave-length of 0.072 A°.

M. General Summary of Results

1. A design of *x*-ray tube is shown in Figure 1 which has served for experimental work up to 300,000 volts (max.).

2. This type of tube can apparently best be operated from either a high voltage transformer with mechanical rectifier and resistance control, or from a suitable source of high voltage direct current. (The *x*-ray output and tube behavior with other high tension systems are also discussed.)

3. An experimental interrupterless machine is described which has operated satisfactorily, even in humid summer weather, at voltages up to 300,000.

4. A constant-potential continuous-current machine, for voltages up to 200,000, is described.

5. As measured by the penetration through 10 cm. of water, 200 kv. direct-current excitation is equivalent to 235 kv. (max.) of alternating current excitation. At these voltages the *x*-ray intensities are the same for equal milliamperage.

6. For the medical application, it looks much safer to judge of *x*-ray intensity and quality, from sphere-gap and milliamperemeter measurements of the electrical energy put into the tube rather than from direct measurements made with an ionization chamber.

7. Even when such outwardly different high voltage sources as the transformer with mechanical rectifier on the one hand and the induction coil on the other, are used, the resulting radiations differ in quantity and quality by scarcely more than the experimental error, when the energy input is controlled by a standard sphere-gap and a milliamperemeter.

8. The voltage at the terminals of the *x*-ray tube should be controlled by a voltmeter connected across the low tension side of the high voltage generator, and the low tension voltage required to produce the desired tube voltage should be frequently determined by means of a standard sphere-gap connected in parallel with the tube. This calibration must be made at the exact milliamperage which is to be subsequently employed.

9. For accurate duplication of results, it is desirable that the design of the high tension source shall be such that, for a given high tension voltage, the required primary voltage will not change rapidly with the milliamperage passing through the tube.

10. For the measurement of tube current in therapy, two milliamperemeters should always be used in series with the tube, and they should be occasionally compared with a standard meter.

11. Where an interrupterless machine with resistance control is employed, and the tube filament is heated from the same source of current supply, the milliamperage should be held very constant by a suitable stabilizer, as otherwise line voltage fluctuations will cause marked fluctuations in the high tension voltage, owing to the presence of the resistance in the low tension circuit.

12. At 200,000 volts (max.), with as much as 0.2 mm. of copper filter, different "high voltage" tubes differ but little in output, the average deviation from the mean in a series of twenty tubes being only 1¼ per cent.

13. At 127,000 volts (max.), with as much as 3 mm. of aluminum filter, different "Universal" type tubes differ but little in output, the average deviation from the mean in a series of seventeen tubes being about 3 per cent.

14. Where no filter is used, tubes differ markedly in output, owing to differences in bulb thickness. This would be of no importance in connection with plate density in diagnostic work, in which the patient's body is interposed between tube and plate or tube and screen. It might, however, be quite important in skin therapy with unfiltered radiation.

15. For the therapeutic application, the effect of tungsten deposit on the bulb can apparently be neglected.

16. Bad pitting of the target appreciably reduces the efficiency of a tube in the direction of the central beam. For this reason, therapy tubes should not be used

[6] F. K. Richtmyer, *Phys. Rev.*, N. S., July, 1921, Vol. xviii, No. 1, p. 21.

for radiographic work, in which pitting might occur.

17. Curves are given showing the distribution of x-ray intensity in different directions around the focal spot, at voltages of 127,000 and 200,000.

18. The intensity maximum does not lie in the "central beam," but from 10 to 20 degrees away from this towards the heel of the target. (This is probably due, in the main, to the fact that the cathode ray stream does not hold to the axis of the tube, but is electrostatically deflected towards the toe of the target.)

19. In the equatorial plane (about the girdle of the tube), the intensity is essentially constant through an angle of about 100 degrees.

20. The distribution curves for a badly pitted target are also given.

21. Absorption curves are given for copper, extending up to 298 kv. max. They show the attractiveness of high voltage excitation if a considerable intensity of very penetrating radiation is required.

The lowest value of the average linear absorption coefficient indicated is 2.31. This corresponds to a wave-length of 0.072 Å.

THE ULTRAVIOLET RAY IN THE TREATMENT OF ROENTGEN RAY TELANGIECTASIS

BY H. H. HAZEN, M.D.

Professor of Dermatology, Georgetown University, and Howard University

WASHINGTON, D. C.

THE present tendency to use the roentgen ray and radium in many conditions has resulted and will result in various types of sequelae to some patients. One of the most frequent of these unfortunate accidents is the production of telangiectasis. As is well known, this condition may result either from one erythema dose, or more rarely from a number of doses where pigmentation was produced. These marks, at times, are extremely unsightly and are the source of much mental discomfort to those having them. It should be noted that there is always some accompanying atrophy of the glandular structure and of the fibrous tissue of the skin.

In the past there has been no thoroughly satisfactory way of removing these dilated blood-vessels. The electric needle, carbon-dioxide snow and multiple punctures with a galvanocautery have been recommended, but all of these methods leave much to be desired. The well-known effect of the ultraviolet lamp in producing an obliterating endarteritis led me to the employment of the Kromayer lamp in attempting to clear up these telangiectases. MacKee in his recent book, "X-Rays and Radium Treatment of Diseases of the Skin," mentions this method favorably and refers to the work of one or two other authors.

Up to the present time eight lesions have been treated. Three were comparatively small telangiectases due to radium placques, two were large areas covering the whole of the thyroid and thymus areas, and the remainder were mild scattered lesions resulting from one erythema dose in acne.

With an active lamp, using a quartz compression lens, I have found it necessary to give from fifteen to twenty minutes to each area. In no instance have more than two treatments been necessary to obliterate the vessels in the areas so treated. The results are a complete disappearance of the dilated blood-vessels, but naturally the atrophy of the skin remains unchanged and usually the result in appearance is that of a small, slightly whitened scar. However, these results are so encouraging that it seems worth while to record them. It might be added that I am not a great believer in the efficacy of the Kromayer lamp for all skin affections. Practically the only condition in which we have had a high percentage of success with it is the one which I have just mentioned.

BEHAVIOR OF THE STOMACH IN ULCER AND CANCER OF THE DUODENUM BELOW THE BULB*

BY A. W. CRANE, M.D.

KALAMAZOO, MICHIGAN

THE two following cases illustrate the subject of this paper. To arrive at a conclusion regarding the behavior of the stomach in ulcer or cancer of the duodenum below the bulb will, of course, require the experiences of many roentgenologists. These cases are too rare for any one to accumulate a long series, and so I venture to report two carefully studied cases in the hope that others will be added from time to time.

Carman states that less than one in ten of duodenal ulcers are located beyond the bulb. According to our own experience exactly one in a hundred are located beyond the bulb.

Regarding cancer of the duodenum below the bulb, information is still more meagre. Judd in the Mayo Clinic, found five cases of duodenal cancer out of twenty-four cases of cancer of the small intestine, and these twenty-four cases comprised less than 1 per cent of the carcinomas of the gastro-intestinal tract operated upon at the Mayo Clinic. How many of these five cases were beyond the bulb is not given. Carman may be quoted as follows: "Cancer in the supra-ampullary area is not to be differentiated roentgenologically from ulcer. But since it has only been seen five times in four thousand operative cases of duodenal ulcer, a failure to diagnose it should be forgiven. The *x*-ray was used in three of the five cases of carcinoma of the duodenum. In the first one the colon only was examined. In the second case the roentgen findings of the stomach and duodenum were indeterminate. In the third case the finding was duodenal ulcer."

In the two following cases there will be seen a marked difference in the behavior of the stomach between duodenal ulcer and duodenal cancer beyond the bulb. If this difference is found to hold good in a large series of cases then a useful point of diagnosis will have been established.

CASE I

Patient. W. R. T., Date 7/10/20.

Clinical Diagnosis. Duodenal obstruction. Dental sepsis.

Operative Diagnosis. Encircling cancer of duodenum below the bulb.

Chief Complaints. Epigastric pain. Vomiting.

Symptoms. Onset of present symptoms was six weeks ago. Patient has epigastric pain when stomach is empty. He is most likely to have this pain about 4 P.M., and then on until supper. He may have the pain at night, perhaps twice a week; may have gas on stomach, and belching then gives some relief. Pain is very irregular; he may go several days without pain. Eating gives relief as a rule, but not always. Pain is never made worse by eating. He may have a good appetite, but may feel distended after eating very sparingly. The pain does not strike through to the back but may extend to lower chest. Exertion does not bring on pain, but he is more likely to have attacks when tired.

Soda may give partial relief between meals when gas is belched; at other times alkalies are without benefit. For the last two nights he vomited, each time more than a quart of very sour fluid, with relief. He has no regurgitation; is never jaundiced.

No particular articles of food disagree.

Causes. Unknown to patient.

Personal History. White, age sixty-one, lawyer, married thirty-five years, two healthy children. Habits: Fairly good. Sleeps well, appetite good, no constipation.

Previous Diseases. Injuries. Operations. Never in bed twenty-four hours continuously to his recollection.

Family History. Father died at seventy-six of some kidney disease. Mother died at seventy of heart disease. Three brothers dead, one of kidney disease. Two brothers and one sister living and well.

Previous Treatment. None except in last few days for temporary relief of pain.

PHYSICAL EXAMINATION

No change in appearance, vigor or weight. Negative finding throughout. Blood-pressure

* Read at the Second Annual Midwinter Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

S. 125, D. 75. Pulse, temperature and respiration normal.

X-RAY EXAMINATION

Chest. The chest was examined by the fluorescent screen in both the upright and horizontal positions. No abnormalities were discovered.

Gastro-intestinal Tract. A glass of barium and water was administered with the patient standing. This passed the esophagus in the usual manner. The filling and unfolding of the stomach showed a moderate ptosis and relaxation. There was but little effort at peristalsis. The barium settled to the lower pole of the stomach, giving the characteristic half-moon appearance seen in cases of obstruction. A plate made in the upright position illustrates these points and shows a single shallow peristaltic wave in the greater curvature. A bubble of trapped gas indicates the approximate location of the duodenal bulb. The indefinite outline of the pyloric antrum of the stomach is suggestive of obstruction.

The first barium meal was administered at 3 P.M. (7/12/20). At 9 A.M. (7/14/20), two days later, there still remained a large gastric residue. A plate made of the abdomen at this time shows also much barium still retained in the small intestines. The colon is fairly well outlined, but not well filled. Another small portion of barium and water was administered to the patient in order to obtain, if possible, a filling of the duodenal bulb. Forty-eight hours later another plate was made of the abdomen. This shows a very large gastric residue, a considerable quantity of barium in the small intestines and a fairly complete filling of the colon.

July 10, 1920, 6 p.m.

CASE I Carcinoma of the Duodenum below the Bulb. Patient prone.

This plate three hours after the first barium meal shows persistent pyloric closure with inhibition of peristalsis. No barium had escaped from the stomach. Compare with later plates showing gaping pylorus also with inhibited peristalsis and marked retentions.

July 12, 1920, 9 a.m.

CASE I. Carcinoma of the Duodenum beyond the Bulb. Patient prone.

Two days after the first barium meal we find a large gastric residue, a contraction of the antrum, a filled bulb and considerable barium in the colon, showing the absence of a demonstrable obstruction.

Three sets of serial plates were made, each showing four views of the antrum pylori, pylorus and region of the duodenal bulb—the first set on the 10th, the second on the 12th, and the third on the 14th. The first serial plate shows deep laborious peristaltic contractions of the antrum without the expulsion of the barium through the pylorus. This plate was made immediately following the first barium meal. A second serial plate was made following the administration of a very thin mixture of barium and water. This shows an incomplete filling of the duodenal bulb and suggests some deformity of the pylorus. Two days later another thin suspension of barium was given in addition to the gastric residue present and a serial repeated. This shows a marked distention of the duodenal bulb, such as to overlap and conceal the pylorus. In the plate made of the abdomen preceding the serial plate and also preceding the administration of the thin barium suspension (the third barium meal) the pylorus appears widely open and the absence of an organic obstruction at the pylorus is thus demonstrated. In none of the plates is there a good delineation of the duodenum beyond the duodenal bulb.

A study of the outline of the stomach does

July 14, 1920, 9 a.m.

Case I. Carcinoma of the Duodenum beyond the Bulb. Patient prone.

Two days after the second barium (suspension) we still find a large gastric residue, an open pylorus, a filled bulb and a delineation of the colon. Pyloric obstruction is excluded by the last two plates.

not show any filling defect or contracture indicative of gastric ulcer or gastric cancer. On one of the serial plates there is a deformity in the usual outline of the pylorus, but this was not repeated in other plates.

On all of the plates there is seen to be a diminution in the normal size of the liver as estimated by its proportion to the rest of the body. The spleen is somewhat enlarged. There is no enlargement of the head of the pancreas, judging from the position of the duodenal bulb and from a few fragments of the arc of the duodenum.

The retention of barium scattered through the small intestines thirty-six and forty-eight hours after the administration of the barium mixture we would attribute to the slow escape of the barium from the stomach rather than to any affection of the small intestines. The abdomen was palpated beneath the *x*-ray screen. No area of pain on pressure and no abnormality of the colon were thus detected.

No gallstones can be detected on any of the plates. This, of course, does not exclude them, because in the majority of cases gallstones are transparent to the *x*-ray.

Mr. T. was recalled on the 16th and a complete set of tooth films made. These films

Case I. Carcinoma of the Duodenum below the Bulb. Patient prone.

This is one of three serial plates showing the absence of a lesion in antrum, pylorus or duodenal bulb. The pylorus is gaping and the bulb distended.

show a very extensive septic process about five of the teeth.

A fluoroscopic inspection was made of the stomach at this time (7/16/20, 11:45 a.m.). This shows that there is still present a very large gastric residue. This residue has remained since the small water suspension more than two days preceding. Another *x*-ray observation was made 7/19/20 at 11:30 a.m. The plate made at this time shows a massive gastric residue. This residue is present at the end of five days, since the last barium.

The patient was interviewed on the morning of the 20th and stated that he had had a very bad night with abdominal pain and vomiting.

The foregoing data are given, so far as possible, without personal bias. The following recapitulation arranges and interprets this evidence and gives the final conclusions under the head of diagnosis. Excepting for condensation this is substantially the report as sent to the attending physician three months before operation.

RECAPITULATION

Case History. The onset of symptoms is recent. The epigastric pain began six

CASE I. Carcinoma of the Duodenum below the Bulb. Patient prone.

This plate (7/19/20) shows a massive gastric residue five days after the last barium taken. The quantity is such that the major portion must be due to the only considerable barium meal, which was given eight days and twenty hours preceding.

weeks before and the vomiting two days before this examination. The occurrence of the pain is rarely in the morning, usually from 4 P.M. until supper, occasionally at night. The vomiting which occurred each time at night showed a large food retention, but the vomitus was liquid, showing digestion.

The appetite is good, but a little food brings a feeling of undue fullness, although eating gives temporary relief from pain. Vomiting has brought temporarily the only complete relief. The patient is more likely to suffer when tired, but exertion is not a factor in the production of his pain.

There is nothing about his habits, previous diseases or family history that appears significant.

Physical Examination. This is negative throughout. Although the epigastrium is the seat of symptom-pain, there is no pressure-pain.

X-Ray Examination. The appearance of the stomach in the upright position is that usually seen in pyloric obstruction. The character of the peristalsis is likewise that of pyloric obstruction:—slow, deep, laborious, ineffectual and finally shallow. But some of the *x*-ray plates show a widely gaping pylorus, the antithesis of obstruction, and also a distended duodenal bulb. Two of the plates indicate closure of the pylorus by spasm. The scattered barium through the small intestines indicates a slow escape of barium from the stomach, and the head of the colon is well outlined by the end of eighteen hours.

It is clear that no pyloric obstruction is present, and yet there was a massive gastric residue at the end of over four days. Two factors are thus probable—pylorospasm, and an obstruction beyond the bulb. A slight deformity of the pylorus on one of the plates suggested ulcer which would explain pylorospasm. There was no demonstration on any plate of a narrowing of the duodenum.

Laboratory Findings. The negative Wassermann helps to confirm the negative history. The normal hemoglobin and red-cell count (for an indoor worker) helps to exclude hemorrhage of any extent. No leukocytosis is present. The differential count is normal.

The urinalysis shows no renal pathology. An excess of indican in one sample calls for repeated examinations.

One half hour after the Ewald test-breakfast of bread and water the Rehfuss fractional tube was passed and five samples of the stomach contents were obtained at fifteen minute intervals. The analyses of these samples show a gastric juice within normal limits. It is noteworthy, however, that in the final sample there is a decided

LABORATORY EXAMINATIONS

(Only those headings which were filled in are given from the laboratory sheet)

Blood:	7–10–20	*Urine:*	7–10–20	7–12–20
Wassermann	Negative	How obtained	Voided	Voided
Hemoglobin	80%	When	P.M.	A.M.
Red-cells, No.	4,130,000	Color	Amber	Amber
Microcytes	0	Sp. gravity	1.030	1.028
Megalocytes	0	Sediment %	½%	–¼%
Poikilocytes	0	Character	Nebular	Nebular
Chromatophiles	0	Casts	Few hyaline	0
Normoblasts	0	Pus	x	0
Microblasts	0	Blood	0	0
Megaloblasts	0	Crystals	0	0
White-cells, No.	5,100	Other elements	0	0
Lymphocytes	27%	Reaction	Acid	Acid
Mononuclears	2%	Indican	x	xxx
Neutrophiles	69%	Albumin	0	0
Eosinophiles	2%	Sugar	0	0
Basophiles	0%			
Myelocytes	0%			

Stomach Contents:

Ewald test-meal given at 8:35					
Removed at	9:05	9:20	9:35	9:50	10:05
By Tube?	Yes	Yes	Yes	Yes	Yes
By Vomiting?	No	No	No	No	No
Quantity	36 c.c.	22 c.c.	32 c.c.	38 c.c.	210 c.c.
Gross Appearance	Moderately 3 layers	chymified 2 layers	Mod. chy. 3 layers	Well 3 layers	chymified 3 layers
Color	White	White	White	White	Cream
Mucous	Present	0	Present	0	0
Filtrate	25 c.c.	13 c.c.	23 c.c.	26 c.c.	
Free HCl.	4.	12.	14.	18.	24.
Combined HCl.	8.	16.	2.	10.	12.
O. A. &. A. S.	2.	4.	8.	6.	6.
Total acidity	14.	32.	24.	34.	42.
Lactic acid	0				
Starches	Erythro-dextrin				
Blood	0				
Pus	0				

jump in the per cent of free hydrochloric acid.

Diagnosis. The history of the case is suggestive of a gastric hyperacidity, the analyses of the stomach contents show practically a normal gastric juice excepting for a suggestion of hyperacidity in the final sample. The vomiting of large quantities of sour, watery material is suggestive of some hypersecretion as well as retention. The *x*-ray examination shows pylorospasm and obstruction below the bulb.

One interpretation of this evidence is that the patient has some irritation at the pylorus, possibly a small pyloric ulcer. There is no disease elsewhere in the abdomen which we were able to discover and which we could look upon as a reflex cause of pylorospasm or inhibition of peristalsis. Following the first examination he was advised to take a diet of eggs and milk. It is possible that this diet absorbed the free hydrochloric acid so as to allow a relaxation at the pylorus as seen in later plates. Obstruction beyond the duodenal cap is not, however, explained. If this were due to ulcer we would expect a different type of peristalsis and a different rate of stomach emptying unless the lumen of the duodenum were narrowed by adhesions or scar tissue. There is no preceding history in this case indicative of an involvement which would lead us to expect the presence of either scar tissue or adhesions.

The one finding, therefore, which we may clearly affirm is that we have a marked gastric and duodenal stasis with a suggestion of a partial obstruction beyond the bulb.

The cause of the vomiting appears to be the obstruction and the consequent retention within the stomach. We find no toxic cause of vomiting. The urine does not indicate renal disease. No source of a toxemia was discovered. In one sample of the urine there is an excess of indican. As a rule an excess of indican is associated with a diminution in the hydrochloric acid secretion. With a hyperacidity this has been described as an indication of open ulcer, doubtless because bleeding gives rise to decomposition products and indoxol. No ileostasis can be diagnosticated to account for indicanuria.

The stools have not been examined for occult blood.

Summary. Gastric stasis due to pylorospasm and duodenal obstruction.

Under recommendations for treatment, in view of the carious teeth found by the *x*-ray, we quoted the following from Barclay, "The Alimentary Tract," page 68: "Bad teeth and septic conditions of the mouth, etc., must be attended to before any reliance can be placed on delay in emptying. I have seen a case cured by removal of carious stumps in which a large quantity of food was still present in the stomach after 24 hours. It is probable that sources of irritation lower down in the alimentary tract may also produce spasmodic pyloric obstruction. I believe that these spasmodic contractions are the direct precursors and probable causes of the formation of actual pathological changes in the stomach walls."

The patient obtained no relief from the removal of teeth but refused operation. He underwent medical and dietetic treatment at the hands of several physicians without improvement and finally after a delay of two and a half months decided to go to the Mayo Clinic. The foregoing report of his case which had been sent to his first attending physician he took with him. There he was again thoroughly examined without a more definite diagnosis being found possible. He had now become uremic, but operation was undertaken as an exploratory measure and a last resource. The following extract from a letter to us by Dr. Charles Mayo after the patient's death tells the story:

"When this patient arrived he had only 10 per cent phenolsulphonephthalein output from the kidneys and one day none at all; his blood urea was 125. While he evidently had obstruction, the blood picture showed so badly that it was deemed best to try to improve his condition with salines and rectal feedings, and when the blood urea came under 100 he was to be operated upon. This occurred; but as it did occur Mr. T. developed gastric tetany. While his condition was a desperate one it was then thought advisable to take the chance, small as it was, of making a gastroenterostomy; W. J. Mayo performed the operation and it was recognized that the patient had an encircling cancer of the duodenum just below the common duct and attached to the pancreas; it was probably a primary cancer of the duodenum, a most rare condition."

It may be observed that cancer was not recognized prior to the operation. Obstruction below the bulb was stated as a deduction but was not demonstrated by the preoperative examinations. The pyloric ulcer which we suspected as the cause of pylorospasm was not found by the surgeon, so that it is evident that pylorospasm and a gaping pylorus alternated as a result of the disease below. That food passed the obstruction is shown not only by the barium filling of the colon but by the fact that the patient lived three months after our demonstration of a five-day residu The obstruction was not in itself sufficient to account for a five-day gastric retention. Hence it is probable that the nature of the disease was largely responsible for this retention. It is possible that there was a reverse peristalsis of the duodenum although we did not perceive it. The secretory and peristaltic functions of the stomach were not inhibited at the time of our examination, and in the absence of a reverse duodenal peristalsis it is difficult to understand how a five-day gastric retention could be maintained.

This case of cancer of the duodenum below the opening of the common duct is in marked contrast with the following case of ulcer of the duodenum also below the common duct.

CASE II

Patient. Mrs. M. T. B. Date 3 24 20.

Clinical Diagnosis. Duodenal ulcer with gastric hyperacidity and anemia.

Case II. Duodenal Ulcer below the Bulb. Patient standing.

Observe the accumulation of barium in the distended portion of the duodenum. The arrow points to the duodenal constriction.

Operative Diagnosis. Duodenal ulcer.

Chief Complaints. Epigastric pain. Vomiting.

Symptoms. The patient has pain, nausea and epigastric soreness immediately after eating. The epigastric soreness has been constant for the last two years. Her husband states that she has vomited frequently for thirty years. Patient states that she has vomited especially during last two years and has vomited after every meal for the last year. Loss in weight began about two years ago, with a corresponding loss in strength. She thinks she had a "bunch" in upper abdomen which she says is growing and which is sore and painful.

She has headaches more or less constantly since the beginning of the epigastric pain. They extend from neck over left side of head into left eye. During last October she was greatly bloated about the abdomen and lower extremities but was relieved under treatment by digitalis. Eyelids still edematous.

Causes. Unknown to patient.

Personal History. White, age forty-five, married thirty years, two miscarriages, no children. Menses ceased two years ago. Three or more cups of coffee daily, often a bedtime cup. Sleeps poorly. Constipated.

Previous Diseases, Injuries, Operations. Twenty years ago spinal abscess, ill five years,

Case II. Duodenal Ulcer below the Bulb. Patient prone.

Observe dilatation of duodenum without stratification of contents. The arrow points to the duodenal constriction.

twelve years ago tumor of left ovary removed. In 1920 was three days in hospital for heart disease.

Family History. Negative throughout.

Previous Treatment. Much medicine.

PHYSICAL EXAMINATION

Patient appears cachetic and very weak. Pulse 60. Temperature 98° F. Blood-pressure S. 150, D. 0.68. Epigastric soreness very marked and accompanied by muscular rigidity. No "bunch" can be palpated. The rest of the physical examination was negative.

X-RAY EXAMINATION

Chest. The diaphragm action, the lung fields, the heart and great vessels all appear normal.

Gastrointestinal Tract. The contrast meal was given in the upright position. There is a marked gastroptosis. Peristalsis and stomach emptying began in this position. The barium which passed from the stomach collected in a pouch-like formation in the duodenum.

In the horizontal position the area of abdominal pain was carefully palpated. This area was situated a little above and to the right of the stomach without apparent connection with the stomach or with the first portion of the duodenum.

CASE II. Duodenal Ulcer beyond Bulb. Patient prone. The arrow points to the duodenal constrictions, found to be site of ulcer. Observe dilatation of the proximal duodenum and normal filling beyond point of constriction.

The duodenum appeared very greatly dilated so that in the upright position a portion of the duodenum gave the appearance of a diverticulum. This was not, however, a true diverticulum but an extreme dilatation of the descending portion of the duodenum. The arc of the duodenum was not sufficiently large to indicate an enlargement of the head of the pancreas. A constricted portion of the duodenum was found just at the beginning of the ascending limb, forming an hourglass duodenum. The ampulla of Vater and the first portion of the common duct appeared to fill with barium, doubtless because of the marked distention of the duodenum. The duodenal cap itself appeared normal. The duodenum could be filled to the duodeno-jejunal flexure without further involvement which was apparent. At the end of five and one-half hours the stomach was empty but the duodenum was still filled with barium. The head of the barium column at this time was in the transverse colon.

On the following morning the colon was practically empty excepting the descending portion and the sigmoid. A second contrast meal was now given and a plate made of the entire abdomen. This shows the stomach situated well to the left of the median line. The pylorus was patulous and the duodenum filled quickly to the point of constriction.

CASE II. Duodenal Ulcer beyond the Bulb. Patient standing.

This plate was one of several taken after a gastro-enterostomy, because of the return of symptoms. The anastomosis, indicated by the arrows, is functional. No vicious circle was found. The duodenum could not be filled.

A study of stomach outlines on the various plates and by means of the fluorescent screen in various positions of the body shows no filling defects or contractures indicative of either ulcer or cancer. The pylorus itself and the duodenal cap appear normal. There is no sign on the x-ray plates of a tumor. The stomach appears displaced to the left but shows no pressure deformity or filling defect.

There is no enlargement of the liver or spleen. No gall-stones could be found on any of the plates.

The following recapitulation is an arrangement and an interpretation as in the foregoing case.

RECAPITULATION

Case History. The symptoms are, briefly, abdominal pain and vomiting. While the patient has had digestive disturbances with frequent vomiting for the past thirty years, the present symptoms were not constant until two years ago. Since then

LABORATORY EXAMINATIONS

(Only those headings which were filled in are given from the laboratory sheet)

Blood:	3-24-20
Wassermann	Negative
Hemoglobin	73%
Red-cells, No	3,760,000
Microcytes	Present
Megalocytes	0
Poikilocytes	Present
Chromatophiles	0
Normoblasts	0
Microblasts	0
Megaloblasts	0
White-cells, No	6,700
Character	Normal
Lymphocytes	24%
Mononuclears	7%
Neutrophiles	66%
Eosinophiles	1%
Basophiles	2%

Urine:	3-24-20	3-25-20	10-6-20
How obtained	Voided	Voided	Voided
When	A.M.	A.M.	A.M.
Color	Straw	Straw	Straw
Sq. gravity	1.012	1.014	1.014
Sediment %	−½%	1/10%	¼%
Character	Gelatinous	Gelatinous	Nebular
Casts	0	0	Few hyaline
Pus	Few cells	Small amount	x
Blood			0
Crystals	Oxalate	0	0
Other elements	Epithelial cells	Epithelial cells	Epithelial cells
Reaction	Acid	Acid	Acid
Indican	x	x	x
Albumin	0	0	0
Sugar	0	0	0

Stomach Contents:

Ewald test-meal given at 9:20.

Removed at	9:55	10:10	10:25	10:40	10:55
By tube?	Yes	Yes	Yes	Yes	Yes
By vomiting?	No	No	No	No	No
Quantity	25 c.c.	15 c.c.	9 c.c.	11 c.c.	27 c.c.
Gross Appearance	2 layers	Homogeneous	Homogeneous	Homogeneous	Homogeneous
	Fairly well chymified	Well chymified		Well chymified	
Color	White	Cream	Cream	Cream	Cream
Mucus	0	0	0	0	0
Filtrate	15 cc.	7 c.c.	4 c.c.	4 c.c.	13 c.c.
Free HCl	24.	26.	35.	30.	6.1
Combined HCl	7.				
O.A.&.A.S	4.				
Total acidity	35.	46.	55.	65.5	88.
Lactic acid					0
Starches	Erythrodextrin				Erythrodextrin
Bile					0
Blood					0
Pus					0
Micro-organisms					Cocci & bacilli
Parasites					0
Fecal Matter					0

she has lost steadily in weight and strength. The symptoms have been persistent and progressive so that for the last year she has vomited after every meal. There is also a constant headache varying greatly in severity.

There is a history of an old spinal abscess and of a pelvic operation twelve years ago. Since onset of present symptoms she was successfully treated for a cardiac decompensation.

Physical Examination. Excepting for a cachexia and epigastric soreness the physical examination is negative.

X-Ray Examination. The essential points in the *x*-ray examination are the active gastric peristalsis, the patulous pylorus, the rapid expulsion of stomach contents, the dilatation of the first two-thirds of the duodenum with a filling of the ampulla of Vater, the constriction of the duodenum so as to form a partial obstruction and the coincidence of this construction with the abdominal pain on pressure. The negative findings do not need to be recapitulated.

Laboratory Examination. Blood. This shows an anemia of the secondary type. No leukocytosis is present. The differential count is normal. The Wassermann is negative.

Urine. Three samples were examined without finding evidence of renal pathology.

Stomach Contents. Five fractions were obtained at fifteen-minute-intervals beginning one half hour after the Ewald test breakfast. The analyses of these samples show a hyperacidity in the three final fractions.

Diagnosis. The abdominal pain and vomiting are accounted for by the hourglass duodenum. The gastric hyperacidity is doubtless a factor in the production of symptoms and makes it probable that the constriction is due to ulcer rather than to adhesions. Cancer as the cause of the obstruction is rendered improbable by the long history of the case, the absence of a palpable tumor and the presence of a constriction instead of a filling defect.

SUMMARY

Our diagnostic findings may be listed as follows:

1. Duodenal ulcer below the bulb producing a stricture of the ascending limb of the duodenum.

2. Distention of ampulla of Vater due to extreme distention of proximal duodenum.

3. Hyperacidity of the gastric juice due to excess of free hydrochloric acid.

4. Secondary anemia.

Subsequent History. Laparotomy was performed and ulceration of duodenum found. A posterior gastroenterostomy was done in the usual way. After a temporary improvement the patient suffered a return of symptoms. An *x*-ray examination showed that the surgical anastomosis was open and that no vicious circle could be demonstrated. The patient refused further surgical treatment. The lapse of eighteen months without the development of cancer confirms the diagnosis of ulcer.

In both of these foregoing cases the chief complaints were epigastric pain and vomiting. In the first case the symptoms were recent a matter of weeks; in the second case the symptoms were chronic, extending over years. In the first case there was epigastric pain without tenderness, in the second the seat of the epigastric pain was exquisitely tender and the recti rigid.

Unless these cases are exceptional it is probable that very persistent gastric retention is the rule in duodenal carcinoma below the bulb and that rapid expulsion of stomach contents is the rule in duodenal ulcer below the bulb. Duodenal ulcer would thus run true to type whether in the bulb or below, with of course the usual gastric residue in cases of sufficient obstruction or pylorospasm. But the behavior of the stomach in cancer of the duodenum seems in marked contrast to its behavior in cancer of the stomach where rapid emptying is the rule with a gaping pylorus and at the same time feeble peristalsis, excepting, of course, in the presence of a sufficient organic obstruction.

In view of these facts, prolonged gastric retention without signs of gastric, pyloric or bulbar involvement should arouse suspicion of cancer of the duodenum. Also the rapid expulsion of stomach contents without achylia and without bulbar changes should arouse suspicion of ulcer of the duodenum below the bulb.

ACTION OF RADIUM AND THE X-RAYS ON THE BLOOD AND BLOOD-FORMING ORGANS*

BY ISAAC LEVIN, M.D.

The Cancer Division, Montefiore Hospital
NEW YORK

IT is difficult to estimate correctly the mechanism of the action of any agent on the blood and the blood-forming organs. The reason for it lies in the fact that the knowledge of the individual function of the various types of blood-cells and their correlation is quite incomplete. This concerns mainly the types of cells which predominate numerically in the blood, namely, the erythrocytes, the polymorphonuclear neutrophile leucocytes and the lymphocytes.

The numerical proportion of the lymphocytes and the polymorphonuclear leucocytes differs in the various animal species. Of the animals studied by the writer and his associates, the normal blood of a turtle contains less than 10 per cent of polymorphonuclear leucocytes and over 90 per cent of lymphocytes. The blood of a frog contains from 10 to 20 per cent of polymorphonuclear leucocytes, about 80 per cent of lymphocytes and from 2 to 5 per cent of eosinophiles. The blood of a guinea pig contains about 25 per cent of polymorphonuclear leucocytes and 75 per cent of lymphocytes. The rabbit's blood contains both types of white cells in about equal amounts, and the blood of a man contains about 75 per cent of polymorphonuclear leucocytes and 25 per cent of lymphocytes. There is no clear conception as to the functional or embryological reason for this numerical difference in the proportions of the two types of white cells present in the blood of the various species of animals.

Nor is there a complete unanimity as to the influence which radium and *x*-rays exert on these various types of blood-cells. The majority of the investigators however maintain that the erythrocytes present the types of blood-cells most resistant to radiations, while the lymphocytes are the most radio-sensitive cells of any in the organism. The writer has indicated in his previous publications that this "selective" biological action of the rays on the leucocytes goes even beyond the apparent structural differences of the cells. The radiations, for instance, destroy the lymphocytes in lymphatic leukemia a great deal more rapidly than the identical morphological lymphocytes in conditions of inflammatory leucocytosis. As a general rule the action of radium and *x*-rays on the normal blood results in the diminution of the number of lymphocytes and a relative increase in the number of the polymorphonuclear leucocytes.

The influence which radium and the *x*-rays exert on the lymphocytes and on the lymphoid tissue generally, of which the lymphocyte is the most important component part, is of greatest significance in the whole problem of radiotherapy. By increasing the intensity of the radiations it is undoubtedly possible to increase the destructive action on the malignant tumor, but with it goes the danger of a severe injury to the blood and the blood-forming organs. This injury will not only destroy the general resistance of the organism, but will also inhibit the power of the organism to form a protective connective tissue barrier around the tumor. It was stated by the writer on numerous previous occasions that the formation of this connective tissue wall is the most important result produced by radium and *x*-rays on cancer tissue, and this connective tissue formation can only take place when the lymphocytes and the lymphoid tissues of the organism remain intact.

In view of all this it is of great importance to study under different conditions and on different species of animals the action of radium and the *x*-rays on the blood and blood-forming organs.

In a previous publication the writer

* Read at the Sixth Annual Meeting of THE AMERICAN RADIUM SOCIETY, Boston, June 6–7, 1921.

reported upon the action of x-rays on the blood of a turtle. Chart I shows the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes before and after x-raying.

Chart I

INFLUENCE OF X-RAYS ON LYMPHOCYTES OF TURTLE

Smears	Leucocytes	Lymphocytes
Before x-ray	3	97
Immediately after	60	40
24 hours later	45	55
96 hours later	45	55
120 hours later	42	58
144 hours later	6	94

Chart I shows the differential count of the blood before the x-ray treatment began, immediately after the treatment, and 24 96, 120, and 144 hours later. Numerical relationship between the two types of cells changes greatly soon after radiation, then it gradually returns to the normal, so that 12 days later the blood contains the same relative number of the cells as before radiation.

The present investigation consisted in subjecting to the action of radium and x-rays normal frogs and also frogs in whom a change in the white blood cells was induced by a preliminary injection of yeast. A similar study was also undertaken on normal rabbits.

INFLUENCE OF X-RAY ON NORMAL FROGS

The experiments were conducted in the following manner. A total and differential blood count of each animal was taken before the treatment. The whole body of the frog was then treated with the x-rays for forty-five minutes using a Coolidge tube, 9 in. spark gap, 7 ma., 8 in. focal distance and no filtration. Blood counts were taken at various intervals after radiation for a period of four days. The following results were obtained: The total leucocyte count showed a very slight difference from the normal count before radiation. The differential count showed a marked change in the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes, while the number of the eosinophiles and transitionals remained practically stationary. This change was most marked twenty-four hours after radiation, and the blood usually became normal about four days after radiation. Chart II shows a type of this series of experiments.

Chart II

INFLUENCE OF X-RAYS ON NORMAL FROGS

Smears	Lymph.	Poly.	Eosino.
Before x-ray treatment	84	14	2
24 hours after treatment	28	70	2

INFLUENCE OF RADIUM EMANATION ON NORMAL FROGS

The method consisted in the introduction into the dorsal lymph-sac of a frog of a minute capillary glass tube about 4 mm. long containing from 1.0 to 0.6 millicuries of radium emanation. This method produces slow and continuous action of the rays of radium on the organism of the animal. The results obtained on the blood were quite analogous to those produced by the x-rays. The important difference, however, consisted in the fact that the change in the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes was most pronounced only about three days after the insertion of the radium emanation capillary. Chart III shows a type of this series of experiments.

Chart III

Blood Smears	Lymph.	Poly.	Eosino.
Before treatment	88	10	1
24 hours after insertion of radium emanation capillaries	64	34	2
72 hours after insertion	13	85	2

THE INFLUENCE OF RADIUM AND X-RAYS ON YEASTED FROGS

The experiments consisted in the injection of an emulsion of yeast into a normal frog. This injection of yeast is followed by a change in the blood of a frog similar to the one induced by the x-rays or radium. This change is most marked twenty-four hours after the injection and continues for a few days. This series of yeasted frogs was treated by the x-rays or radium emanation in the same manner as the first and second series reported above. Now the remarkable phenomenon observed in this series consisted in the fact that neither the x-rays nor the radium produced any further noticeable change in the numerical relationship between the polymorphonuclear leucocytes and the lymphocytes, or at the most a very slight additional decrease of the number of lymphocytes. Chart IV presents a type of this series of experiments.

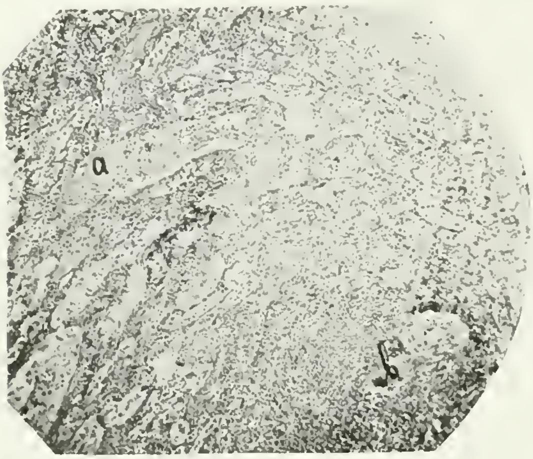

Fig. 1. Shows an area of necrosis at *a* and an altered blood-vessel at *b*.

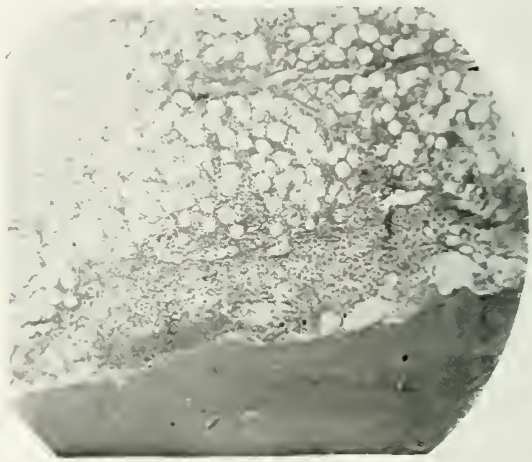

Fig. 2. Shows compact bone necrosis and alteration of bone-marrow.

Chart IV

Blood Smears	Lymph.	Poly.	Eosino.
Before yeasting	76	22	2
17 hours after yeasting	40	60	0
Immediately x-rayed and blood tested	29	68	3
24 hours later	19	80	1

THE INFLUENCE OF THE X-RAYS AND RADIUM ON NORMAL RABBITS

Normal rabbits were x-rayed with the same technique as was reported above for normal frogs. The whole body of the animal was x-rayed. The total leucocyte count again showed only a slight difference from the normal count before radiation. The change in the numerical relationship of the polymorphonuclear leucocytes and the lymphocytes was similar to those observed in the turtles and frogs. The blood-picture became normal again in about three to four days after radiation.

The radium applications in the rabbit were done in the following manner: A laparotomy was performed and from two to four radium emanation capillaries were inserted into the spleen. Blood examination was done before the operation and then was repeated daily for a week after the operation. In no animal was there any change noted in the blood structure. The spleen itself showed necrosis and extravasation and endarteritic changes in the walls of the blood-vessels. Figure 1 shows an area of necrosis and a cross section of an altered blood-vessel. All these changes were found in a small area surrounding the region into which capillary was placed. At a further distance from the capillary the structure of the spleen appeared to be normal. In another series of rabbits an opening was drilled into the shaft of the long bone and two or four radium emanation capillaries were placed into the bone marrow, the opening in the bone sealed with surgical wax and the skin opening sutured. All the operations on the rabbits were done under ether anesthesia. The blood of the animals was examined before the operation and daily for a week after the operation. Again no change was noted in the blood structure. The marrow surrounding the capillary showed changes similar to those found in the spleen. Figure 2 shows an area of bone necrosis and altered bone marrow.

CONCLUSIONS

The results of the analysis of the experiments of this investigation tend to confirm the prevailing opinion that the lymphocyte is the most radio-sensitive cell in the animal organism. The change in the numerical relationship of the two types of white cells was not accompanied by a noticeable change in the total leucocyte count. Apparently the mechanism of the action of the rays on the leucocytes of the blood consists in the destruction of the lymphocytes, which is then followed by the release of the polymorphonuclear leucocytes from the bone marrow or by an overproduction of this type of cells by the blood-forming organs.

Certain investigators maintain that the polymorphonuclear leucocytes are the type of the blood-cells most readily destroyed by the rays. However, the analysis of their results shows that the destruction of the polymorphonuclear leucocytes only takes place as the final result of the action of a lethal dose of the rays which produces ultimately a severe general leucopenia. The following instance from a publication of Zoellner illustrates the point. The blood of a guinea pig before radiation showed 85 per cent of lymphocytes and 15 per cent of polymorphonuclear leucocytes, two days after radiation it showed 46 per cent of lymphocytes and 54 per cent of polymorphonuclear leucocytes, and three days after radiation 24 per cent of lymphocytes and 76 per cent of polymorphonuclear leucocytes. The total blood count was not changed perceptibly all this time. Since the animals received a lethal dose of radiation, there developed near death a severe leucopenia of from 12,000 to about 600 white cells, so that the whole blood smear showed one or two lymphocytes and no polymorphonuclear leucocytes.

In the present investigation, however, only such amounts of radium and x-ray were given that the animals could completely recover after the lapse of a certain time and the blood picture again became normal. The most important phenomenon observed in the course of this study is the difference with which the two species of animals, the frog and the rabbit, react to the action of radium and the x-rays. In the frog the same general effect was obtained on the blood by the amount of x-raying employed in this investigation, as well as by the insertion of a glass capillary containing 1.0 to 9.6 millicuries of radium emanation. The blood of the rabbits reacted to the x-rays in a manner identical with that of the frog. On the other hand, an insertion into the spleen or the bone marrow of a rabbit of 2 or 4 capillaries, *i.e.*, two or four times the amount of radium emanation inserted into the frogs, produced no change in the blood of the rabbit, though it produced marked local effect on the spleen and bone marrow. These comparative findings in the two species of animals and the two types of radiation are of considerable importance to the subject of radiotherapy from two following standpoints:

The subjects of the relative therapeutic efficiency of radium and x-rays, of the higher or lower voltage of the electric current producing the x-rays, of the correct methods of physical measurement of the rays, whether photographic or ionization methods, for instance, and the correct amounts to be used, are in the order of the day. However, these subjects are treated chiefly from the standpoint of physics rather than from that of biology. There cannot be any doubt that measured by photographic or ionization methods or generally considered from its physical aspect one x-ray application as employed in the present investigation and one capillary tube containing 1.0 or less millicurie of radium emanation inserted into the frog and left there to decay represent two qualitatively and quantitatively different entities. Nevertheless they must be considered quite analogous biologically, since they produce the identical effect on the blood of the frogs. This indicated clearly that for biology and medicine a biological standard of measurement would be of far greater value than the physical methods. It may be added here in parenthesis that the action of the rays on normal blood and lymphoid tissue is of greater importance than their action on the skin, the more so that the radium and *x*-ray burns are most probably due to change in the lymphoid tissues of the walls of the blood-vessels.

The second phenomenon observed in this investigation further illustrates the importance of the biological differences for the ultimate results of the action of the rays. The *x*-rays produced a change in the blood-picture of the rabbit because the square surface of its body is greater than that of the frog, and consequently the former received a greater amount of radiation though all the other conditions of the *x*-ray apparatus were the same as those used in the frog. The radium emanation tubes produced no change in the blood of the rabbit, though the amount was more than sufficient to produce a change in the blood of the frog. The reason for it lies in the fact that the effect is distributed in the larger quantity of the blood of the rabbit and becomes so small as not to be perceptible. At the same time the local effect of the radium emanation is very marked.

Two conclusions may thus be drawn from the analysis of the experiments. First, that radium, as compared with *x*-rays, will produce the same and even a more marked local effect with far less general disturbance of the blood. Second, that the larger the square surface of the entry of the *x*-rays into the organism the more severe is the general effect on the blood. In view of all this, biological conditions must be studied at least as much as the purely physical conditions before a true estimation of both the correct quantity and the quality of the radiations to be used in therapy will be obtained.

DISCUSSION

Dr. Henry Schmitz. In the first place, it has always seemed to me the more anatomy a surgeon knows the better surgeon he is. In the second place, the more physics a radiologist knows the better radiologist he is. I make these statements so that you will not give up your interest in physics and go back to the old days when radiology was not a science at all.

One question I wish to ask is whether the total number of blood corpuscles in the cu. mm. in these animals has been counted and what the proportion is. If an actual decrease in the total number of corpuscles has occurred, then I will admit the differential count, but if the total number of white corpuscles in a cu. mm. remains the same, then it is only a temporary affair and has no real effect upon the condition at all.

I wish to get nearer to a point of such great interest in studying the changes which occur in the blood, in order to see whether they give us any explanation of the sickness that occurs after raying. Possibly Dr. Levin can give us some information on these points.

Mr. Gioacchino Failla. I find Dr. Levin's experiments very interesting and I am glad they will be in the literature, so that, as we know more about the effects of radiation on the blood-forming organs, the biologist and the physicist working together can find the correct explanation of the results obtained. I know that Dr. Levin is a good scientist, and, as a good scientist, he will change his ideas about radiation as he acquires further knowledge. This morning I was pleased to see Dr. Levin show a specimen illustrating the effects of emanation tubes embedded in tissue. About eighteen months ago I spoke to Dr. Levin about this method of treatment, but at that time he was very much opposed to it. Since then, however, he has had more experience and has come to the conclusion that the method is not so bad.

TREATMENT OF GLANDULAR METASTASES OF CARCINOMA*

BY RUSSELL H. BOGGS, M.D.

PITTSBURGH, PENNSYLVANIA

When the program committee requested me to discuss the treatment of glandular metastases, I do not believe they realized what a difficult subject it is at the present time, because there are so many methods of employing radium and the roentgen rays, and naturally the results vary accordingly. At present there are those who advocate very high penetrating, heavy filtered roentgen rays alone, others radium alone, and still others advise a combination of both agents. There is still much to be done by physicists, radiologists and biologists.

The three most important factors to be considered in the treatment of metastatic glands are: first, the situation, extent and depth of the disease; second, the amount of cross-firing necessary to make up for the loss of energy by divergence and absorption of the rays in the tissues; and third, the ratio between the erythema and lethal dose in malignancy.

It is known clinically what glands usually metastasize first in carcinoma of the various organs of the body, and by studying anatomy a chart can be made showing the exact location of the lymphatic vessels and glands. The extent of involvement usually depends on the stage of the disease, but there is no method by which we are able to determine whether metastases have taken place in a lymphatic chain or not. The size of the lesion and its duration are not dependable in giving a prognosis or determining the extent of metastases. When the glands of one lymphatic chain are palpably enlarged, the next chain is nearly always microscopically involved. This has been given very little consideration until lately, and most surgeons, when they operate, consider the palpable glands rather than those that are microscopically involved at the time of operation, although the surgeons have realized for years that, when all the palpable lymphatics have been removed, there usually are cancer cells left behind on account of the number of cancer deaths that follow the most careful glandular dissection. Likewise, most radiologists have not given this part of therapy sufficient attention.

Metastasis is the spread of disease from one part of the body to another and is the natural way by which a cancerous growth progresses, while a recurrence is the return of the malignant process in the vicinity of the primary growth. The two terms should not be used synonymously, as it leads to confusion. Post-radiation is usually given to destroy metastatic cancer cells left after operation rather than to prevent a recurrence, and it is oftener the metastases which kill the patient.

When the cancer cells escape from the primary growth into the lymphatic vessels, these cells may become lodged in the lymphatic vessels, proliferate and form a secondary growth, or are carried by the lymph stream to the lymphatic glands. Many consider that the lymphatic glands act as a filter for a time in preventing the spread of the disease. In the lymphatic glands the cancer cells may be destroyed or may proliferate and produce a secondary growth or metastasis. The regularity with which the lymphatic nodes are involved at some stage of carcinoma makes it imperative that all the lymphatic system adjacent to a primary growth should be rayed. In some cases the first chain of glands is not involved, but glands further distant may contain cancer cells. The question in such instances is, "Do the cancer cells pass through the first set of glands and are they checked by the second?" The more probable explanation is that the cancer cells are carried around the first set of glands by the lymphatic vessels and are deposited in a second chain. It is our aim in every

*Read at the Sixth Annual Meeting of The American Radium Society, Boston, June 6–7, 1921.

case of carcinoma to check cell proliferation and destroy all infected cells by radium and *x*-ray, not only in the primary growth, but in the lymphatic system, as soon as possible. If cell proliferation is allowed to go on and metastasis to become general, serous cavities may be invaded and the disease may even be spread later by the vascular system to the various parts of the body.

The intimate relation between carcinoma and the lymphatics has been carefully studied, and it is essential that the radiologists should know the modes of extension or paths of dissemination. By continuous extension of cancer cells of the primary infiltrating tumor through the lymphatics, metastasis appears at points widely distant from the original growth. The frequency of lymphatic metastasis varies with different types of tumors and with different locations of the same kind of tumors.

Handley's study of mammary carcinoma and metastasis has been very valuable to both the surgeon and radiotherapeutist and will apply to metastasis of any other organ. Ewing has summed up Handley's conclusion in the following paragraph:

"In cancer of the breast Handley has shown that there may be continuous extension of tumor cells through the lymphatics of the deep pectoral fascia to the axillary and supraclavicular nodes; thence to overlying skin and to humerus; through the deep lymphatics to the ribs, pleura, lung and spine; across the chest wall to the opposite breast; downward through the abdominal wall to the epigastric region and thence by the falciform ligament to the liver; and further to the inguinal region with the involvement of lymph-nodes, skin and femur. Extension through superficial lymphatics is much less wide. Invasion of the humerus occurs at the deltoid insertion and of femur at the trochanter, where these bones are closest to the skin, through the deep lymphatics of which the bone invasion follows. The leg and arm bones escape infection, which is inconsistent with a free embolic origin through the blood-vessels. Passing through the deep lymphatics of chest or abdominal wall, the cells enter the pleura and peritoneum and become implanted on the serous surfaces and produce superficial infiltrations of the lungs, liver, intestines and ovary. Or the viscera may be invaded through their main lymphatic vessels giving central tumors. The liver is involved through the lymphatics of the falciform and round ligaments, or by transperitoneal implantation, or by way of portal nodes; the lung by transpleural implantation or through bronchial nodes and hilus. Abdominal invasion by the epigastric route is earlier and more frequent than the thoracic, occurring without thoracic lesions in 12 per cent of all cases. The diaphragm is invaded by the epigastric peritoneal route, and through the descending lymphatics of its crura the retroperitoneal nodes and kidneys are attacked. This process of lymphatics permeation Handley believes is the master process of general dissemination in cancer. Lymphatic embolism he would reduce to a very secondary factor. Handley bases his conclusions on the study of long slices of thoracic and abdominal parietes in advanced cases of mammary cancer. In such material he finds the lymphatics continuously filled by tumor-cells. The only breaks occur as the result of perilymphatic fibrosis, an inflammatory reaction excited by the tumor process and resulting in complete atrophy of tumor-cell cords at many points."

In line with Ewing's statements, it is just as important for the radiologist to know what glands drain each area in the mouth and throat, and the manner in which metastases take place. The lymphatic glands in the neck are closely connected, and those of one side of the neck anastomose with the other. The lymphatics draining the lip are submental and receive the vessels from the central portion of the lower lip, chin and floor of the mouth. The submaxillary, consisting of five or six glands, drain the lateral halves of the lip, the cheek, part of the tongue and lower portion of the nose. There is an anastomosis between the submaxillary glands of each side and the submental, and when one group is invaded, it is only a short time until metastases spread to the next chain. There are from twenty to thirty important cervical glands extending from the mastoid process to the junction of the subclavian and jugular veins. There are two main lymphatic chains which are connected with the tongue; the submucous, and the intra-muscular. The lymphatics from the tips of the tongue pass to the submental and the inferior cervical; those from the lateral border terminate in the submaxillary salivary glands and some pass directly into the deep cervical, while most of those in the posterior part of the tongue enter a group of glands lying between the large vessels and the parotid glands, and another group of vessels pass into the submaxillary. The vessels passing from the tongue are closely connected with glands of both sides of the neck.

Metastases into the pelvic lymphatics have been studied by many observers and it has been shown that the period of invasion varies greatly with the location and type of disease. It is relatively early in cervical carcinoma and late in carcinoma of the fundus. It has also been shown that there is much variation in the course of the involvement of the lymphatics. Recent studies show that in from 30 to 50 per cent of early cases of cancer of the cervix, the disease has formed metastases into the lymphatics and about 40 per cent of the late cases of the pelvic glands have been found to be entirely free from metastases. This makes it impossible to give a prognosis from a pelvic examination, from tissues removed at the time of operation, or even by a pathological examination. Then the entire glandular system draining and anastomosing with the uterus should be treated by modern radiation; that is, with radium applied locally and either radium packs or deep roentgenotherapy from the outside in every case of cancer of the cervix regardless of the stage of the disease. This means a more extensive raying than the glands in the parametrium, broad ligaments, those situated along the sacro-uterine ligaments, around the rectum and in front of the sacrum, because when these glands contain cancer cells, it is only a short time until the abdominal lymphatics metastasize. Later the liver and lungs metastasize and finally the bone becomes involved.

There is no universal method of raying metastatic glands. Some therapeutists use large areas with very little cross-firing; some cross-fire from every possible angle, using small ports of entry; some imbed radium, and others use large quantities of radium placed on a pack covering a large skin area, while many use a combination or a modification of these methods. There is a wide variation in filtration, spark gap, tube distance and the time of exposure in roentgentherapy, the same as there are great variations in the methods of applying radium. Then, would it not be conceit on the part of any radiotherapeutist to say that his technique is absolutely correct? All have the same object—that is, to give a lethal dose to all the glands which have metastasized. However, it is true that, with all these variations, in the selection of radiation and the different methods of technique, many are producing similar results because these radiotherapeutists know dosage, the difference between skin dosage and depth dosage and the difference between a lethal dose and an erythema dose, and know what should be expected in a given case coming for treatment.

The method of treating deep metastatic glands by the *x*-ray until the last year was by using many ports of entry and cross-firing as much as possible. The equation ordinarily used was nine-inch spark gap, 5 ma., eight-inch tube distance, and filtered through from 4 to 10 mm. of aluminum, time of exposure from seven to thirty minutes depending upon the rest of the equation. With this equation it had been calculated that at a depth of four inches from the surface of the skin from six-sevenths to eight-ninths of the radiation was lost by absorption in the tissues and divergence of the rays, the registered radiation being from one-seventh to one-ninth. This included both the direct and scattered radiation and was measured by placing pastilles in the vagina. Then after the lethal dose was determined, the number of ports of entry was figured out. Of course, this data was obtained by a chemical process and was not exactly the same as if it had been worked out by the use of ionometric measurements.

About a year ago it was learned that

the Germans were employing very large ports of entry, higher voltage, more filtration and greater tube distance. They claimed that by the use of larger ports of entry, more scattered or secondary radiation was obtained. At the Freiburg Clinic, they employed a spark gap of 40 cm., tube distance, 30 cm., filtration 1 mm. of copper or its equivalent, 18 mm. of aluminum, using as large a port of entry as possible over the anterior part of the abdomen, and the time of exposure was about three hours. The dosage was measured by a Wulf electrometer. This measured at 10 cm. depth, the calculated dose is 8.4 per cent, while the measured dose was 31 per cent. This considerable difference depends on the secondary or scattered radiation coming from the tissues, the primary radiation only representing about 30 to 40 per cent of the radiation registered by the iontoquantimeter. This created considerable excitement among the radiologists and physicists and many extravagant statements were made. It started the manufacturers to investigate and to work on improving the entire therapeutic outfit, something which had been badly needed.

At the Erlangen Clinic, Seitz and Wintz used a spark gap of 30 to 40 cm., filtered through $\frac{5}{10}$ mm. of zinc (which is equal to 11 mm. of aluminum), tube distance 23 cm., and with a port of entry 6×8 cm. They found that a dose received at a depth of 10 cm., or four inches, is about 20 per cent of the surface dose, meaning registered dose. In cancer of the cervix, they used three ports anteriorly and three posteriorly and a seventh through the vulvular region. Through these seven ports they claim 110 per cent of the skin dosage. Seitz and Wintz's technique is somewhat similar to that which we had been using for some time. The principal difference was that we use more ports of entry, using twelve anteriorly, twelve posteriorly, three right and three left lateral. Then large doses of radium were used locally. For the past two years I have been using 10 mm. of aluminum. It seems that since Seitz and Wintz directed the rays through relatively small skin area to the cervix many abdominal glands were omitted. It seems that some of us in this country have produced about the same end results which they have reported in carcinoma of the uterus, when we used large doses of radium locally, supplemented by deep therapy. In treating glands in the neck and chest our technique has been about the same, except smaller ports of entry were used.

Imbedding radium has many points of advantage in the treatment of carcinomatous growths as well as in the treatment of metastatic glands. It is particularly valuable in malignancy of the mouth and throat following surface applications. Cancer cells located in the sublingual, submaxillary, submental, parotid and cervical glands can be successfully destroyed in more advanced cases than can be removed by surgery, without producing any deformity. In carcinoma of the breast, imbedding radium is a valuable addition to surface applications of radium and the *x*-ray. Thirty to thirty-five 10 mg. needles imbedded in the breast, in the axilla and in the tissues between the breast and the axilla and beneath the clavicle, has more effect than a gram of radium on the surface, because it is more efficient and can be given after the overlying skin has received all the radiation it will tolerate. When radium is buried, surface raying should always be given before and after. It is a valuable method as an ante-operative procedure.

A physician or surgeon cannot do or direct radiotherapeutic work unless he has studied both radium and the *x*-ray from A to Z, the response of different tissues both healthy and diseased, and realizes that the patient dies from metastases, not the local disease. There are many methods by which primary carcinoma can be successfully treated, but there is no positive method by which extensive metastases can be eradicated or cured. Radiation is the only procedure which offers anything when more than one chain of lymphatics are involved, even microscopically.

In the treatment of metastatic glands, the most efficient method is one by which the largest amount of radiation will reach all cancerous cells with the least injury to the skin and overlying structures.

The most disappointing feature of the reports from the German literature is that they speak of an erythema dose, and state that even less than an erythema dose will destroy all cancerous cells. I am sure that they are wrong because the erythema dose is not always the lethal dose for every type of carcinoma; and if their clinical reports are correct, then we must attribute it to their giving the entire treatment in one day. Now, this does not seem reasonable if you study the cases which we have treated during the past eight or ten years, because we certainly did produce results with the old induction coil using about 1 ma. of current, no filtration, and a spark gap of about six or seven inches, and the erythema dose was given in fractional doses within three weeks. Of course, we all realize that these results were more superficial, and were not equal to those of to-day, but it can be positively stated that cancer cells can be killed by the fractional method. This might be compared to the imbedding of radium emanation which acts on the cancerous tissues for a period of thirty days. The results produced by emanation, so distributed through a cancerous mass acting for thirty days, produces about the same results as imbedding radium steel needles for a few hours. However, this is a question still under controversy.

A large amount of radiotherapy is given by unqualified radiologists. The dermatologist claims that he only intends to treat superficial cancers, then he would be only treating a few superficial epitheliomas around the eyelid and upper part of the face. Lower lip epitheliomas come under deep therapy and very deep at that; the surgeon claims breast carcinoma until it is hopeless; and as a rule when ante- and postoperative treatment is given, many lymphatic glands are omitted and usually a lethal dose is not given. Many of the gynecologists use 50 to 100 mg. of radium locally, and usually no radiation is given to the metastatic glands.

DISCUSSION OF R. B. WILSEY'S "THE EFFICIENCY OF THE BUCKY DIAPHRAGM PRINCIPLE"*

Dr. Potter. I was very much interested in getting these reports of Mr. Wilsey because they showed what we knew before in a general way. They showed it in a very intelligible and scientific way. We knew there were a heap of rays suppressed by these secondary and scattered rays—now we know it is 85 or 90 per cent cut off. We knew we lost definition when the grid was a long way from the plate. He shows just how much we did lose. In other words, he shows exactly those points which we now can build on to improve this little instrument so that it will be at the maximum of its efficiency. I did not say much about it until I was satisfied that the thing was about right. I never could go along and give percentages on this sort of thing. I made very lengthy qualitative experiments where you can estimate in a rough way with a string of plates just how much was cleaned up. Seventy-five per cent was my guess. Glad to hear Mr. Wilsey's estimate is 83 per cent.

Dr. Pariseau. I would like to ask a question of Mr. Wilsey, Dr. Potter, or any members present who have had large experience with the Potter-Bucky diaphragm. I have had one since it has been on the market and I could not dispense with it. On one point at least I was very disappointed. My gall-bladder work was poor through faulty technique and through inherent effects of the method of examination, and I thought I would improve it considerably by the Potter-Bucky diaphragm. In looking over my gall-bladder plates made with the diaphragm and without the diaphragm, using duplitized film or plate and screen, I found that I actually visualized the gall-bladder oftener by the ordinary straight method than with the diaphragm. There is no doubt that the Potter-Bucky diaphragm differentiates very much better than the ordinary plate, so why were my results not better? I think the only possible explanation is this: In any case where movements are to be avoided, the lengthened exposure necessary in the Potter-Bucky diaphragm actually annuls any gain that you make in definition. I do not know whether I am right. I have come to the conclusion of Dr. George in his book that the Potter-Bucky diaphragm for gall-bladder work, in general, is of very little use. The lengthened exposure more than annuls any gain that we may have both in contrast and definition. I would like to know if the experience of members here has not been that for gall-bladder work, where suspended

* This article appeared in the January number.

respiration is absolutely essential, they have not had better results with the straight screen and plate than with the diaphragm.

The cross-grid type—not above the subject but under the subject—was used in France as far back as 1916. It is a cross-grid flap that passes under the patient and is extremely convenient in many ways because it is thin. My actual experience is that as far back as 1916 the cross-grid was not only tried in France, but sold. They called it the "anti-diffuser" which defines it. I would like to hear the experiences of others.

Dr. Pirie. Mr. Wilsey mentioned that if you cut down the diaphragm and make a picture 3″ in diameter you get as good results. Acting from that principle I used to take spines this way. What I did was to have a moving diaphragm above the tube and a piece of lead which went slowly across the tube; and for taking spines I found it increased the detail very much. However, it increased the length of exposure so much that I gave it up. It improved the spine pictures very much ten years ago.

Dr. LeWald. I would like to answer in my small way Dr. Pariseau's question. There is no question in my mind that the Potter-Bucky diaphragm aids very materially in diagnosing gall-bladder lesions. I would like to ask Mr. Wilsey if there is enough advantage to use the combination of cone with the diaphragm.

Mr. Wilsey (in closing discussion). I appreciate very much Dr. Potter's kind remarks. It is gratifying to know that these results substantiate the results obtained by him in his series of experiments. Regarding gall-stone technique, I would hesitate to make any suggestions; not being a roentgenologist and being only a physicist I can only investigate and report upon the physical factors involved. When it comes to the practical application of these, you have in your work motion of the patient and other factors which must be taken into account. The roentgenologist must take this information and apply it with his own knowledge and determine what is the best technique to obtain the best results. I feel sure that if the diaphragm is altered in the way suggested by making the slit more shallow, definition will be much improved.

Dr. Cole has done a great deal of work with the double slot method and undoubtedly it would have many advantages. Whether it is superior to the Potter-Bucky diaphragm, I have no measurements to determine. One thing it prevents—scattered radiations being thrown off. By using the slit and slot both below and above the patient, the effect of scattered radiation from the patient is eliminated.

I doubt very much if there is any appreciable advantage in using the combination cone above. The advantage of the cone used by itself, without the diaphragm, is to diminish the distance between the film and the patient. If you use the diaphragm, the cone on top will not help a great deal.

Another point which I would like to bring out is the suggestion of Mr. Van Allen regarding the use of curved cassettes which brings the patient nearer the film and gives equal definition on the whole roentgenogram.

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DR. JAMES G. VAN ZWALUWENBURG

James G. Van Zwaluwenburg, Professor of Roentgenology at the University of Michigan, died of pneumonia in the University Hospital, after a week's illness, January 5th, 1922. He was born on May 5th, 1874, in Ottawa County, Michigan, and was thus forty-seven years of age. He was a student at Hope College, Holland, Michigan, from 1889 to 1894, and remained there in 1895 as a teacher of chemistry until he entered the University as a sophomore in the same year. He was graduated in 1898 with the degree of Bachelor of Science. For the next five years he was associated with his brother in chemical work. In 1903 he entered the Medical Department at the University and graduated in 1907.

He was by nature a teacher. Before graduation he served as a demonstrator of anatomy and after graduation remained in the University as Instructor in Internal Medicine until 1910. He then became especially interested in *x*-ray work and was given the task of building a department of roentgenology in the medical school. In 1913 he was made an Associate Professor of Roentgenology, and in 1917 full professor.

His professional life in brief is thus seen to be an orderly development. He was singularly well qualified by temperament and education for the career of a professor and a roentgenologist. His interests from the time of his first college work are seen clearly to be pedagogical and scientific. He entered the *x*-ray field only after a prolonged training in the department of internal medicine, which is incomparably the best training for a roentgenologist. During his period of service in this department he was carefully drilled in medical research and collaborated with Professor Hewlett in the publication of much experimental work.

In this work, was developed a naturally quick and keen perception, a genius for invention, and the clever adaptation of instrumental means to experimental ends, an insight into the classification of data and the evaluation of scientific evidence, and finally the power to correlate apparently unrelated facts and give them coherent expression—all of which characterized his later work in roentgenology to the admiration and despair of his confrères. These faculties were activated by an unquenchable enthusiasm and an industry that taxed the utmost resources of his strength.

Dr. "Van" had reached a point in his work when accumulated data permitted literary presentation. There was of necessity a period of years during which he must gain experience and learn to classify the immense diagnostic material which flowed in ever increasing volume into the department of roentgenology. By well planned organization and capable assistants he had relieved himself of most if not all of the technical work, so that he could give his undivided attention to the interpretation of cases, to teaching, to improvements of methods and apparatus and to the writing of papers and books. Those of his friends who have penetrated to his sanctuary, the "workshop," know something of what the world of roentgenology has lost by his premature death. The meaning that lies locked upon those shelves of plates and records could yield only to the key of the master of the shop. It is melancholy proof of the point which he had reached in his career that his last act, shortly before his final illness, was to block out a book on pelvic pneumoperitoneum and to write a portion of the preface.

His literary remains are nevertheless considerable and of genuine value. The complete list which is appended, was kindly furnished me by Dr. S. W. Donaldson, acting head of the Department of Roentgenology. He added something to every subject that he touched. His discovery and study of the pleural cap would alone preserve his memory to future generations of roentgenologists. The full value of his work upon the heart is not yet fully appreciated.

His work in pelvic pneumoperitoneum, which was carried on with the cordial and able collaboration of Prof. Reuben Peterson, displayed his capacity for original and practical research. So sure and complete was his grasp of both technique and interpretation of plates that his methods have virtually fixed the mode of procedure of this most important application of the *x*-ray in gynecology.

His influence upon his pupils was notable. His power as a professor lay not only in his mastery of the art of roentgenology and his extraordinary knowledge of that expanding science, but also in that gift of inspiring the student mind with something of his own enthusiasm, which is the mark of a true teacher. Another attribute which was beyond price to the school in which he held his chair was his unfaltering loyalty to the University. His hopes, his career, his personal fortunes, were cast with his beloved school without reservations. This was tested by his refusal to enter lucrative private practice in a large city with famous and congenial partners. He chose the laborious life of a scantily paid professor among his students and fellow teachers under the mantle of the great University to which he gave his life.

What his fellow professors on the medical faculty thought of Dr. Van Zwaluwenburg is thus set forth with an eloquent affection by Dr. Hugh Cabot, Dean of the Medical Department:

"In the death of Dr. 'Van' the University has lost an invaluable servant, science has lost an important exponent, and the world has lost a great man. In his work he demonstrated integrity to a very high degree. Utter self-forgetfulness was his, even to excess, and the only thing he ever neglected was himself.

"His capacity for organization and his knowledge of business methods were of a grade rarely found in medical men. His previous training as a chemical engineer gave him a broader outlook than is commonly found in medical specialists. Of his scientific work in roentgenology it would be difficult to speak too highly, though his actual publications were few.

"He insisted for himself and others on a degree of absoluteness of demonstration which often made him unwilling to publish work which was anything short of complete. Most catholic in his thinking, he never allowed his theories to become for him facts.

"A keen reasoner, a sharp critic, a good loser, and a modest winner, he left a place in the clinic staff of the Medical School which it will be very difficult to fill. He has left the impress of his personality upon all of us, and though he has gone, we shall go forward more steadily and more generously than would have been possible without the inspiration of his example."

Dr. "Van's" domestic life was an underlying double source of happiness and strength. He married Miss Neal Benjamin on Nov. 27th, 1903, and was the father of a son and daughter, all of whom survive him. One of his last joys was the enlargement of very successful photographs of his children. He leaves also two brothers, one a well-known chemist, the other an eminent surgeon in California. The latter was for many years a leading practitioner in Kalamazoo where the writer first formed the acquaintance of Dr. "Van" many years before his interests were turned to roentgenology.

In his home the doctor gave rein to his love of music. He was fond also of general literature and read often far into the night. He was a delightful host and was never seen to better advantage than when relaxed and animated in the society of his friends.

He was a moving spirit of an informal association of Michigan roentgenologists; an association which has no officers, no roster of members, no dues, and no regular time or place of meeting. It was a singularly successful society and its last and most successful meeting was with Dr. "Van" in his famous "shop." He showed everything with the open simplicity and sincerity of the true scientist. This society of his fellows gathered at his home before the funeral to pay him personal tribute of affectionate friendship.

Dr. Van Zwaluwenburg was a valued member of various medical and roentgenological societies, which will join with his Michigan brethren in finding in his life an inspiration to do better scientific work. Particularly The American Roentgen Ray Society has reason to mourn his loss and to honor an active and loyal member who has added luster to the achievements of American roentgenology.

A. W. Crane.

The following is a list of publications by Dr. Van Zwaluwenburg:

The Diagnostic Value of the Orthodiagram in Heart Disease, *Arch. Int. Med.*, Feb., 1911, vii, 137. (In conjunction with L. F. Warren, M.D.)

Backache, *J. Mich. M. Soc.*, Sept., 1916, xv, 428.

Capillary Circulation, Am. J. Roentgenol., Nov., 1916, iii, 532.

Lantern Slide Demonstration of Radiographic Findings, *J. Mich. M. Soc.*, Feb., 1917, xvi, 73.

Roentgenographic Findings of the Month, *J. Mich. M. Soc.*, April, 1917, xvi, 185.
Correlation of Roentgenographic and Surgical Findings, *J. Mich. M. Soc.*, Aug., 1917, xvi, 370.
Foreign Bodies in the Eye, Am. J. Roentgenol., Oct., 1917, iv, 512.
Review of Month's Roentgenograms, *J. Mich. M. Soc.*, Jan., 1918, xvii, 28.
Plea for Use of Fluoroscope in Examination of Heart and Great Vessels, Am. J. Roentgenol., Jan., 1920, vii, 1.
Tonsillar Route of Infection in Pulmonary Tuberculosis, *Am. Rev. Tuberc.*, Mar., 1921, v, 57. (In conjunction with G. P. Grabfield, M.D.)
Apical Pleuritis and Its Relation to Pulmonary Tuberculosis; Statistical Study of Stereoscopic Roentgenograms of 366 Consecutive Adult Chests, *Am. Rev. Tuberc.*, June, 1921, v, 323.
Pneumoperitoneum of the Pelvis; Gynecological Studies. Am. J. Roentgenol., Jan., 1921, viii, 12. (In conjunction with Reuben Peterson, M.D.)
Pelycograph, Its Field and Its Limitations. Read before Am. Rad. Soc., Chicago, Dec. 9, 1921. Manuscript to be submitted to publisher.
Apical Pleuritis: A Statistical Study of Stereoscopic Roentgenograms of 267 Presumably Normal Student Chests. (In conjunction with A. D. Wickett, M.D.) Supplementary to the report entitled "Apical Pleuritis and its Relationship to Pulmonary Tuberculosis." Read before the Trudeau Society of Michigan, Oct. 14, 1921. Manuscript to be submitted.
Experience with Pneumoperitoneal *X*-Ray as an Aid to Gynecological Diagnosis. *Minn. Med.*, July, 1921, iv, 412. (In conjunction with Reuben Peterson, M.D.). The *X*-Ray Diagnosis of Accessory Sinusitis. Am. J. Roentgenol., Jan., 1922, ix, 1.

THE CHEMIST IN MEDICINE

THERE has been published lately a report by a committee of the American Chemical Society, whose Chairman is the Editor of the *Journal of Industrial and Engineering Chemistry*, on "The Future Independence and Progress of American Medicine in the Age of Chemistry." The purpose of the report, as stated in the Foreword, is to point out "the need for intensive chemical research, under more favorable conditions than exist today, devoted to the alleviation of human suffering." It deals especially with the need for close cooperation of the physician with the pharmacologist and chemist. In this connection it mentions numerous instances in which progress in medicine was greatly delayed because of lack of such cooperation. Ether, for instance, was discovered in the thirteenth century, but its value as an anesthetic was not recognized until 1846. The report places great emphasis on the dependence of medicine upon the fundamental sciences, chemistry and physics, and recounts in considerable detail the services that these sciences have already rendered to medicine. It also lays out the lines of attack for future work.

One needs only to recall a few of the accomplishments of chemistry to recognize the invaluable aid it has been to the advancement of medicine. Among them are the isolation of pure principles, such as strychnine, quinine, morphine, atropine, cocaine, and many others, from the crude drugs; the creation of synthetics, such as salvarsan; the improvement of drugs so as to remove their toxic or other harmful effects, notably the production of procaine, codeine, and homatropine; the isolation of the active principle of the internal secretions, such as epinephrine and thyroxin.

These are only a few of the accomplishments of chemistry that point out what may be expected when other still unsolved problems are adequately attacked.

To the thoughtful radiologist this report must suggest many possibilities. The need for the thorough investigation of numerous problems in connection with roentgen and radium therapy has long been recognized. For instance, the work of the radiotherapist is greatly hampered by roentgen sickness. The cause of this condition is still unknown. It seems not at all improbable that the solution lies in the field of work of the physiological chemist cooperating with the radiologist. If we were able to answer the questions that arise in connection with roentgen sickness, we might be far on the road to a solution of the problem of the ultimate effect of radiation in the human body. Until we know what changes are produced in the living tissues by the application of the *x*-ray or radium little further rational progress can be expected in the treatment of disease by these agents.

It seems reasonable to believe that the solution must be sought in the changes that take place in the cells and secretions of the living body during and after its subjection to radiation, rather than in a study of the end results in tissues removed from the body, however valuable the latter studies may be. An explanation is needed for many of the phenomena known to follow x-ray or radium treatment of various conditions. What, for instance, is the reason that we have roentgen sickness in one patient and not in another, apparently given the same dosage in the same region of the body? Why does sickness vary in the same patient at different times? What is the cause of the exceedingly rapid reduction in the white cells in a case of leukemia treated for very short periods over small areas of the body? Why in the same class of cases is the spleen so quickly reduced to normal size? How can one account for the reported cases of Hodgkin's disease in which treatment over one area is followed by disappearance of the enlarged glands in distant areas?

It seems probable that these and numerous other questions could be answered by careful investigation on the part of men properly trained to undertake it.

It will well repay one to read carefully the report mentioned above. It may very well be the introduction to a new era in our specialty and in the progress of medical science.

A. C. Christie.

CORRESPONDENCE

To the Editor:

In the November issue of the Journal there occurs an article entitled "A Preliminary Report on the Effects of Roentgen Rays on Gastric Hyperacidity" by Bryan and Dormody. Its opening paragraph is the following: "In Germany Bruegel and Wilms have been using the roentgen ray with very promising results in cases of duodenal and gastric ulcer with hyperacidity." Because I feel I can add something of interest in this connection, and because it seems unfair to give foreigners the credit for originality when an American had so distinctly antedated them and maintained a steady application and interest in the same thing for years before them, I hope this will be published in the Journal.

Back in the days when the first roentgenograms of the stomach were made by static machines, with the early forms of coils and through its perfected forms, and for years now with the transformer, every case of gastroduodenal ulcer under my care has had from three to ten x-ray treatments in the first month or two they were out of bed. In the first edition of my work on "Diseases of the Stomach," published in 1910, four pages of context were devoted to the therapeutic use of x-rays in treating gastroduodenal ulcer, the work then being done with a Cole coil. Since that time over 900 cases have been so treated by me in the expectation, as stated then, of "more perfect repair in bringing about a firm cicatrix, favorably influencing the persistent symptoms of hyperacidity, the sensory phenomena of an irritative type, and resulting atony." The reasoning that their use might be beneficial was assumed from the discutient effects on scars of healed carbuncles on the neck, and those of injuries, the stimulation of skin ulcers, keloid, etc., and what was known at the time of the atrophying effects of the x-rays on specific cells of highly specialized parenchymatous tissues—the acid or parietal cell of the gastric tubules being one of these.

Roentgenologists generally have agreed that cases of malignant disease after extirpation of the neoplasm should be treated by x-rays. There are still some (notably among the surgeons) who doubt this. But it may definitely be stated that no case of gastroduodenal ulcer medically treated should be denied the benefits possible to be brought about from a course of x-ray treatments, particularly when hyperacidity is present. In 537 cases carefully selected as those suitable for medical treatment up to two years ago, 87 per cent are cured, and I feel this high percentage was brought about by the employment of the x-rays, because many of them were treated before the days of the Sippy diet (when von Leube's diet and that of Lenhartz were employed) and neutralization of the gastric acidities by giving alkalies steadily was not in vogue.

No case of hyperacidity not due to ulcer should be treated by x-rays, because the dietetic and vagus forms are best handled without it, and hyperacidity is so often due to distinct pathology extragastric in the abdomen that it should not be standardized as the treatment of only a symptom. In acida gaster (Reichmann's disease) some bright results have been brought about by the persistent use of the x-ray.

The article in question suggests the employment of the x-rays during the active treatment of the ulcer. In my experience the best time to do this is after the patient is out of bed during the second month of the beginning of the treatment and after thorough and continued alkalization had been carried out for weeks and was still being continued. Instead of three treatments of from 25 to 35 ma.m. with a 10 in. distance skin target, I employ from 10 to 20 ma.m. with a 15 in. distance, a 3 in. spark-gap, using a 3 mm. aluminum and 5 mm. sole leather, and about 60 kv.—this being modified at times according to skin reactions. Six rayings at weekly intervals are given. At each raying the stomach contains 2 oz. of bismuth subcarbonate. I do not know why this intensifies the good effects from the rayings, but I feel quite sure that it does.

Anthony Bassler, M.D.
21 West Seventy-Fourth Street
New York City
Dec. 23, 1921

RESOLUTION ADOPTED BY THE CENTRAL SECTION

The following resolution was adopted at the meeting of the Central Section:

Whereas, Roentgenology has suffered a great loss in the untimely death of Dr. James G. Van Zwaluwenburg of Ann Arbor, Mich., whose achievements gave promise of even more important contributions to science,

Whereas, We the members of the American Roentgen Ray Society feel so keenly the loss of our friend and member,

Be it resolved, That the Secretary engross on the minutes of the Society expressions of our deep sorrow and convey to the family our sincere sympathy in their deep affliction.

ANNOUNCEMENT

The Twenty-Third Annual Meeting of the American Roentgen Ray Society will be held at Los Angeles, September 12–16, 1922. Arrangements have been made with the management of Hotel Ambassador both for the meetings and for the exhibits.

The President-Elect, Dr. Wm. H. Stewart, 222 West Seventy-Ninth Street, New York City, is arranging the program, and it is hoped that especially those members living west of the Mississippi will communicate with him at their earliest convenience to the end of informing him as to the papers they wish to read.

A number of men living on the Atlantic seaboard have expressed a desire to arrange large parties and visit the interesting points en route. Those interested in this matter should communicate with Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

Western members have always attended the Annual Meetings with a regularity that is most commendable, and since this is the first meeting ever held west of the Mississippi, the matter of reciprocity should obtain among all the Eastern members; they should attend the meeting at Los Angeles in numbers as gratifying as if the meeting were in the East, thus giving evidence in no mistakable manner of their appreciation of the high regard in which they hold the Western members.

BOOK REVIEW

Injuries and Diseases of the Bones and Joints, By Frederick H. Baetjer, M.D., and Charles A. Waters, M.D. Containing 350 pages, 332 roentgenograms and 1 line drawing. New York: Paul B. Hoeber. Price $10.

The authors of this volume have written succinctly and with clearness upon a subject which, although a simple one to the roentgenologist in so far as roentgenographic technique is concerned, is one of the most difficult in the matter of diagnostic interpretation. Thus, Chapter IX, dealing with joint lesions in children, and Chapter XI, on the subject of bone tumors, become the important chapters of the book. Chapter IX is well prefaced by another on the epiphyses (Chapter III), a knowledge of which is so essential in the interpretation of infantile and adolescent bone and joint conditions. The authors tend to simplify the subject of joint lesions in children of the first "age-period," usually of difficult interpretation, by dividing it into three groups, based also on subjective age. For purposes of diagnosis by exclusion, these groups are of great help.

In the chapter dealing with bone tumors, Baetjer and Waters utilize their access to a wealth of material which alone gives the highest authoritative value to their writings. Since upon the roentgenologist is so often placed the responsibility of a decision between malignancy of bone and conditions less grave, the value of this chapter to the student is beyond appraisal. Here are found some of the best illustrations of the book, born of invaluable clinical data, as aforesaid.

The authors very wisely judge that a proper consideration of the spine, as the seat of osseous and synovial abnormality, is worthy of a separate chapter. One regrets somewhat the paucity of illustration and description concerning the low lumbar and sacral regional relationships, as presented by the lateral posture of the patient.

Any literary consideration of the nontuberculous joint lesions in the adult revives old moot points with reference to a classification based upon the findings by *x*-rays. In their description of these processes, the authors use the classification now generally accepted, it is believed, by most clinical investigators, and which is well represented both in description and by illustration.

Many newer fields of diagnosis are suggested. For example, the occurrence of bone genesis in traumatic blood-clot, of which, one may be confident, roentgenologists are destined to see more in the future. This probability is brought to mind by the illustration on page 234, although here the ossifying process is said to be subsequent to, and perhaps complicated by, an arthritic condition.

Chapter XIII, describing anomalies, deals chiefly with those of the spine, although certain anomalous conditions of the extremities are well illustrated, as is also a chapter, immediately following, concerning the dystrophies.

This work is presented in a volume so fashioned that it well serves its purpose of clear exposition and description. The quality of the paper has been chosen carefully with reference to the illustrations, some of which could not otherwise be presented with sufficient clarity. The type is large and therefore clear. As a whole, the excellent features of the volume far outweigh the occasional appearance of typographical errors.

Percy Brown.

TRANSLATIONS & ABSTRACTS

Studies on Experimental Rickets. 1. McCollum, E. V., Simmonds, Nina; Parsons, H. T.; Shipley, P. G., and Park, E. A. The Production of Rachitis and Similar Diseases in the Rat by Deficient Diets. (*J. Biol. Chem.*, January, 1921, xiv, 333.)
2. Shipley, P. G.; Park, E. A.; McCollum, E. V.; Simmonds, Nina, and Parsons, H. T. The Effect of Cod-Liver Oil Administered to Rats with Experimental Rickets. (*J. Biol. Chem.*, January, 1921, xiv, 343.)
3. Shipley, P. G.; Park, E. A.; McCollum, E. V., and Simmonds, Nina. A Pathological Condition Bearing Fundamental Resemblances to Rickets of the Human Being Resulting from Diets Low in Phosphorus and Fat-Soluble A: The Phosphate Ion in Its Preventions. (*Johns Hopkins Hosp. Bull.*, May, 1921.)

In the first paper the writers describe eleven diets and clearly point out the deficiency in each case. Deformities very similar to those noted in rickets are produced by some. From these investigations the writers believe that rickets might be caused by a deficiency of fat-soluble A or calcium in the food or a disturbance of metabolism of these factors. They apparently sum up their observations by saying that at present it is only possible to say that the etiologic factor is to be found in an improper dietetic regimen.

In the second series of investigations, the animals were fed on a diet low in fat-soluble A and another formula deficient in sodium, calcium and chlorine ions. They soon began to lose weight, became extremely irritable, reacting to any stimulus with violent activity. About forty days later, the rats began to develop xerophthalmia. When it became evident that the animals could live only a few days longer, cod-liver oil in addition was administered to part of them, the others being kept on deficient diets as controls.

The bones of the test and control animals showed no difference except on microscopic examination. No calcium was found in epiphyseal cartilages of those animals not receiving cod-liver oil. Following the administration of cod-liver oil, calcium was deposited in the cartilages even though the intake of calcium in some cases was below normal. The deposit of calcium salts i-s linear and apparently propor tional to the length of time the cod-liver oil was given. The calcium is deposited at right angles to the long axis of the shaft of the bone.

The writers believe the cod-liver oil contains some substance or substances which cause calcium to be deposited in rats suffering from experimental rickets in the same manner as it is deposited in the spontaneous healing of rickets in man.

Quick, D. The Combination of Radium and the X-Ray in Certain Types of Carcinoma of the Breast. (*Surg., Gynec. and Obst.*, February, 1921.)

The author gives a résumé of the literature on the use of the *x*-ray and of radium in breast cancer. He states that "a review of the literature creates the impression that in general the worker confining his efforts to *x*-rays alone tends to minimize other physical agents, while the radium therapeutist has attempted to cover too large a field with the amount of the element at his disposal."

During the past two years a consistent effort has been made at the Memorial Hospital to combine the two agents. The use of radium over localized recurrent nodules together with *x*-rays over the regional areas has been of distinct advantage; but it is not in these cases that the combination has the most value. In bulky localized tumors, whether recurrences, metastases or primary inoperable growths, he has been able to imbed radium emanation in the tumors so as to give uniform, diffuse radiation, especially in deeper portions of the mass where the *x*-rays have least effect. The use of the buried emanation does not interfere with the use of the *x*-rays, and unless there is some definite contra-indication the *x*-rays are then given in massive doses over the entire local and regional surface. The *x*-ray treatment is as thorough as though no radium were available.

Seventy-eight cases have been treated by the combined method during the past two and a half years. Seven have shown complete regression of the treated areas and have remained clinically free from the disease for periods of three months to over two years. There were twenty-one partial regressions which are still progressing favorably but are not yet clinically free. Many cases were temporarily benefited, among these being twenty-four cases in which there was local improvement but final spread of the disease by distant metastases. Ten cases showed no improvement, but all of these were not only far advanced locally but had widely disseminated metastases. Of the seventy-eight cases fifty-seven were recurrent and twenty-one primary.

Attention is directed to the fact that most cases presenting themselves for treatment by physical agents are the worst types of cancer; treatment must be looked upon as palliative, and where cure is obtained it must be looked upon as a distinct victory. In certain cases of recurrent cancer where the lesions are localized or grouped, and in cases in which there is pleural involvement, he especially advises treatment by radium. Even localized bone lesions should receive radium treatment.

CONCLUSIONS

1. The x-ray occupies a place in the treatment of every case of carcinoma of the breast.

2. In certain cases radium may be used to considerable advantage in combination with the x-rays.

3. The cases in which radium proves valuable in this combination are mainly:

(*a*) Localized flat recurrences, where surface applications of radium can be made directly over the lesion.

(*b*) Bulky recurrences, where radium emanation can be imbedded directly in the tumor.

(*c*) Axillary involvement, which is always difficult to influence favorably with x-rays alone, where radium emanation can be imbedded in the neoplasm or in axillary fat tissue so as to give a diffuse radiation of the axillary space from within.

(*d*) Inoperable primary cases, where imbedded emanation can be utilized to radiate the tumor from within, as well as the axilla, and even supraclavicular space in the same way if necessary.

(*e*) Primary cases refusing operation, where treatment may be carried out much in the same way as in the inoperable primary cases.

4. The combination of radium and x-rays may in some instances change an inoperable into an operable case.

He finally points out reason for encouragement in pursuing the study of radium and x-ray treatment of mammary cancer, in that such treatment produces a powerful destructive effect on the tumor tissue amounting to local necrosis, the lymphatics may be considered sealed, invisible vagrant cells are incarcerated or destroyed, and all this accomplished without removing the natural barriers which exist against progressive carcinoma. Both types of radiation tend to increase the exudation of lymphocytes and plasma cells and growth of connective tissue around the tumor, and these are the only natural agents of resistance to carcinoma.

Treatment, therefore, is based on sound theory, since it intensifies the natural reaction of the tissues to carcinoma while producing in addition a strong destructive action on the tumor cells.

Hence he feels that the scope of operability of mammary cancer should be reduced. The same principle should be applied as in uterine carcinoma; early cases should be operated and later ones radiated.

A. C. C.

Kleinberg, S. Traumatic Spondylolisthesis; Report of Two Cases. (*Arch. Surg.*, July, 1921.)

A review of the literature indicates that dislocations of the 5th lumbar vertebra are very rare.

Roentgenographic findings are difficult of interpretation because (1) the 5th lumbar vertebra has a wide range of normal morphologic variation; (2) the forward inclination of the 5th lumbar and sacrum makes it difficult to obtain a clear outline of these bones; (3) overdeveloped transverse processes of last lumbar or 1st sacral segment change or obscure the relation of the 5th lumbar, sacrum and iliac bones, and (4) the proximity of the iliac bones interferes with obtaining a good lateral view

In studying the lumbosacral region it is necessary to take antero-posterior, lateral and oblique views. Stereoscopic roentgenograms are preferable to flat views.

The cardinal clinical evidences of spondylolisthesis are (1) prominence of the sacrum; (2) a hollow, palpable and frequently visible, immediately above the sacrum; (3) pains in the back and lower extremities; (4) weakness and stiffness of the back; (5) lordosis; (6) forward bending of the trunk; and (7) tenderness of the lumbosacral region.

The combination of these symptoms, especially after trauma, strongly suggests dislocation of the 5th lumbar, but roentgenograms are necessary to demonstrate the lesion.

The writer reports two cases in detail and comments upon them.

The roentgen appearance of the 5th lumbar vertebra in spondylolisthesis is peculiar and pathognomonic. In antero-posterior plates are seen the crescentic outline of the body and the pedicles of the 5th lumbar, its laminæ, spinous process and spinal foramen. The lateral view shows the shadow of the body of the 5th lumbar in front of the sacrum. The writer believes the roentgenographic appearance is characteristic and diagnostic of spondylolisthesis.

A. C. Christie.

Johnson, H. McC. *X*-ray in the Diagnosis of Prostatism. (*Surg., Gynec. & Obst.*, February, 1921, p. 179.)

Under the term "prostatism" the author includes those urinary difficulties of men caused by obstruction at the bladder neck due to glandular enlargement of the prostate, to fibrous changes in it, or to coarctation of the internal orifice of the bladder. The diagnosis is usually based upon the symptoms, information gained by palpation, determination of urethral length and presence of residual urine, and cystoscopy. There are certain conditions that will escape diagnosis by these methods. The cystoscope will not tell the size and shape of diverticula or presence of prostatic calculi, and may overlook an encysted stone. It gives no information of the ureters above the orifices. There are also cases where cystoscopy is contraindicated. The author's purpose is to emphasize the value of cystoscopy and roentgenography when used in conjunction. He employs the following technique: Three *x*-ray exposures are made, the first with the bladder empty, the second with the bladder filled with room air, and the third with the bladder filled with 10 per cent sodium iodide or bromide solution. The object of Plate I is to locate calculi in the prostate and free or encysted calculi in the bladder, and to outline gas in the bowel that may confuse the reading of Plate II. The object of Plate II is to outline an enlarged prostate or other tumefactions. Plate III is made to show diverticula, to show the shape and size of the bladder, and the presence of saccules or dilated patulous ureters.

The author believes that some of the unsatisfactory results of prostatectomy will be eliminated by the routine use of roentgenography in conjunction with cystoscopy.

A. C. C.

Renon and Degrais. Remote Results of the Radium Treatment of Myelogenous Leukemia. (*Bull. Acad. de méd.*, February 15, 1921.)

Since 1910 the writers have treated eight patients with myelogenous leukemia by applications of radium to the spleen. The technique consisted in applications of 2.4 mm. radium element filtered by 2 mm. lead, and 1 cm. of gauze to each square cm. of surface treated, representing 4.848 mgm. hours of radium. The total amount of radium used was 101 mm. of radium element represented by 189 mgm. of radium bromide. The treatment extended over forty-eight hours.

Death has occurred in all eight of the cases treated. The intervals between the treatment and death were as follows: Two years two months; thirteen months; three years, one month; six years, six months; one year; three years, six months; one year, eight months; two months.

The immediate effects were remarkable; the spleen which occupied the entire abdominal cavity diminished rapidly in volume and returned to normal. The number of white cells fell from 320,000 to 7,000; the blood picture was changed; the myelocytes disappeared, and the number of red cells increased; the general condition was improved; the fever disappeared, and the weight increased one kilo or more a week. Two of the patients became pregnant. One of them went to term and the child, living to-day at the age of six years, has shown no evidence of leukemia.

After four to six weeks of treatment the patients are apparently cured. In reality this cure is only apparent, and after two to eighteen months the symptoms of leukemia reappear. The white cell again increase in number and the spleen enlarges. The application of radium is again commenced but the result is not equally good; the number of white cells falls off less rapidly and a longer time is required for the reduction to normal of the spleen. Apparently the patients develop a tolerance to radium; the white cells become apparently radio-resistant and eventually the radium appears to have on influence upon them. The pathogenesis of this resistance has not yet been determined. It may be a simple acquired tolerance of the white cells to radium, analogous to the tolerance of the spirocheta for arsenic, or it may be that the fibrous transformation of the leukemic spleen under the action of radium has some effect upon the myelocytes. Recurrences take place more quickly in patients who have been previously treated by the *x*-rays than in those previously treated by radium.

The writers recommend that the spleen be treated by radium in large doses and that the long bones receive radiation with the *x*-ray.

Lowell S. Goin.

Hirsch, O. The Radium Therapy of Hypophyseal Tumors. (*Arch. f. Laryngol. u. Rhinol.*, 1921, xxiv, No. 1).

Because of rather uncertain results obtained by surgery in hypophyseal tumors, Hirsch has been led to attempt their radium treatment. His early results were bad, but by progressively increasing the dose of radium he was able after seven failures to obtain some very satisfactory results. His statistics include 28 cases, about one-half of which are still under treatment.

In his hands radium therapy has habitually been preceded by surgical intervention. A cure may be effected surgically in cases of cystic tumor, but in the case of acromegaly without visual disturbances, or a hypophyseal adenoma, radium treatment is indicated.

The first application of radium is not made until the operative wound is healed in order to avoid all risk of infection.

The technique consists in the use of 20 mgm. of radium filtered by from $\frac{1}{2}$ to 1 mm. of brass and placed in contact with the tumor for twelve hours. At times one treatment is sufficient to excite a reaction, but more often a number of applications are required.

The action of radium, however, varies with each case. It may manifest itself by an improvement in the visual disturbance and the acromegalic hypertrophies, by an improvement in the trophic disturbances, or by a return of menstruation. In general, one may say that the results are better when the hypophyseal tumors are accompanied by acromegaly and symptoms of hypersecretion then when accompanied by ocular disturbances and the phenomena of hypersecretion.

In two cases the author observed accidents which might be imputed to the radium therapy. The first was a man, twenty-four years old, with acromegaly and marked visual disturbances. He received two applications of radium, with a five weeks' interval, with much improvement; but at the end of six weeks a severe glycosuria appeared and the patient promptly died in coma. It is possible that because of his youth this patient was particularly susceptible to the action of radium. In the second case a fatal hemorrhage occurred one year after a series of fourteen applications of radium. No autopsy was had and the cause of death has not been satisfactorily explained.

L. S. G.

Kirklin, B. R. A Plea for Routine X-Ray Examination of the Gall-Bladder Region in Every Chronic Abdomen. (*J. Radiol.*, Vol. II, No. 4.)

One should not limit one's efforts to the demonstration of the gall-stones, which are usually of secondary importance, but should attempt a demonstration of the pathological gall-bladder. As to technique, the writer administers a cathartic on several evenings preceding the examination and examines the fasting patient. From three to six exposures of the gall-bladder region, including the area between the tenth rib and the crest of the ilium, are made, varying pentration, time, etc., but with constant time factor in development, thus obtaining plates of varying densities. A barium meal, is then administered and search is made for secondary signs of gall-bladder disease. Any shadow on the *x*-ray plate which is interpreted as being gall-bladder shadow, represents, in the writer's opinion, a pathological gall-bladder. The secondary signs are:

1. Hepato-fixation of the stomach, the pyloric region being drawn upward and to the right.
2. Characteristic deformity of the first portion of the duodenum and possibly the second portion, due to adhesions.
3. Outlining of enlarged gall-bladder by pressure on the duodenum or the antrum.
4. A definite small area of pain on pressure accurately localized on the outer side of the shadow of the duodenum, usually accompanied by a delay in the duodenum.
5. Pressure of Riedel's lobe of the liver when demonstrable, following gas distension of the stomach and colon.
6. Hypermotility of the stomach and unusual visibility of duodenum.

The writer reports 128 cases of gall-bladder disease demonstrated by *x*-ray methods, in 92 per cent of which diagnosis was verified by operation.

L. S. G.

Rosenfeld, Arthur S. Idiopathic Purpura with Unusual Features. (*Arch. Int. Med.*, Vol. XXVII, No. 4.)

Purpura is an extremely rare condition, considered by many as being merely a manifestation of some other disease, but there are familiar tendencies to the purpuric diathesis which rather speak for the disease as a definite entity. The writer reports two cases occurring in brothers showing constant bone changes as seen in the radiograms of the knees and elbows. These changes consist in an enlargement of the piphyses of the bones with well defined areas of rarefaction, slight roughening of the articular surfaces as in osteo-arthritis and, in the knee joint, a definite thickening of the soft structures of joint, such as one sees in bloody joint effusions.

Our knowledge of pathology of this condition has been gained by *x*-ray study, operation, and by a few autopsies in cases that have succumbed to intercurrent conditions. The hemorrhages occur most often in the knee-joint. Following a slight blow, or often spontaneously, there develop signs of acute joint affection with effusion. If the effusion persists it goes on to inflammation with a fibrinous effusion, as in the ordinary tuberculous "white swelling." This condition is simulated almost perfectly, but the x-ray will show that the bone is not involved, and that the process is confined to the soft parts of the joint. In this stage synovial villæ are present as well as defects in the joint cartilages. The x-ray shows changes in the epiphyseal lines, which are zig-zag and have a worm-eaten appearance. The condylar outlines are not sharp. There is bone atrophy with rarefaction of the condyles. If hemorrhages occur in the joint often enough there is a third stage in which there are contractures, bone and joint changes, thickening of the periarticular structures and even ankylosis.

L. S. G.

Ingraham, C. B. Impressions Gained from the Use of Radium During the Past Year. (*Colorado Med.*, Vol. xviii, No. 4.)

The writer's results in the treatment of superficial epitheliomata have been universally good. Three cases of cancer of the face, two of which involved the antrum, and one of the cheek inside the mouth, have been disappointing. Of three cases of cancer of the tongue, two died and one made gratifying improvement. Two cases of cancer of the esophagus died. A cancer of vulva remained well for seven months when the patient died of pneumonia without any sign of recurrence. In two cases of sarcoma, one arising from ethmoid and one from frontal, gratifying immediate results were obtained. Much improvement followed the radium treatment of four cases of vernal conjunctivitis. Marked improvement followed the treatment of eight cases of carcinoma of the cervix. The writer expresses satisfaction with results following radium treatment of the uterine fibroids.

L. S. G.

Ashbury, Howard E., and Goldstein, Albert E. The Combined Examination of the Urinary Tract by the Urologist and the Roentgenologist. (*South. M. J.*, September, 1921.)

The essay is based upon the study of 250 cases that have come to the Urological Clinic of the Hebrew Hospital of Baltimore during the past two years, in which a combined study was possible; it outlines the method of procedure and basis of interpretation, which save time and the annoyance of repeated cystoscopies, and which make possible a prompt and accurate visualization of existing pathology. The deductions offer a fair example of the limitations of the two methods individually and give a practical idea of the value of the combined study in so far as the reduction of the percentage of failures and the large percentage of proven correct diagnoses are concerned.

In all the cases studied, plain roentgenograms were made of the entire urinary tract, and then the cases were studied urologically, using all recognized methods of procedure.

Capacity in all cases was first determined with sterile water or salt solution. The administration into the renal pelvis of opaque solutions should be performed by competent urologists, who may use either the syringe or the gravity method, the syringe being used in these cases.

The plain roentgenograms in urological cases necessarily divide themselves into those giving positive findings and those giving no evidence of disease. The latter far exceed the former, and include a large percentage of non-radiable calculi, of uric acid composition. These are located principally in the bladder.

Of the 250 cases studied, 152, or 60.8 per cent, demonstrated pathological lesions in the urinary tract, and 98, or 39.2 per cent, demonstrated no urological lesions. The plain roentgenograms gave evidence of disease in 50 or 32.7 per cent.

Out of a total of 46 urinary calculi, 41, or 89.1 per cent, gave evidence on the plain plate; 5 cases in which no evidence of shadow was seen on the plain plate were vesical calculi and were diagnosed by cystoscopy and cystography. It is interesting to note that all the ureteral calculi that were diagnosed gave a definite shadow in the plain plates, which is contrary to the published statistics.

One hundred and forty-eight cases, or 97.3 per cent, gave evidence of disease by the urological method; 104 or 61.7 per cent, were positive from the urological findings, and 44, or 38.3 per cent, were doubtful. The 44 doubtful cases were finally diagnosed by the combined method, leaving only 4 cases undiagnosed.

The entire 152 cases which presented pathology were verified by an operation of some character. In the 4 undiagnosed cases exploratory operations were advised, and pathological conditions were demonstrated at the operation.

CONCLUSIONS

1. By the combined method of examination our results show only 1.6 per cent of failures.

2. Urological lesions were demonstrated frequently by aid of the x-ray where they were doubtful in the two examinations individually.

3. In over 50 per cent of the cases in which the plain roentgenogram was negative pathological conditions were found by the combined method of examination.

4. The plain x-ray findings should in all cases be verified by the urologist before a conclusive diagnosis is given.

5. The combined method is the ideal procedure for the diagnosis of urological conditions.

Auer, John, and Witherbee, William D. Studies on Decreasing the Reaction of Normal Skin to Destructive Doses of X-Rays by Pharmacological Means, and on the Mechanism Involved. (*J. Exper. M.*, June, 1921, Vol. xxxiii, No. 6.)

When a fixed area of the ears of rabbits is subjected to the action of a standard destructive dose of x-rays (30 skin units), the type of reaction resulting depends upon the previous treatment of the rabbit. (1) In normal rabbits a mild acute inflammation develops in the x-rayed area which leads at once to a perforating gangrene within an average of fifteen days. (2) If rabbits are x-rayed and about two weeks later injected with horse serum for the first time, a mild acute inflammation appears which heals for a time; then a second, subacute inflammation sets in which leads to a perforating gangrene. The average time of the process from the first inflammation to gangrene is thirty-two days. (3) If rabbits are sensitized with horse serum and ten days later are exposed locally to the standard dose of x-rays, the ensuing ear reaction is either similar to the second reaction described above, except that it may last up to 110 days, or the first inflammation leads to a healing which may be apparently permanent (340+ days). (4) If rabbits are first sensitized with horse serum, exposed locally to the standard dose of x-rays ten days later, and thirteen days after the x-ray treatment reinjected with horse serum, the reaction of the x-rayed area of the ears is in general similar to the second reaction described above (inflammation-healing—inflammation-gangrene). The average time of the whole process is about forty-two days.

On the basis of the general hypothesis that an anaphylactic reaction is initiated in the body when the specific antibody meets its antigen, and that both antibody and antigen are rendered more or less functionally inert by their interaction, the following inferences may be drawn from our experimental results. (1) The protection from the effects of a standard destructive dose of x-rays which a previous sensitization confers is referable to the presence of anaphylactic antibodies in the x-rayed area. (2) This protection is largely due to the anaphylactic antibodies which are anchored in the x-rayed area, and not to those which are free in the circulation. (3) An anaphylactic reaction renders the anchored anaphylactic antibodies largely impotent as protective factors against the standard destructive x-ray dose, even though sensitization preceded exposure to the x-rays. (4) An area treated with the standard destructive dose of x-rays is unable to produce or to anchor a sufficient amount of anaphylactic antibodies for protection from necrosis, when the x-ray treatment precedes the sensitization, or when the locally anchored anaphylactic antibodies are rendered functionally inactive by a general anaphylactic reaction.

It is possible that the procedure of increasing the resistance of the skin to a destructive dose of x-rays by means of a previous sensitization with protein may be applicable in the treatment of certain types of inoperable disease, when it is important to use massive doses of x-rays.

Animals which have been sensitized, or sensitized and reinjected with any undenatured alien protein, should not be reemployed as normal controls in any investigation unless trial has shown that these proteinized animals react quantitatively and qualitatively like normal animals.

The presence of an abnormal reactor in a group of supposedly normal animals may be an indication of a previous proteinization.

Murphy, Jas. B., Witherbee, Wm. D., Craig, Stuart L., Hussey, Raymond G., and Strum, Ernest. Effects of Small Doses of X-Rays on Hypertrophied Tonsils and Other Lymphoid Structures of the Nasopharynx. (*J. Exper. M.*, June, 1921, Vol. xxxiii, No. 6.)

The small series of cases reported here shows the possibility of materially reducing the lymphoid deposits of the nasopharynx by comparatively small doses of x-rays. Animal experiments had shown that it is possible with x-rays to induce any degree of atrophy of the lymphoid tissue without damaging other tissues. In the series of treated individuals, in all but three or four instances one treatment gave an entirely satisfactory result. In two refractory cases a second treatment was followed by the desired degree of atrophy and a clearing up of the pathological condition. It is most probable that the other few individuals who did not respond to the one treatment would have yielded on further exposure to x-rays, but unfortunately the observations were discontinued before this point could be determined.

The degree of atrophy to be aimed at is a matter that experience will decide. If a reduction below the normal size and the clearing up of obvious pathological states is sufficient, as has been indicated in the majority of the cases treated and observed by us, there seems to be no reason for carrying the treatment beyond this point. In view, however, of the mild nature of the treatment recommended it appears entirely safe to repeat it at suitable intervals so as to secure almost any degree of atrophy that may be desired.

The original idea in taking up this work was that the excess of lymphoid tissue interfered with the clearing up of local infections of the pharynx. It seems probable, however, that the disappearance of infection of the tonsils and change in bacteriological flora after *x*-ray treatment are due to the opening up and proper drainage of the crypts which follow atrophy, rather than the actual removal of the excess lymphoid tissue.

Tonsils which have been exposed to the *x*-rays and not sufficiently reduced in size would in all probability be as amenable to surgical removal as before the *x*-ray treatment, for we have never seen any evidence of fibrosis in the lymphoid organs of animals after similar treatment.

Forty-six individuals with tonsils both hypertrophied and otherwise pathologically altered and some of whom had in addition adenoid masses and lymphoid deposits posterior to the pillars of the fauces, were given exposures to *x*-rays. In all but four cases the treatment was followed by marked atrophy of the tonsils and the other lymphoid deposits, attended by an opening and drainage of the tonsillar crypts. As this process progressed the previously enlarged tonsils assumed a smooth and normal appearance and the hemolytic bacteria—streptococci and staphylococci chiefly—which were often present in the affected tonsil, disappeared usually within four weeks of the treatment.

Spinelli (Naples). Contributions to the Radium-Roentgenological Treatment of Cancer of the Uterus.

The author gives his cancer patients the benefit of special service to determine the organic resistance and to stabilize the general condition. Thus he tests the blood and the renal functions. In order to increase the resistance he treats the patients with neosalvarsan and colloid metals. He injects mesothorium solutions into the primary tumor and metastases whenever this is possible. He then uses both radium and *x*-rays.

Radium is indicated in precancerous lesions and localized primary growths either in the cervix or corpus uteri; the *x*-rays are indicated in infiltration of the parametria and should be ultra-intensive.

The author also believes that diathermy is valuable for increasing organic resistance, or, better, that it makes the cancer cell more sensitive to the action of the rays.

Fischer, Joh. Fred. (Copenhagen). The Roentgen Treatment of Morbus Basedowii. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

Among 490 patients treated for goiter there were eleven men. The material at hand is divided into two parts, viz., those treated at hospitals, and private out-patients, the majority of the former belonging to the working classes, and the latter for the most part to the well-to-do classes.

The prognosis varies within these two classes; it is most favorable for the well-to-do, because the working-class patients are not, as a rule, able to take the care so necessary in this disease. In four-fifths of the cases a positive result was attained, with complete or partial cessation of symptoms. Recurrences occurred principally among the poorer patients; on the whole, the duration of the results attained was satisfactory. Nervousness and pulse rate decreased, increase in weight was usual, in several cases the increase was about 20 kilo. Perspiration and diarrhea disappeared, likewise glycosuria which was observed in 3 per cent of patients. In 25 per cent the pulse had become normal and in 50 per cent it had decreased considerably in frequency. Exophthalmia in several cases had disappeared.

Serious complications are precluded if the administration of roentgen rays is carried out with care, so that in the severe cases one should not run the risk of roentgen intoxication.

The usual dose has been 10 H. with 3 mm. aluminum filters in 4 fields, the one on thymus.

Heyerdahl, S. A. (Kristiania). Radium Treatment of Changes in the Thyroid Gland. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

In the Radium Institute of the Rikshospital twenty-four cases of goiter have been treated with radium since 1913.

The eight cases of plain goiter have been partly serious cases. In all of them the goiter has diminished during radium treatment. In two cases almost complete cure was achieved. In six cases there was a change for the better.

Of the eight cases of toxic goiter one case was almost cured, five cases improved and two not improved. The radium treatment had an absolutely favorable influence on the general state of health and on the nervous symptoms. The sleep and appetite improved, the weight increased and the state of mind became more composed. The pulse calmed and the size of the goiter diminished. The exophthalmos was least influenced.

Of the eight cases of struma maligna five were temporarily improved; in three cases there were no good effects on the tumor.

Klason, T. (Stockholm). Pericarditis Calculosa and Heart Calcifications. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

The author calls attention to the fact that pericardiac calcifications have a tendency to be situated on the lower surface of the heart. He is of the opinion that these calcifications are often split, having the shape of a net, and form a ring around the heart below the sulcus coronarius. One calcification inside the annulus fibrosus was sharply limited and had no rays. As to the diagnosis, the most important thing is fluoroscopy with a sufficiently hard tube. The seat of the calcifications along the sulcus coronarius is the cause of the often unimportant symptoms of deranged circulation.

Sinding-Larsen, Chr. M. F. (Kristiania). A Hitherto Unknown Affection of the Patella in Children. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

The author gives the records and roentgenograms of two otherwise healthy girls, aged ten and eleven years, who after overstraining themselves by dancing, jumping, etc., had complained of pain *in their knees*. When seen by the author the affection in both cases was *clinically unilateral*, located in one of the patellae, which was painful on percussion; only in one of the cases were the soft parts above and below the patella slightly inflamed (swollen).

Roentgen plates of the knees taken in profile showed the anterior or lower outlines of the painful patellae hazy, with abnormal calcium salts—or bone shadows in the soft parts (periosteum?) along and below them, *the author thinks as a result of periostitis or epiphysitis through overstrain*. The tibia in one of the cases showed a mild form of Schlatter's disease.

The roentgenograms of the apparently healthy knee in both cases showed similar abnormalities of the patella in a less degree.

One case had a plaster of Paris bandage for six weeks; the other was simply ordered to keep quiet.

After about one-third of a year the patellae of both cases were quite all right, and their roentgenograms normal.

Abrahamsen, H. (Copenhagen). Koehler's Disease, Especially with a View to Its Pathogeny. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

It concerns a seven-year-old boy who drags his right leg somewhat. On objective examination only an atrophy of the lower leg was found. The roentgen examination made on April 22, 1920, showed that the os naviculare was missing. It may be imagined to be the "preliminary stage" of Koehler's disease. He was treated with thyroidin for a couple of months or so, and the roentgenogram showed that the os naviculare had grown considerably and was 7 mm. in diameter. The contours are irregular and the picture is typical of Koehler's disease. One month later the diameter was 9 mm.

This case seems to speak in favor of Koehler's view, namely, that the disease is due to an anomaly in the development. One cannot divest one's mind of the idea that the thyroidin preparation has played a certain part in the development of the bone.

Strom, S. (Stockholm). On the Roentgen Diagnostics of Changes in the Appendix and Cecum. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1, No. 2.)

A normal appendix can be proved at the roentgen examination just as well as a pathological one.

The pathologic-anatomical changes in chronic appendicitis are of several different kinds, and the roentgen picture is therefore not uniform, but shows different combinations of anatomical and functional changes.

In the roentgen examination of the appendix one should attach special importance to pronounced changes in its form, such as stenoses and kinks together with adhesions. Hereto may be added, as pathological symptoms, spasm, hypermotility and tenderness on pressure. Retention in the appendix after the emptying of the cecum should be interpreted as a pathological symptom only with extreme caution.

Incompetency in the ileocecal valve, established by examination with enema, is of no value as a symptom of changes due to chronic appendicitis and probably not as a pathological symptom at all.

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VEILS IN THE RIGHT HYPOCHONDRIUM AND THEIR DIFFERENTIATION FROM OTHER ORGANIC LESIONS AND SPASM*

BY LEWIS GREGORY COLE, M.D.

NEW YORK CITY

THE roentgen findings and the clinical symptoms of congenital or acquired veils in the right hypochondrium simulate those of gastric cancer, gastric ulcer, or postpyloric ulcer or pylorospasm to such a degree that they demand special consideration; first, because their recognition will materially reduce a percentage of erroneous roentgen diagnoses, and secondly, because some of these veils are of sufficient clinical significance to demand surgical procedure. All these conditions deform the cap, stomach, or duodenum, hence the characteristic roentgen findings of gastric cancer, gastric ulcer, postpyloric ulcer and pylorospasm have been more or less accurately described in previous articles. Time will not permit of their reiteration here. But an attempt will be made to describe the roentgen findings of these congenital or acquired veils.

Veils in the right hypochondrium have been recognized by surgeons and pathologists and described in various terms. Morris in 1905[1] referred to them as "cobwebs in the attic" and Harris in 1914[2] described them in a more scientific but less picturesque term, and his friends have connected his name with this condition, namely, the Harris membrane. Morris considered that this condition, which he referred to as "cobwebs in the attic" was of "gall spider" origin and therefore an acquired pathological condition caused by the penetration of toxin through the thin wall of the gall-bladder and its ducts. He states: "When there is an infection on a mucosal side of these thin-walled structures, toxins penetrate the walls in sufficient force to cause a toxic desquamation of the endothelium on the peritoneal side, endothelial cells are shed, plastic lymph exudes, coagulates, and is replaced by connective tissue"—and "webs of adhesions are spun," from the biliary tract to the adjacent hollow and solid viscera.

Morris evidently intended to differentiate these "cobwebs in the attic" from the dense inflammatory adhesions associated with an acute, subacute, or chronically inflamed gall-bladder, or one that contained stones or thick inspissated bile that could not be expelled. My reason for believing this is the following. Morris says: "Many a surgeon has been nonplussed by operating for gall-stones, finding no stones, and yet having the patient make a remarkable gain in general health, the fact that these adhesions were separated, incidentally, having been overlooked as a factor." He further states: "It is safer not to speak of gall-stones anyway, speak of choleocystitis." If this is the surgeon's privilege, why not the roentgenologist's?

In this article we will only consider the veil, or membrane, or cobweb adhesions in the right hypochondrium which occur in cases where the pathological condition of

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[1] *Am. Med.*, July 15, 1905, x, No. 3, 95–97.

[2] *J. Amer. Med. Assn.*, April 1, 1914.

the gall-bladder *is not sufficiently extensive* to enable the surgeon to detect it by inspection or palpation of the gall-bladder and where the gall-bladder does not contain stones or inspissated bile which cannot be expelled, that is, in those cases where the gall-bladder is apparently normal. Harris recognized veils in the right hypochondrium; and in the first case operated on he considered that it was of inflammatory origin resulting from gall-bladder infection, although the bladder contained no stones and was apparently normal. Subsequently, from a study of six operative cases and an extensive study of embryological development of the peritoneum in this region, he concluded that this veil or membrane was an abnormal fold of the anterior mesogastrium, this mesogastrium being what medical students of my day knew as the "gastrohepatic ligament." In his article Harris graphically describes the embryological development of the peritoneum in this region and recites the clinical symptoms of these six cases and describes the roentgen findings.

The veil or membrane which Harris describes extends from the gall-bladder to the descending duodenum, or from the hepatic flexure of the colon to the descending duodenum.

Harris' reference to the roentgen diagnosis is as follows: "The use of the roentgen ray with the bismuth meal is a very valuable aid in the diagnosis, the long large caput showing a dilated first and perhaps a second portion of the duodenum with a fixed point at the right of the constriction." I believe that these roentgen findings described by Harris were what he thought they should be rather than what they really are, or, if we are to take him absolutely at his word both as to the location and extent of the veil which he described, the roentgen findings would then coincide with this condition; but, veils of the particular type and of the extent that he described form such a small proportion of the veils in the right hypochondrium that one would not be justified in applying his description or name to them; but I do believe that great credit should be given to him for drawing attention to the fact that at least some of these veils are of congenital origin.

During an intensive roentgenological study of this region of the alimentary tract, many cases of cap, stomach, and duodenal deformities were observed which were not characteristic of cancer, ulcer, postpyloric ulcer, pylorospasm, or of definite choleocystitis, with or without stones, and these simulated each other to such a degree that it was evident that these roentgen findings were all caused by the same or similar conditions. In hunting for a pathological condition to account for this group of roentgen findings I ran across Harris' article, and in spite of the roentgen findings which he described and his pathological description of the veil I have often used his name in describing them; but from a more careful study of his article, particularly if we accept his roentgenological findings, one is compelled to admit that the roentgenological and surgical findings of my cases do not coincide with those which he described.

I am convinced that Morris' "cobwebs in the attic" of "gall spider" origin and the abnormal fold of the anterior mesogastrium, part of which was described by Harris, are so similar that they cannot all be differentiated from each other either by roentgenological examination or by surgical exploration, but whether the etiological factor is a "gall spider" or some prehistoric monkey is of little interest to me; therefore, this condition will be referred to as a veil, congenital or acquired. I believe that both Morris and Harris were right in concluding that this veil causes symptoms. Whether or not surgical procedure is necessary in these cases depends on the severity or persistency of the symptoms; and whether or not permanent relief is obtained by surgical procedure is not within the scope of this article. Too short a time has elapsed since these cases have been operated upon, to determine this, but immediate relief has been obtained in most of the cases, and one of the cases has been free from symptoms for about six years.

The roentgen findings which are characteristic of a veil in the right hypochondrium are as follows:

1. The cap and perhaps the extreme pyloric end of the stomach are partly constricted or compressed, and fail to fill

FIG. 1. Sketch of anatomical specimen showing a veil in the right hypochondrium involving: 1, the cap; 2, the neck of the gall-bladder; 3, the descending duodenum; 4, the pyloric end of the greater curvature of the stomach; 5, the hepatic flexure of the colon.

FIG. 1. Plan d'un spécimen anatomique démontrant à la vue une voile dans le hypochondre droit comprennant; 1, le bulbe duodénale; 2, le cou de la vésicule biliaire; 3, le duodénum descendant: 4, l'extrémité pylorique de la courbure plus grande de l'estomac; 5, la flexion hépatique du colon.

FIG. 1. Esquema de espécimen anatómico demostrando un velo en el hipocondrio derecho, que envuelve: 1, el bulbo duodenal: 2, el cuello de la vesicula biliar: 3, el duodeno descendiente: 4, el extremo pilórico, de la gran curvatura del estómago: 5, el asa hepatica del colon.

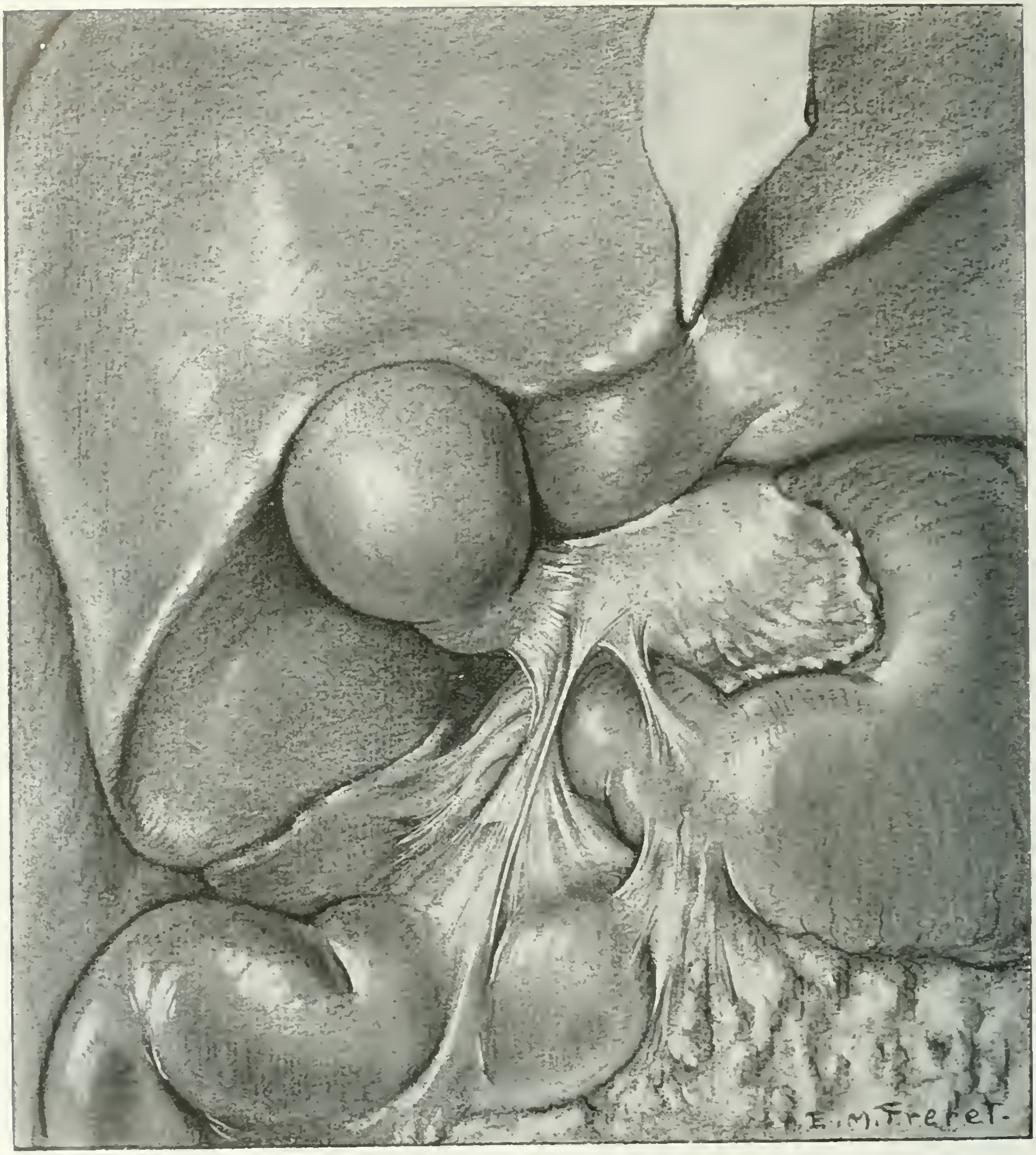

FIG. 2. Sketch of anatomical specimen (female, aged seventy) showing a veil involving: 1, the cap; 2, the pyloric end of the stomach; 3, the gall-bladder; 4, the hepatic flexure of the colon.

FIG. 2. Plan d'un spécimen anatomique (une femme ayante soixante-dix ans) démontrant à la vue d'une voile comprenant: 1, le bulbe duodénale; 2, l'extrémité pylorique del'estomac; 3, la vésicule biliaire; 4, la flexion hépatique du colon.

FIG. 2. Esquema de especimen anatómico (mujer de 70 años) mostrando un velo que envuelve: 1. el bulbo duodenal: 2, el extremo pilórico del estomago: 3, la vesicula biliar: 4, el asa hepàtica del colon.

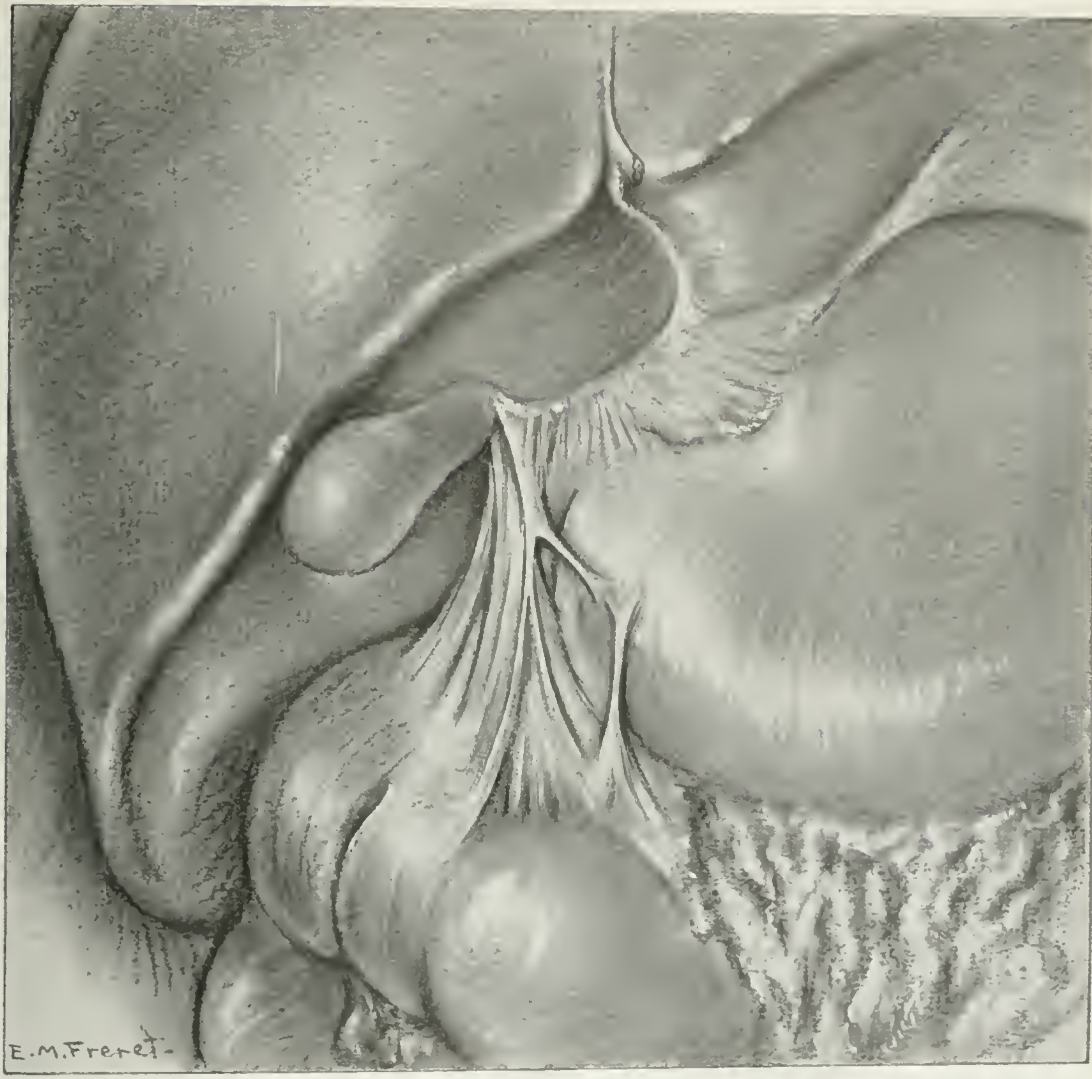

Fig. 3. Sketch of anatomical specimen (boy, aged seventeen) showing a veil involving: 1, the cap (slightly); 2, the pyloric end of stomach; 3, the cystic duct; 4, the hepatic flexure of the colon.

Fig. 3. Plan d'un spécimen anatomique (un garcon ayant dix-sept ans) démontrant à la vue d'une voile comprennant: 1, le bulbe duodénale (un peu); 2, l'extrémité pylorique de l'estomac; 3, le canal cystique; 4, la flexion hépatique du colon.

Fig. 3. Esquema de espécimen anatomico (varon, de 17 años) mostrando un velo que envuelve: 1, el bulbo duodenal (ligeramente); 2, el extremo pilorico del estomago; 3, el conducto cistico; 4, el asa hepática del colon.

FIG. 4 and 4'. Illustrates a veil that involves the outer surface of the cap, the gall-bladder and hepatic flexure of the colon filled with gas.
FIG. 4 et 4'. Démontrant une voile qui comprend la surface extérieure la du bulbe duodénale, vésicule biliaire et la flexion hépatique du colon emplie par le gaz.
FIG. 4 et 4'. Ilustrando un velo que envuelve la cara externa del bulbo y duodenal, la vesicula biliar y al asa hepática del colon llenos de gas.

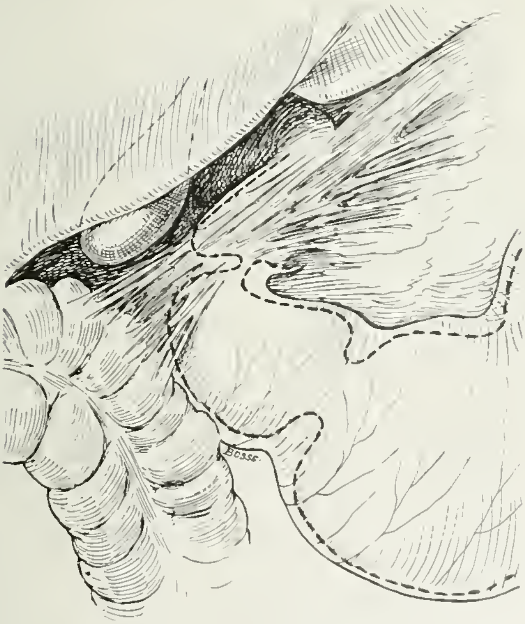

FIG. 5 and 5'. Illustrates a veil that involves the anterior surface of the cap and hepatic flexure of the colon.
FIG. 5 et 5'. Démontrant une voile qui comprend la surface antérieure du bulbe duodénale et la flexion hépatique du colon.
FIG. 5 et 5'. Ilustrando un velo que envuelve la cara anterior del bulbo duodenal, y el asa hepatica del colon.

FIG. 6 and 6'. Illustrates a veil that involves the lesser curvature of the stomach and the superior surface of the cap.
FIG. 6 et 6'. Démontrant une voile qui comprend la courbure moindre de l'estomac et la surface supérieure du bulbe duodénale.
FIG. 6 et 6'. Ilustrando un velo que envuelve la curvatura menor del es, tomago y la cara superior del bulbo duodenal.

Fig. 7 and 7′. Illustrates a veil that involves the anterior surface of the cap, anterior surface of the descending duodenum and the hepatic flexure of the colon. The gall-bladder indenting the upper surface of the descending duodenum is also probably involved in this veil.

Fig. 7 et 7′. Démontrant une voile qui comprend la surface antérieure du bulbe duodénale, la surface antérieure du duodenum descendant et la flexion hépatique du colon. La vésicule biliaire poussant la surface supérieure du duodenum descendant est probablement aussi affectée dans cette voile.

Fig. 7fet 7′. Ilustrando un velo que envuelve la cara anterior lde bulbo duodenal, la cara anterior del duodeno descendiente y el asa hepatica del colon. La vesicula biliar, indentando la cara superior del duodeno descendiente, está probablemente tambien en este velo.

Fig. 8 and 8′. Illustrates a veil that involves the anterior surface of the cap. The deformity of the cap so closely resembles the deformity of a post pyloric ulcer that the differential diagnosis is very difficult.

Fig. 8 et 8′. Démontrant une voile qui comprend la surface antérieure du bulbe duodénale. La déformité ressemble tellement la déformité d'un ulcère post-pylorique que le diagnose différentiel est bien difficile.

Fig. 8 et 8′. Ilustrando un velo que envuelve la cara anterior del bulbo duodenal. La deformidad del caput asemeja de tal modo a la deformidad de una úlcera posterior del píloro que hace muy difícil el diagnostico diferencial.

to their normal dimensions, particularly on the anterior superior surface (Fig. 4).

2. The left superior surface of the cap has a thin feathered-out appearance, whereas the right side of the cap has a clear-cut, definite, well-defined line (Fig. 5).

3. If the veil also involves the extreme pyloric end of the lesser curvature of the stomach, this region has a puckered appearance, somewhat simulating the finding observed in cases of prepyloric folds (Fig. 6).

4. The pyloric sphincter is clear cut and well defined if the veil involves only the cap. But if it also involves the stomach, the pyloric sphincter, particularly on the lesser curvature surface of the lumen, is irregular and often thickened by comparison with the sphincter on the opposite side of the lumen (Figs. 5 and 6).

5. The deformity is more marked with the patient in the erect or prone posture, and may be absent with the patient lying on the right side.

6. The line or torsion runs downward and to the right from the gastrohepatic ligament (mesogastrium) toward the gall-bladder, the under surface of the liver, or the hepatic flexure (Figs. 4, 7, and 8).

7. These veils are rarely if ever obstructive to the pylorus, and if gastric retention occurs, it is probably functional rather than organic.

8. If the veil fails to extend as far up as the cap, or stomach, it may then involve only the anterior surface of the descending duodenum, causing that to be adherent to the under surface of the liver, gall-bladder, or hepatic flexure. This is the type of pathology described by Harris, but the veil in Figure 7 also extends up across the cap. I have seen no case where the veil is limited to the descending duodenum.

9. There may be an angulation, rarely amounting to a partial obstruction, involving the midportion of the descending duodenum; it is evident that this was accentuated to such a degree in the cases described by Harris that he did not realize that this veil extended up to and across the anterior surface of the cap; or, perhaps in his case, the cap was not involved in this veil (Fig. 7).

These veils, either by direct contraction

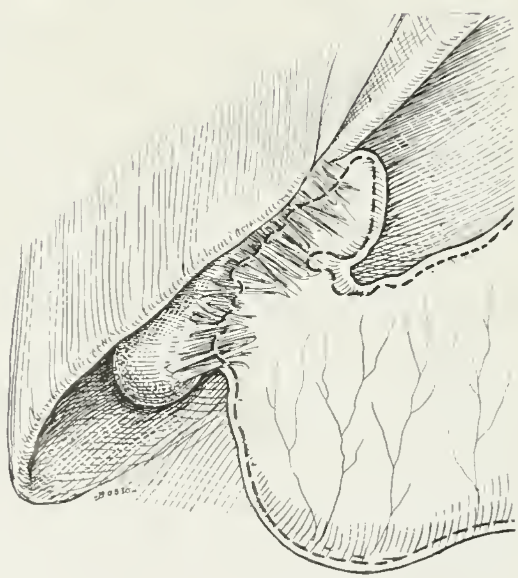

Fig. 9 and 9′. Illustrates a veil that involves the right side of the cap, the pyloric end of the stomach and the gall-bladder in such a manner that it cannot be determined whether this is of gall spider origin or a congenital membrane.

Fig. 9 et 9′. Démontrant une voile que comprend le côté droit du bulbe duodénale, l'extrémité pylorique de l'estomac et la vésicule biliaire d'une telle façon que l'on ne peut determiner si l'origine est la vésieule biliaire ou une membrane congénitale.

Fig. 9 et 9′. Ilustrando un velo que envuelve el lado derecho del bulbo duodenal, el extremo pilorico del estomago y la vesicula biliar de tal manera que no puede determinarse si su origen es secundario a inflamacion de la vesicula biliar. o es una membrana congenita.

or by tortion with the patient in certain postures, cause a deformity of the hollow viscera in the right hypochondrium, particularly the cap. This results in roentgen findings which so closely simulate either postpyloric ulcers or gall-bladder adhesions, that it probably accounts for most of the erroneous roentgen diagnoses of postpyloric ulcers, especially in those cases where a sufficiently extensive series of plates has been made and carefully studied by a competent observer. (Figure 8 closely resembles postpyloric ulcer; Figure 9 simulates gall-bladder adhesions.)

Unfortunately, when such an erroneous roentgen diagnosis is made and surgical procedure results therefrom and no ulcer or pathological gall-bladder is found, the surgeon, unless he is familiar with these veils or membranes and knows how to look for them, will fail to recognize them and will refer to the case as an absolute roentgenological error, when in fact a pathological condition exists which could and should be recognized and relieved by surgical procedure, thereby rendering the roentgen diagnosis only partly erroneous, in that it showed a pathological process which was not properly differentiated from ulcer or gall-bladder adhesions.

In several instances I have reported such veils as of unknown origin, and on one occasion the surgeon insisted on knowing whether I thought they were of gall-bladder origin or the result of a postpyloric ulcer. I insisted that as far as I was concerned, they were unknown. At operation the veil was found like a group of silver threads; there was no ulcer or gross evidence of gall-bladder pathology; and when I turned the tables on the surgeon and asked him what the origin of this veil was, he said, "I don't know what caused it"—it, therefore, remained of unknown origin.

The symptoms associated with these veils are often out of all proportion to the extent of the pathology. It seems that when these membranes are fairly local and involve the cap and stomach in close proximity to the pyloric sphincter, perhaps because of the nerve supply or because of local torsion, the pain—a stitching or burning pain—is most frequently felt, especially when the patient is in the erect posture. It is often relieved by lying down and often associated with a meal because the weight of the full stomach will drag on the veil or membrane. In other cases, especially where this veil extends to the hepatic flexure, it is associated with a full ascending or transverse colon and may then be temporarily relieved by catharsis.

While it is possible in many cases to make a positive differential diagnosis between cancer, ulcer, gall-bladder adhesions, spasm, and this veil or membrane, yet there are cases where these conditions so closely simulate each other that I have allowed myself the privilege, in about 10 per cent of the cases, of reporting the roentgen findings in the following manner: "One is justified in making a positive diagnosis of an organic lesion, not a spasm, involving the cap, or stomach, or duodenum; this may be due either to an ulcer, gall-bladder adhesions, or a veil, the weight of evidence being in favor of the one which it most closely resembles." In such cases the surgeon should be forewarned and go armed in the search of a veil, especially if he does not find an easily recognized ulcer or pathological gall-bladder. An erroneous diagnosis is thereby turned into a correct one, the pathology detected, and the patient relieved of his symptoms.

Figures 1, 2 and 3 are sketches of anatomical specimens made for Dr. J. P. Hoguet at the Cornell Medical College.[3] These give one a very graphic picture of some of these types of veils in the right hypochondrium. These are accentuated by the manner in which the liver and gall-bladder are drawn up by the retractor in order that E. M. Freret, the artist, might get an adequate exposure. This retraction upward of the liver and gall-bladder makes the torsion appear to be upward and to the right, instead of down and to the right, as it would be if the liver was dropped back into its normal position.

Figures 4, 5, 6, 7, 8, and 9 are roentgenograms of various types of veils in the right hypochondrium and figures 4′, 5′, 6′, 7′, 8′ and 9′ are explanatory drawings made by Mr. K. K. Bosse. The dotted line is an

[3] Many thanks are extended to Dr. Walter Weller who observed these cases during his demonstration of anatomy at Cornell Medical College. An additional photograph of another specimen was sent to me by Dr. H. E. Schaef, London, Ontario, Canada.

exact duplicate of the corresponding roentgenogram of the stomach and cap. The liver, the gall-bladder, and, in some of the figures, the colon and duodenum sketched into the picture to show the relation of these viscera to the stomach and cap, and the drag that is caused by this veil.

All the accompanying lead pencil sketches are only diagrammatic; and for the sake of demonstration the liver is shown to be further away from the stomach than normal in order to demonstrate the line of the veil.

In Figure 4 the veil runs downward and to the right from the under surface of the liver and across the anterior surface of the cap and is adherent to the gall-bladder, and possibly the colon.

In Figure 5 the veil extends from the under surface of the liver to the right side of the cap, apparently not involving the gall-bladder, but extends down to the hepatic flexure of the colon.

In Figure 6 the veil runs from the under surface of the liver to the lesser curvature of the stomach and left side and superior surface of the cap. This is a rather broad veil.

In Figure 7 the veil runs from the anterior superior surface of the cap downward and to the right, across the anterior surface of the descending duodenum to the hepatic flexure of the colon. It may possibly extend as far up as the liver. The gall-bladder is observed lying against the upper surface of the descending duodenum.

In Figure 8 the veil involves the left superior surface of the cap, running downward to the colon, causing a constant indentation which so closely resembles induration of a postpyloric ulcer that one would not be justified in making a positive differentiation between a veil and a postpyloric ulcer. This is one of the 10 per cent cases where the cause of the deformity of the cap could only be determined by surgical exploration, and perhaps not even by that method.

In Figure 9 the veil extends from the under surface of the liver and gall-bladder to the right side of the cap and extreme pyloric end of the greater curvature of the stomach, drawing it upward and to the right. This type of pathology is, I believe, definitely of "gall spider" origin as described by Morris, and might readily be diagnosed definitely as gall-bladder adhesions. But if a perfectly normal gall-bladder were observed on surgical findings and these adhesions were not noted, the case would be reported as a roentgen error.

Considering that it requires as much surgical skill and experience to recognize these veils after the abdomen is opened as it requires roentgenological experience to interpret the findings before the abdomen is opened, and since this is a subject that has not been extensively considered either from a surgical or anatomical standpoint, it seemed wise to collaborate with some surgeon in the publication of a monograph on the subject, discussing it from its embryological, anatomical, clinical, roentgenological and surgical aspects.

Dr. J. P. Hoguet, after operating on several of my cases, became interested in this subject and has consented to collaborate in such a monograph which we hope to finish shortly.

DISCUSSION

Dr. Imboden. I wish to thank Dr. Cole for presenting this paper. I have been interested in this question ever since 1914, and I wish to say "Amen" especially to two things he has said. First, that the thing is there and that it is comparatively frequent; and second, that you have got to insist that the surgeon find your lesion. There is one little point in technique in which I differ slightly from Dr. Cole; that is, I have been able to make diagnoses at the Presbyterian Hospital by use of the screen entirely.

Dr. LeWald. In a discussion of any of the pathological conditions about the duodenum, just as a matter of interest one should never forget the analogy of non-rotation of the colon in which case the duodenum also runs an abnormal course. I have known two operations to be performed on a diagnosis of duodenal lesion in which the condition found at operation was exactly as one would expect in this type of duodenal anatomy.

The duodenum merges with the jejunum without distinction of any first, second, or third portion. It simply passes off to the right side. If one is not familiar with this he might make an error in believing he is dealing with a pathological condition of the duodenum due to ulcer or adhesions.

Dr. White. Dr. Cole describes these findings which are very definite and very characteristic, and which occur, apparently, in the gall-bladder region, and which apparently join the cap to the colon or to the gall-bladder region. It seems to me very difficult to distinguish whether we are dealing with a truly jejunal veil or whether we are dealing with something left from previous gall-bladder involvement. It does not seem to me that this would rule out gall-bladder inflammation. There may be involvement of the gall-bladder, which may clear up for a time, and the surgeon finds the gall-bladder pretty normal, but the inflammation remains and leaves some adhesions in that region.

Dr. Cole. I am thoroughly convinced that if a man wants to examine by fluoroscopic methods, he can do it. This may be the easier way. For some reason or other I do not take to fluoroscopy, and it can be done by roentgenological methods. I want to emphasize, however, that if you are going to do it by roentgenological method, do not do it by two or three plates. Fluoroscopy is better than two or three plates.

MINIMUM ERYTHEMA DOSE WITH DIAGNOSTIC VOLTAGES*

BY ARTHUR W. ERSKINE, M.D.

CEDAR RAPIDS, IOWA

A SEARCH of the literature shows that it is almost impossible to find two writers who agree as to the limits of safety in roentgenography. Interest in this subject has lately been stimulated by the popularity of the Potter modification of the Bucky diaphragm, requiring, as it does, a fixed target-skin distance, and longer exposures. It was with the hope of accumulating some accurate data that the experiments described in the following paragraphs were undertaken.

Using a Victor Universal Machine, and a standard broad focus Coolidge tube, the setting was found which would just break a gap of 30 mm. between two polished metal spheres with a diameter of 125 mm. This was found to give a constant reading of 58 on the kilovolt meter, and was assumed to indicate that the voltage was 60,000. Ten ma. were allowed to pass through the tube so that the lower scale of the milliammeter could be used, thus insuring greater accuracy. The milliammeter was tested against a standard one furnished through the kindness of Mr. G. H. White, and its accuracy found to be within the limits of permissible error. Upon measuring the thickness of patients weighing more than 200 pounds, it was found that in no case did the anteroposterior diameter exceed 17 inches without compression, or 15 inches with compression. I assumed that, with a target-plate distance of 25 inches, it would not be necessary to bring the tube nearer to the skin than 10 inches, and the experiments were conducted with a 10 inch target-skin distance.

By a simple arithmetical calculation based upon a supposedly known dosage, checked by comparative photographic measurements, it was estimated that at a target-skin distance of 10 inches, with no protecting filter, 800 ma. seconds would produce a visible erythema. When 1 mm. of aluminum is used as a filter, with a voltage of 60,000, the ratio of time between the filtered and unfiltered dose is as 7 is to 3; that is, in order to produce the same effect through 1 mm. of aluminum, the exposure must be two and one-third times as long. Accordingly, it was assumed that 1,800 ma. seconds would produce an erythema when 1 mm. of aluminum was used as a protecting filter.

The minimum erythema dose can properly be defined as the smallest amount of *x*-rays which will produce a visible reddening of the skin. To demonstrate that a given amount of *x*-rays is a minimum erythema dose, it must not only be shown that it will cause reddening of the exposed skin when compared to adjacent protected skin, but also that a smaller part of the same dose will not produce redness.

*Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., September 27–30, 1921.

Accordingly I exposed four areas, on the backs of each of the first group of patients, to unfiltered rays for 500, 600, 700 and 800 ma. seconds respectively, and four areas to rays filtered through 1 mm. of aluminum for 1,200, 1,400 and 1,800 ma. seconds respectively. In each case, all the areas became red, showing that the minimum erythema dose was 500 or less ma. seconds of unfiltered rays and 1,200 or less ma. seconds of rays filtered through 1 mm. of aluminum. Exposing the second group of patients, the length of the exposures was reduced to about half of that in the first group. All the patients showed a reaction in the areas exposed to 400 ma. seconds of unfiltered rays, and 800 ma. seconds of rays filtered through 1 mm. of aluminum. The skin of only one patient, a blonde, became red in the area exposed to 350 ma. seconds of unfiltered rays, and in no case did the skin exposed to less than 800 ma. seconds of rays filtered through 1 mm. of aluminum, show any redness. I concluded, therefore, that at 60,000 volts, with a 10 inch target-skin distance, an exposure of 400 ma. seconds is the minimum erythema dose, and that double this exposure must be used to produce the same effect through 1 mm. of aluminum.

Even with this apparently successful method of measurement, one must not forget that there is considerable variance in the estimation of erythema. The degree of reddening is a very potent factor. The susceptibility of the skin is also to be considered; as there are a few individuals, especially those of fair complexion, whose skins are much more sensitive to the *x*-ray than others.

I was very much surprised to note the slight difference between the appearance of the areas receiving the minimum erythema dose, and those receiving twice as much. I formerly believed that doubling the erythema dose would produce blistering. I find, in checking up, that what I have been calling a minimum erythema dose, is from one and one-half to twice that amount.

DISCUSSION

Dr. Hickey. I would like to ask Dr. Erskine how large an area he exposed.

Dr. Pirie. I would like to ask Dr. Erskine how many patients he tried this minimum erythema dose on. Imagine getting half a dozen patients all exposed at the same distance and same time. Would they all absolutely respond in the same way? Suppose you exposed half a dozen people in the sunshine for a day. Would they all respond in the same way?

Dr. Darling. I would like to supplement that question with one specifically raising the question of idiocyncrasies whether Dr. Erskine finds anything in that.

Dr. Kreisel. I would like to ask at which time—how many days or hours, after exposure was observation made and how long did the erythemas last.

Dr. Ullman. I would like to know the size of sphere.

Dr. Erskine (closing discussion). The size of the sphere was 125 mm., the standard size as given by the American Institute of Electrical Engineers. This work was started almost a year ago when we could not buy spheres. We had to have them made. A break gap at 30 mm. we assumed indicated that the voltage was 60,000. The size of the areas was 2 cm. They were square with lead protecting surrounding skin. The number of patients in the first group in which all areas became red, was six. Then we saw that we were wrong in our estimations, that we were giving none of them a minimum dose; and after correcting our technique we started again.

Dr. Pirie. How many patients were exposed the same day?

Dr. Erskine. Four. These were not all patients. We used the girls in the offices on the floor and anybody who would serve. The part of the body used was the back. We checked that with treatment cases on the front. The earliest erythema appeared three days after treatment. Observations were made in about three or four days, a week, and in ten days. The slowest ones to appear were in ten days. The part of the back exposed was between the shoulders. About thirty patients in all were exposed. There was a little difference between blondes and brunettes.

Dr. Pirie. Did you find primary erythema and secondary erythema afterward?

Dr. Erskine. In one patient only—and then very little. We saw very little variation in idiosyncrasies. One blonde reddened up in the area which was exposed 350 ma. seconds, but not in the one that was exposed 400 ma. seconds.

Dr. Pfahler. With 400 ma. seconds, how soon did this redness appear?

Dr. Erskine (final closing). The average would be seven or ten days.

POSSIBILITIES OF ROENTGEN-RAY TREATMENT IN CANCER OF THE PANCREAS*

BY G. E. RICHARDS, M.B.

Associate in Radiology, University of Toronto
TORONTO, CANADA

THE intention originally in presenting a short paper on this subject was to link together chronic pancreatitis with cancer of the pancreas, in view of the more than merely theoretical grounds which we have for believing that a rather definite relation exists between the two. Regarding such a sequence Ewing[1] says, "Carcinoma of the pancreatic parenchyma may be regarded as beginning in a functional hyperplasia following cirrhosis and carcinoma of the ducts from chronic irritation and stasis in these canals." Such irritation and stasis is very commonly present, as we know, in many forms of gall-bladder infection, while chronic pancreatitis has frequently been reported as following upon cholecystectomy, although we have seen no such reports after adequate drainage of the gall-bladder and ducts.

Deaver[2] is authority for the belief that "the disease is secondary to the more common forms of abdominal inflammation, and infection is by way of the lymphatics, while obstruction plays little part." He, however, urges the importance of adequate drainage in the surgical treatment.

Nicoll[3] points out that "chronic pancreatitis is a disease of much more frequent occurrence than has been commonly supposed. It commonly complicates catarrhal affections of the biliary apparatus, of the duodenum and of the vermiform appendix but may exist as an affection standing alone."

These are merely a few of the many references available, but it is not our desire to pursue this side of the subject since we have no definite proof to offer that there is a sequence. The possibility, however, is sufficient to stimulate us to every effort in the direction of early and accurate recognition of the disease before the further progress shall have become established.

I shall, therefore, limit myself to the subject of cancer of the pancreas. Here, one is convinced there is room for more improvement in diagnosis. Cancer of the pancreas has been variously reported as ranging from 1.2 to 2 per cent as based upon autopsy findings. In the living subject it is certainly not recognized so accurately as we should expect with our present methods.

In the analysis recently published by Lafferty of 1,100 gastro-intestinal examinations he reports one case of cancer of the pancreas and no cases of pancreatic cyst, or chronic pancreatitis. Other publications make no reference to the subject as a finding in gastro-intestinal investigations. This led me to look up our own figures and I find that in the last 11,000 bismuth examinations at the Toronto General Hospital we have recognized prior to operation 10 carcinomas of the pancreas, 3 pancreatic cysts and 2 cases of chronic pancreatitis. This gives a figure fairly close to that of Lafferty but still far below the actual occurrence of the disease. With more thoroughness and more routine examinations it ought to be possible to recognize these conditions with much greater certainty than has hitherto been the case.

The importance of such early recognition, especially of cancer of the pancreas, takes on added emphasis if the prospect of successful treatment is not more than a fortunate coincidence in a few cases. It is largely with the hope of bringing to light other cases similar to our own and stimulating interest in the subject generally, that I have had the temerity to come before you with any report based upon so few cases.

In a review of the entire literature I have not succeeded in finding a single reference to *x*-ray or radium therapy in carcinoma of the pancreas, and yet if any

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

considerable number of cases respond, as ours have up to the present, it is quite a possibility that this disease will be found to be more easily influenced than some other forms of carcinoma, particularly of the gastro-intestinal tract.

CASE I. Male, age fifty-two. Roentgen-ray examination on December 1, 1920, showed the characteristic wide sweep of the duodenum with restriction of the pyloric end of the stomach and great lack of pliability in the area included in the circle of the duodenum. A roentgen diagnosis was returned of pancreatic carcinoma, probably primary in the head of the pancreas.

At operation on December 4, 1920, this diagnosis was confirmed and a section removed, but no other surgical procedure was attempted.

Pathologist's report was adenocarcinoma.

The patient was then referred for deep therapy partly as a placebo, partly to relieve pain which was severe, and partly to test the possibilities of higher voltage treatment, as we had recently installed a machine giving a 12 inch gap.

The first series of treatments was commenced on December 10, 1920. At this time the patient was greatly emaciated, weighing only 91 lbs., and his general condition was so low that it was thought wise to administer a modified series. This consisted of three areas, each 6 in. square, over the front and sides of the abdomen. Each area received an exposure according to the following formula: Ma. 5, distance 12 in., spark gap 12 in. between blunt points, filters 10 mm. of aluminum + 1 cm. of sole leather; time forty-five minutes.

Following the treatments pain was entirely relieved almost at once. A brisk erythema ensued but without vesication, and it subsided promptly. Considerable clinical improvement occurred, and early in January a second series of six areas was given, the same formula being used as before. Two months later a third series of six areas was administered. At this time he had gained 29 pounds and was in every way wonderfully improved. This improvement has continued up to the present time. He now weighs 139 pounds, which he states is his normal weight, and has carried on his regular business actively all summer. Roentgen ray examination shows no evidence of any mass, and he appears to be free from active disease.

CASE II. There was a history of long-continued digestive disability with three abdominal operations, without relief. Roentgen ray examination shows a somewhat similar appearance to that described in Case I, but with much more irregularity and fixation. A roentgen diagnosis of pancreatic carcinoma was made, the abdomen again opened and the mass found. A section of this was reported as pancreatic adenocarcinoma. The mass was quite extensive, everywhere adherent, and, of course, inoperable.

This operation was performed July, 1919, but we did not get the patient for treatment until January, 1920, about the time the improvement in Case I began to be apparent.

Treatment was similar and need not be detailed. When it was commenced he was confined to bed, emaciated and steadily going downhill. Great pain was present and this again was promptly relieved by treatment. At the present time he is practically symptom-free, has gained 20 pounds in weight, and he, also, appears to have no active disease.

CASE III. This case was referred about the same time as Case II. No roentgen ray examination had been made, but at operation in another city a large mass had been found, apparently primary in the pancreas but involving by extension the entire pyloric end of the stomach and the liver and gall-bladder.

We administered one series of four areas, using the same formula as previously detailed. Five weeks later a severe hemorrhage occurred and masses were vomited, said to be cancer tissue, though none was saved for section. The patient died forty-eight hours following this; no autopsy. I have previously reported this case during a discussion and quoted it as a possible danger in intensive therapy with high voltages. Since looking up the literature more carefully, it appears that this should be regarded as one of the normal terminations of such extensive involvement. This case was obviously too far advanced to offer any reasonable prospect of cure, and probably should not have been subjected to treatment.

Other cases have since been treated with gratifying preliminary results, but none is over six months' duration, and will not be referred to further at this time.

We, therefore, have 2 cases out of the 3 treated, which are apparently well, nearly a year after treatment. All 3 cases have been proven, by every means at our disposal, to be cancer of the pancreas. In both the living cases the condition was advanced so that the expectation of life was very short: Case I, probably only a few weeks, Case II, a few months at the most. In both these the immediate result of treatment was more prompt and complete than has been our experience in any other form of carcinoma. I, therefore, feel that there is something more than a mere coincidence and that we may possibly be dealing with a disease which is more susceptible to radiation than other forms. If this should prove to be the case, remembering the utter helplessness of surgery, and every other therapeutic agent, then we are presented with a great opportunity for service.

In any case the results up to the present time are sufficiently encouraging to justify us in drawing these three conclusions:

1. It is possible favorably to influence the growth of pancreatic cancer, and this is sufficient to justify the intensive irradiation of every case as early as the diagnosis can be established.

2. It appears probable that adenocarcinoma of the pancreas is more susceptible to irradiation than some other forms of adenocarcinoma.

3. Efforts should be made to perfect our ability to recognize the disease as early as possible.

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DISCUSSION

Dr. Holmes. I would like to know whether examination of the urine was made to determine the presence of sugar.

Dr. Richards (closing discussion). I could reply to Dr. Holmes' question by saying that examinations for sugar in the urine have been made. Sugar was present in the urine in both cases when treatment was commenced.

THE RELATION OF TEMPERATURE CHANGES TO ROENTGEN-RAY SKIN REACTIONS*

BY CHARLES L. MARTIN, M.D. AND GEORGE T. CALDWELL, PH.D., M.D.

DALLAS, TEXAS

From the Laboratories of the Baylor Medical School, Dallas, Texas

IN therapeutic work the erythema dose, is commonly referred to as a definite fixed entity often expressed mathematically: and yet most experienced roentgenologists who are constantly administering the same dose of rays to the skin of numerous patients must have been struck with the varying degrees of reaction obtained. This is particularly noticeable in clinics where deep therapy is done, since the effect of a single dose can be observed when the patient returns for further treatment. The attitude of the profession toward such variations during the past decade was aptly put by Gawalowski[1] who stated that the tendency to blame uncritically all untoward results of roentgen-ray therapy on idiosyncrasy soon met with opposition, and many authors went to the other extreme and denied the possibility of idiosyncrasy, explaining poor results by errors in dosage and imperfection of the methods used. MacKee[2] has seen fit to devote a chapter of his recent book to the subject of idiosyncrasy and has summed up the opinions of thirty-two

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of the leading roentgenologists and dermatologists of this country. The majority of these men believe that there is a definite variation in the susceptibility of the skin of a degree too small to be called idiosyncrasy.

Fig. 1. Note the more marked skin reaction in the lower portions of the exposed squares. They were covered by the elastic belt.

Variations in sensitiveness to the roentgen rays have been explained in many ways by various authors. Menstruation, pregnancy, diabetes, arteriosclerosis, gout, cachectic states, injuries, age of the patient, area of the body exposed, local anemia, dryness of the skin, acidity of the sweat, cutaneous vasomotor irritability and many other factors have been designated as the underlying causes of such variations. If it be assumed that skin reactions do vary, a careful elimination of some of the many controlling factors should in time lead to the determination of the actual causes of the so-called idiosyncrasy. Simpson[3] in 1916 advanced the theory that the severity of a roentgen ray dermatitis was dependent to some extent on skin temperature. He based his conclusions on the occurrence of severe reactions appearing after the applications of ice bags to the necks of his patients irradiated over the thyroid region. He was convinced that lowering the skin temperature caused an accentuation of the reaction observed.

The more recent work of Bovie and Klein[4] on unicellular organisms suggests that temperature changes may be of vital importance in roentgen-ray work. These investigators exposed Paramecia to rays from a small hydrogen discharge tube and

Fig. 2. This animal has an adhesive band applied over the upper portion of the exposed area.

found that the administration of a certain dose would produce no ill effects while the temperature of the culture was maintained at 17–18 C., but that most of the organisms died when the temperature was raised to 24–28 C. soon after irradiation.

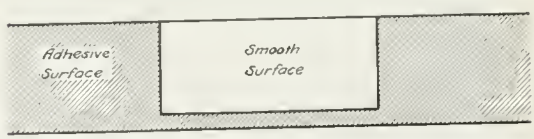

Fig. 3. The modified band used in applying a non-adhesive surface over the upper portion of the exposed area.

The work of Rohdenburg and Prime[5] on heat sensitization seems to point in the same direction. They observed that virulent mouse and rat tumors could be killed by exposure to a certain degree of heat or by a definite dose of roentgen rays.

However, the same result could be obtained by combining a sublethal degree of heat with a sublethal dose of roentgen rays. The heat could be administered either before or after the irradiation without changing the outcome. The temperature increase used in producing the combined effect was remarkably small. Kaestle[6] and James,[7] in articles published six years ago, claimed that an erythema could be provoked after a heavy treatment by hot applications or a hot bath.

Fig. 4. Rabbit R-3 one week after exposure and just prior to the removal of the protective band.

Such observations make it seem likely that the temperature of irradiated skin may be a factor in the production of a reaction. In support of this supposition we have often observed that treated areas lying in the axillae, in folds of the skin of obese patients, beneath pendulous breasts, and over the portions of the buttocks coming in contact with a chair, are likely to show a more severe reaction than areas which are more freely exposed to the air. This may possibly be due to the higher temperature maintained at these points although the effects of moisture, the reaction of the perspiration, the lack of air, etc., should be ruled out. A patient was treated some months ago who had been operated on for carcinoma of the rectum. An artificial anus had been made just above the original opening and it was necessary for him to wear an absorbent pad held in place by an elastic belt. This belt covered about half of each area treated over the lower abdomen. After several weeks had elapsed there was a

Fig. 5. Rabbit R-3 about one month after exposure. There appears to be a little more ulceration in the covered than in the uncovered portion of the exposed area.

definite tan under the belt, whereas the uncovered skin showed little reaction. A photograph of this patient is shown in Figure 1. Areas treated through heavy dressings will sometimes show very marked reactions. Areas covered by anointment by some well-meaning physician seem to show a more marked reaction than those to which some cooling lotion such as "whitewash" has been applied. Vigorous full-blooded individuals of goodly proportions are more likely to have marked skin reactions than are the pale, delicate, slender type. Hyperthyroid patients, who, according to our ideas of basal metabolism must be dissipating unusually large quantities of heat through the skin, often show a mild skin reaction a few hours after the treatment is administered. This type of early reaction is, so far as we know, rarely seen except in Graves' disease.

Since so much evidence seemed to point toward temperature as one of the governing factors controlling skin reactions, a series of experiments was undertaken in an effort to throw some light on the matter. Such work is time-consuming and this paper is presented more as a preliminary report than as a finished piece of research.

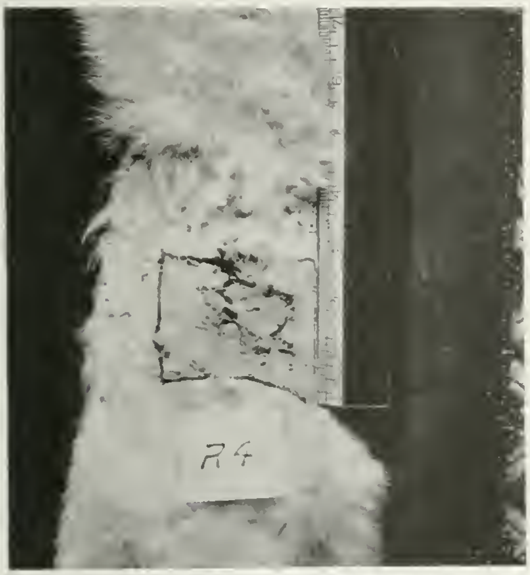

Fig. 6. Rabbit R-3 twenty-five days after exposure. The ulceration appears to lie mostly in the upper portion which bore a non-adhesive covering for eleven days after exposure.

The reaction obtained under the elastic belt made it seem probable that a simple covering might accentuate the skin effect. With this point in mind, shaved areas on the abdomens of rabbits were exposed to heavy doses of rays, after which they were partially covered with bands of adhesive plaster as shown in Figure 2. The areas were $3\frac{1}{2}''$ square and received 20 to 30 min. exposures with 5 ma. flowing and a $5''$ parallel gap at a skin-target distance of 10 inches. No filters were used. A broad focus Coolidge tube energized by an interrupterless transformer was used as a source of roentgen rays. The distal portion of each area was left uncovered in order that it might act as a control. After about ten days the adhesive plaster was removed. After applying this procedure to several animals, it became apparent that adhesive plaster applied over irradiated skin would pull away the superficial layers of the skin when it was removed, leaving a shallow ulceration at its site of application. This was objectionable since it brought in the additional factor of mechanical irritation. As a control experiment, a band of adhesive plaster was applied to a shaved area on the abdomen of one animal which had not been irradiated. The skin was not

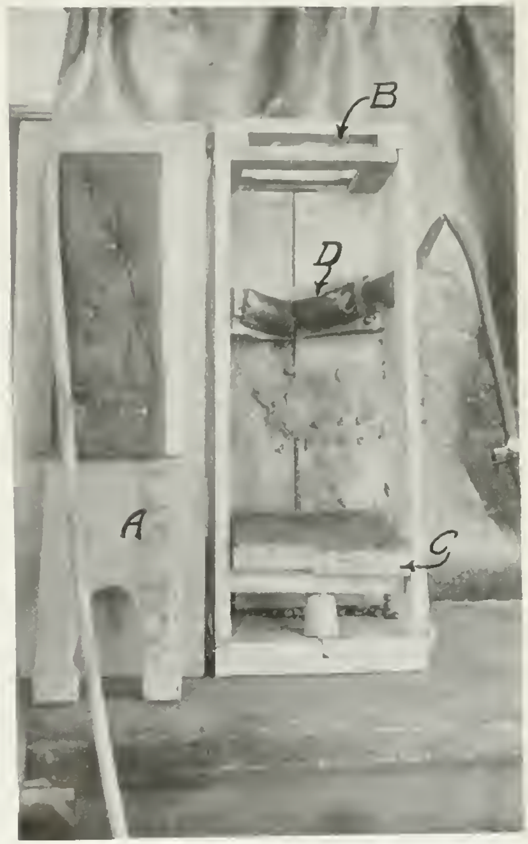

Fig. 7. The rabbit box propped up on end with the lid thrown open.

appreciably injured by the removal of the plaster at the end of ten days. These experiments seem to justify the warnings issued by certain roentgenologists against the application of adhesive plaster to irradiated surfaces.

A second set of experiments designed to eliminate the adhesive effect was next undertaken. To a band of adhesive plaster of the type used in the previous experiments, a second small strip was applied so that the adhesive surfaces were in contact as shown in Figure 3. When the band was in place the non-adhesive surface covered the upper portion of the exposed area. The small strip was not quite as wide as the large one and this allowed a narrow strip of adhesive surface to lie across the middle of the exposed area. It was found necessary to do this in order to hold the covering in exactly the right position.

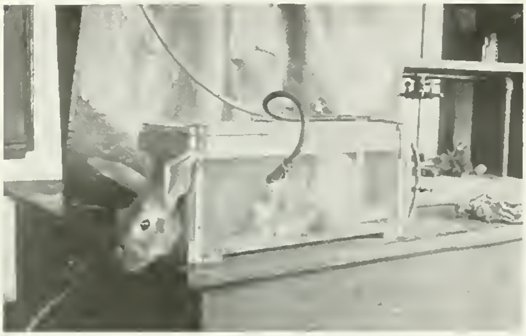

Fig. 8. The rabbit box in operation. The bag is held firmly against the animal's upper abdomen.

Rabbits R3 and R4 were exposed in the same manner as the animals used in the first experiment. The modified adhesive bands were then applied at once. Figure 4 shows rabbit R3 one week after exposure at the time that the plaster was removed. While taking away the covering a narrow strip of epithelium was pulled away with the adhesive portion, but no other variation from the normal was observed. At the end of the thirteenth day the entire exposed area showed a light even tanning and a definite contraction of the whole area parallel to the long axis of the rabbit. After a month had elapsed the appearance was that shown in Figure 5. The shallow ulceration which appeared at the point of application of the adhesive strip in the middle of the area slowly spread out in both directions, until it assumed the dimensions shown. The process is more extensive over the area that was covered than over the unprotected surface.

Rabbit R4 was treated in exactly the same manner except that the covering was allowed to remain in place for eleven days. Figure 6 shows the appearance of the lesion at the end of twenty-five days. It is evident that the greater part of the ulceration lies in the upper half of the area, that is, in the covered portion. For some reason it does not involve the whole of the exposed area from which the hair has been removed by the dose given.

These findings seem to indicate that a covering placed over an exposed area for a number of days after it is irradiated increases the degree of skin reaction obtained. It has not been definitely proven

Fig. 9. View of complete apparatus showing the supply reservoir and the drain bottle below.

that the temperature beneath the adhesive strip was higher than that of the uncovered skin, but it seems likely that such was the case. Rabbits do not perspire, so that the influence of sweat is ruled out. The mechanical irritation set up by the removal of the narrow adhesive strip might possibly be the exciting cause of all of the ulceration produced. Perhaps future experimentation with more ideal types of covering materials will make the interpretation of these findings easier.

Attempts to study temperature effects

produced by merely applying a covering to the skin proved so unsatisfactory that the piece of apparatus shown in Figures 7, 8 and 9 was set up with the hope that the variable factors could be more accurately controlled. A rabbit box was so constructed that an animal placed inside could sit in a normal comfortable position, but could not move. This box is shown standing on one end with the lid thrown open in Figure 7. "A" represents a slide which fits into the slot at "B." This slide has a hole in it which fits snugly about the rabbit's neck. "C" represents an adjustable back board which is used in making the length of the box suitable for animals of different sizes. The rubber bag marked "D" is set on an adjustable curved platform and is so arranged that it is pressed firmly against the abdomen of the experimental animal. Figure 8 shows the box set up with a rabbit in place. The box was devised for the purpose of cooling or warming a certain area of skin by allowing cold or hot water to pass through the rubber bag held in contact with the skin. Figure 9 illustrates the completed apparatus. The supply reservoir is placed well above the box, while the drain bottle is placed below it.

Fig. 10. Rabbit R-6 found dead thirteen days after exposure. Note the crusting over the upper portion of the area. It was this portion which was cooled.

Fig. 11. Rabbit R-8 twenty-four days after exposure. The crusting in the mid portion of the exposed area represents the location of the cooling bag.

Since skin coverings seemed to accentuate the cutaneous reactions slightly, it was thought wise next to investigate the effect of cooling. Rabbit R6 was given a 30 min. exposure over an area from which the hair was not completely removed and then placed in the box so that the cooling bag only covered the proximal portion of the area. An attempt was made to cool the area for about 8 hours each day although this routine was not strictly adhered to with rabbit R6. The cooling was continued for a total of 33 hours distributed over 4 days' time. The rabbit was not healthy, and on the 13th day it died after showing a rapid loss of weight and developing a diarrhea, both of which symptoms pointed to a roentgen-ray toxemia. Figure 10 shows the exposed area as it appeared after the death of the animal. The tanning and crusting of the portion of the area covered by the bag is quite marked, whereas there is not even a loss of hair in the uncovered portion. This result was so striking and unexpected that a second rabbit, a large healthy individual (R8) was treated in the same manner. The cooling bag was adjusted so that it lay across the midportion of the area. This animal was in the cooling chamber during a total of 39 hours scattered over 5 days' time. It was put into a cage each night and given food and water. At the end of 8 days a definite erythema developed over the entire exposed area. At the end of 13 days the diameter of the area parallel to the long axis of the rabbit had contracted until it measured only $2\frac{1}{8}$ inches, and the whole area showed a marked tan and beginning desquamation. At the end of 3 weeks, sharply defined brown lines appeared within the tanned region. These lines lay parallel to the upper and lower borders and about $\frac{1}{4}''$ from them. It seems fair to assume that these lines represented the borders of the cooled area. At the end of 24 days the crusts that had formed between the brown lines and the outer borders of the area had practically all fallen away, leaving a smooth, hairless skin beneath. However, there was at this time a heavy crust over the cooled area. This crust was broken in many places and serum was seen oozing from beneath it. The appearance is illustrated in Figure 11.

These findings seem to substantiate the clinical observations made by Simpson and indicate that cooling the skin after roentgen irradiation is likely to accentuate the skin reaction. The element of moisture could not be eliminated in these experiments, since water was constantly condensing on the rubber cooling bag. In order that this work may be of definite value, many control experiments should be undertaken. As the weather becomes cooler it is our desire to try the effect of using warm water instead of ice water in the rubber bag and to determine the effects produced by various substances applied to the skin of the irradiated areas.

CONCLUSIONS

1. Adhesive plaster appears to produce ulcerations upon its removal from an irradiated skin surface.

2. The evidence at hand suggests that a covering placed over irradiated skin causes some increase in the reaction. This may or may not be due to an increase in the temperature of the skin.

3. Cooling the skin, by means of an ice bag for several days after irradiation, seems to accentuate the reaction obtained.

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DISCUSSION

Dr. Pariseau. The experiments of Dr. Martin gave a significance and support to an isolated fact that I observed a few months ago. I had occasion to treat a case of cervical adenitis and I decided to make two radiations. I decided to protect the lower part with lead, and in order to hold the lead in place I used strips of adhesive plaster. As the adhesive was of pure quality I heated it over a spirit lamp and applied it. I gave the first dose and the second. I had a very severe reaction, marking exactly the surface of the adhesive plaster. I first attributed it to the fact that I had burned my patient merely with a too highly heated plaster, but on observation I found that only that part which had received the roentgen rays gave severe reaction; therefore, I concluded that by using hot adhesive plaster applied to that skin I had hypersensitized it to the roentgen ray. This gives some support to the experiments of Dr. Martin who is right in saying that the study of temperature effects on skin sensitiveness is not new.

As far back as 1906 Dr. Hart of Paris gave a lecture in Montreal before the Medical Society and the object of his lecture was to bear out a law that he claimed to have discovered. All things being equal, the radiosensitiveness of tissues is the function of their temperature. However, Dr. Hart's law was not accepted then, because, I believe, it had insufficient experimental proofs. His work proved the hypersensitiveness of tissues when heated, but all his efforts to prove the hyposensitiveness of tissues were remarkably unsatisfactory. Therefore, the law could not be accepted because the extremes were not proved. There was part of his observation which today, in the light of our new work in deep therapy, may be of great significance. He claimed that heating the tissues made them hypersensitive to the *x*-rays and that he obtained better results in neoplasm of the uterus when he had previously, for several hours, given hot intrauterine douches.

However, I believe that Dr. Martin's work and such work on the sensitiveness of the skin is very precious, for we cannot speak, I believe, of a cancer dose. We must give as much rays as we can without harming the skin. Experiments which will show the causes of hypersensitiveness will help the progress of therapy.

Dr. G. W. Holmes. I would like to confirm some of the very excellent observations made by Dr. Martin. I have not the slightest doubt that the high temperature of the skin of goiter cases makes them unusually sensitive to radiation. In relation to adhesive plaster there is another factor to consider. Most plaster contains zinc, and, whether or not secondary radiation from the zinc has something to do with the producing of an erythema, I do not know. Not long ago, we rayed a patient who had adhesive strapping on the back. We rayed her for fibroid. She developed a well-marked erythema underneath the plaster only. The plaster contained zinc. After that experience, we used adhesive plaster that did not contain zinc, and placed it over small areas in cases being rayed over the breast. Erythemas were produced in these cases just the same (so far as I could tell) as in those cases where the adhesive plaster containing zinc was used. In other words, the increase in the erythema seemed to be due to heat, or rising of temperature, underneath the adhesive plaster, rather than to secondary radiation. Our experiments along these lines are not completed yet, and I do not wish to report them as accomplished facts. Ointments, as Dr. Martin mentioned, undoubtedly do the same thing. We have had considerable trouble with cases coming from the Skin Department, because there they put on ointments after treatment, with the result that we get a number of erythemas. With regard to cooling lotions, we have used "whitewash" for a long time, and, from clinical observations, we cannot help being convinced that it reduces the possibility of an erythema. In cases where we know we have given an overdose, we have applied whitewash immediately, and they have not developed erythemas. This has happened a sufficient number of times to be convincing. We had a case not long ago in which the filter slipped out during the exposure. I do not know how long it was out, but the dose through the filter should have produced a mild erythema. The case was a hospital patient and we applied ice bags and whitewash immediately and no erythema developed.

Some of the experimental work that has been done tends to show that any injury to a cell tends to increase the action of the rays, and it is possible that long-continued exposures to cold may injure them sufficiently to produce a bad effect. But cold applied for a shorter period of time may be beneficial.

Dr. R. W. Holmes. In connection with Dr. Martin's very interesting experiments and in line with Dr. Holmes' discussion, I want to report a rather trying experience I had in treating a case of hyperthyroidism. I treated the patient a number of times before (this was her fourth series) with no unusual effect. This time she came into the laboratory, was treated, and given the usual dose which I have been giving her, 9 inch spark gap, 5 ma., 10 inch distance, through 4 mm. aluminum and one thickness of sole leather for five minutes. I treated three areas. This was at 11 o'clock, and at 2 o'clock the nurse came to me and said the nervous patient was very much disturbed because of the redness over the areas treated. I found the portals of entry well defined on the skin with bright red erythema. That was four hours after the dose. In twenty-eight hours it had entirely disappeared and there was no more reaction. I have never been able to clear up in my mind just what it was that happened. There was plenty of space between the cone and the tissue treated.

Dr. Remer. We have made quite a few experiments in the use of drugs in connection with roentgenotherapy. We divide them into three classes—those which accentuate the action of the ray; those which are questionable; and those which are perfectly safe. We have found that there are between fifteen and twenty drugs which do accentuate the action of the rays. If the rays are to be used, these drugs should not be used ten days to two weeks previous nor for ten days to two weeks subsequently. Regarding the erythema which the last speaker mentioned, I think we frequently find that erythemas come on within three to twenty-four hours following the exposure and then disappear within twenty-four to forty-eight hours. We regard these as quite temporary erythemas and that they are ordinarily due to static electricity and can be overcome by grounding the lead.

Among the drugs which are contraindicated are iodine, stronger mercury preparations, salicylic acid, stronger solutions of nitrate of silver, balsam of Peru, and particularly scarlet red. Scarlet red will in every instance produce a third degree radiodermatitis where you would get only a mild erythema without its use. We have a case under treatment now in which scarlet red was used and we did not know it. The man was given sufficient radiation to produce a mild erythema and he afterwards developed a third degree burn which is still under treatment, and that is eleven months ago.

In the safe drugs we include carbolic acid, 2 to 4 per cent, zinc oxide, witch hazel, alcohol, bay-rum, boric acid, and plain vaseline.

The questionable drugs are stronger camphor preparations, picric acid, and menthol. The reason we put picric acid among the questionable drugs is that we have had comparatively little experience with it.

Dr. Pirie. I wish to bring out this point that when a big dose is given to the skin and the skin reddens, the skin is then on the way towards destruction. The cells, as we have described before, are sickened and on the point of dying; if left alone they will recover. Take for instance a baby that is sick and on the point of dying. You are not going to apply strong ointments, extreme heat, extreme cold, irritating rubbing. All these things are harmful. It is the same way with the skin which has received a large dose of roentgen rays. It will react more strongly the more it is irritated, whether with cold, heat, with rubbing, or irritating ointments which you put on.

Dr. Pfahler. Major Simpson of the Fox Hills Sanatorium has claimed that the application of ultraviolet light will decrease the sensibility of the skin to radiation. I have never tried it, because I have been afraid to do so. I am wondering if anyone in this room has made any such experiments or can give information as to whether ultraviolet light will increase or decrease the sensibility of the skin.

Dr. Manges. It might be interesting during this discussion to tell of a little occurrence at Jefferson. A patient was treated for tuberculous glands of the neck. The filter had been taken out of the tube stand and the operator did not notice it. The patient got a full dose, 5 ma., 9 inch spark gap, 9 inch distance, five minutes. Of course, within two weeks reaction came on and was rather severe. Blistering occurred and the skin surface bled very freely. The only treatment the patient had was 5 per cent bicarbonate of soda ointment. I was astonished at the comparatively little discomfort, and also surprised at the rapidity with which the wound healed up. I am wondering whether the reaction from the hard penetrating rays was much less severe than the old roentgen-ray burns we used to get when we were using very much softer rays and therefore healing was very much more easily brought about. Nothing but 5 per cent bicarbonate of soda ointment was used and it healed up very promptly—in about six weeks.

Dr. Abbe. This is an extremely interesting paper—one that appeals to all of us. We are all interested in finding the causes which lead to these hypersensitive conditions. In connection with these experiments, perhaps in connection with the adhesive plaster, not only is the zinc one of the factors, but possibly also the non-zinc oxide adhesive; with the lead plaster—the lead is also one of the factors, it being sensitized and giving off secondary rays. I believe almost any of those heavy metals in ointments and in plasters are going to give the same effect. In connection with goiter cases, do we not have an increased iodine reaction, thereby stimulating metabolism, and giving an effect similar to what we get with iodine applications to the skin? Again, one of the features that was mentioned was menstruation. Is there not perhaps the same stimulation of metabolism going on in increased menstruation as there is in certain of these hyperthyroids? Do we not find that the cases with excessive menstruation or ovarian conditions, —not the bleeding of fibroids or intra-uterine bleeders, but the excessive menstruation which we see occasionally in a girl in her early teens, with the profuse everlasting flow that cannot be stopped, due to the metabolism proposition, —are not those cases sensitive to our rays, and is there not the same metabolism upset that we get in hyperthyroid cases? One thing in connection with dosage and static electricity. The first cases in which I noticed hypersensitiveness of the skin were hyperthyroid cases where applications of radium plaques were made. In them there was no question about dosage, except so far as time was concerned. The radium plaques were applied to the skin with merely a sheet of blotting paper as filter. In these cases frequently I found that an application of five minutes would produce a very definite transient erythema which was not produced in any other cases I have treated.

Dr. LeWald. I want to record an error in a milliamperemeter which led to an *x*-ray burn and a suit against the hospital, which is now pending.

I was asked to go to the hospital and express an opinion as to why this burn had occurred. There was no question but that the milliampère reading was fully 50 per cent too low, as evidenced by the appearance of the Coolidge tube.

Dr. Coolidge called attention to the possibility of a milliampèremeter going wrong in his remarks yesterday morning. I believe it is a thing we must always bear in mind. Dr. Coolidge recommends the use of two milliampèremeters or a careful checking of one meter from time to time.

Dr. Schmitz. We hardly ever treat a case in deep therapy that we do not produce an intentional burn, and it sometimes happens that the burn may be very severe. In treating these burns we have found that if we leave them entirely exposed to the air or on a sunny day expose them to the sunlight, and on a cloudy day use a therapeutic light, we get better results than by any other means. If we use external applications, we have found that if vaseline is used the condition is made worse instead of better. In applying preparations with heavy metals, etc., which contain organic substances, we notice that no benefit is derived.

Dr. Flynn. I wish to cite a case that bears out Dr. Martin's paper very well. I had a patient, a very stout woman with rolls of fat over the entire abdomen. I used the usual distance of 10 inches, 9 inch spark gap, 5 ma., for six minutes. Instead of using a filter of three, two were taken out and one left in. She was given six minutes, and when she came back in a month she called my attention to the marked blistering between the rolls of fat. I believe this was due to heat or moisture between the layers of fat.

Dr. Von Poswick. I come from a town where there are many foreigners. When I went there we had quite a few roentgenray burns. My first case was very severe, and I thought a good deal as to what I should do. Now when anyone comes to me I will never treat the patient. The first thing I do is to get a paste made of zinc ointment, boric acid, and olive oil. Especially in acne cases I have the patient apply the paste over the entire face at night, and in the morning wipe it off with the olive oil. After this is done treatment is given for one week. By doing this I avoid the sensibility of roentgen rays.

Dr. Martin (closing discussion). I want to express my deep appreciation of the ample discussion accorded such an incomplete piece of work. It has acted as a stimulus to further investigation.

In our adhesive plaster experiments, there was no effect from secondary radiation emitted by metallic elements in the plaster, since the adhesive strips were not applied until after the doses of roentgen rays had been given.

The application of ice bags to the skin, following an overdose of rays, with favorable results as described by Dr. Holmes, brings up a point of interest. A patient in our clinic received an overdose over the skin of the neck after a filter had slipped out of place. Ice bags were applied to the area for about eighteen hours. Only a mild superficial erythema resulted and the skin was healed in six weeks. Both our case and the one described by Dr. Holmes were treated with cooling applications over a period of time much shorter than that used in the animal experiments. This suggests that the time element may be a factor of importance.

Someone mentioned the electrostatic effect resulting from the use of a metal shield as the cause of an early erythema in hyperthyroid cases. It has been our custom to use the same shields in all our work and we have never observed the early erythema occurring on the day of treatment except on the skin of our hyperthyroid patients.

THE VALUE OF INTERSTITIAL RADIATION*

BY DOUGLAS QUICK, M.B. (TOR.)

Attending Surgeon, Memorial Hospital

NEW YORK CITY

During the past few years our knowledge of the physical and clinical actions of radium has been steadily increasing. With this, the problem of treatment in malignant diseases has become, largely, one of more accurate radium application.

At present, radium is undoubtedly the greatest single agent at our disposal in combating cancer. It does not, however, fulfil the first principle of being a cancer cure—that of being a constitutional agent. Work now under way with the intravenous use of an active deposit of radium may ultimately place it in this class. In the meantime, our main energy must be directed toward increasing its value for local application.

In the earlier use of radium, failure resulted in many fields, partly because of a lack of knowledge of filtration and dosage, but largely because it was a practical impossibility to place and retain the element in a position that would permit of adequate effect on malignant tissue without undue destruction of normal tissue.

In almost every instance, radium applied to the surface delivers the greatest intensity of its dose to the least vital part of the neoplasm. With even the simple skin lesions it is frequently necessary to produce

*Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27-30, 1921.

surface destruction in order to efficiently reach the deeper and more actively infiltrating zone of the new growth. Whenever it is applied to the surface of a lesion only a small fraction of its energy is directed toward the diseased part. The remainder is wasted on surrounding healthy parts—

Fig. 1. Showing filtered tubes of radium arranged end to end in rubber tubing for insertion in base of operative wound.

frequently damaging them—or goes off into space. Furthermore, its practical application to a surface necessitates some sort of protecting filter which, in many instances, cuts off a large amount of useful radiation.

From both physical and economic standpoints it is therefore necessary to place the radium in such relation to the diseased part as to give uniform distribution and obviate loss of energy.

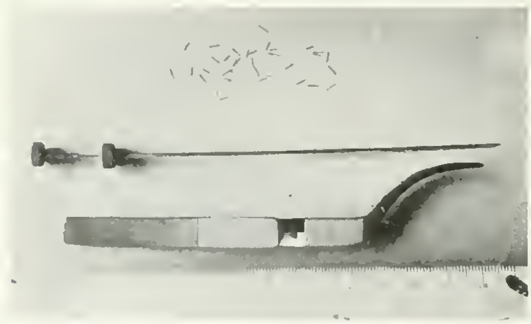

Fig. 2. Showing small radium emanation tubes and trocar needle used in inserting them interstitially.

That these principles have long been recognized is evidenced by the occasional reports of several years ago recording cases improved or cured by incising the tumor and laying in the base of the wound filtered tubes of radium. From a physical standpoint this was an advance, but the method could only be condemned because of the extensive and unwarranted surgical trauma. The Dominici tube obviated this question of trauma to a considerable extent and the principle still obtains for those who use the salt itself rather than the emanation.

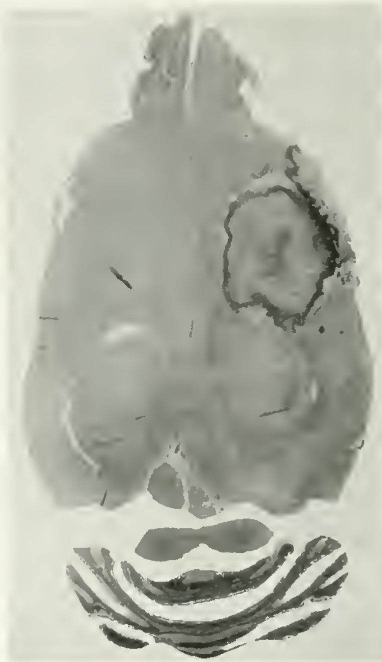

Fig. 3. Section of rat's brain showing zone of necrosis about a 1 mc. emanation tube. (Courtesy of Dr. Halsey Bagg.)

The use of radium salt in small tubes, with a sharp point to facilitate introduction, buried within a tumor mass, is certainly a great advance over surface radiation alone. Trauma is a factor, but is much less than that incident to surgical exposure by incision of the mass. If sufficient tubes are available a proper and uniform distribution can be made. There are, however, certain limitations and drawbacks to their use. The size even of the smallest tubes prevents their use in some locations, especially if they have to be kept in place several hours. Even with the greatest care they may be dislodged by movement of the part or tension on the linen thread which acts as a guide and stay. The walls of the tube or needle cut out a very considerable amount of the beta radiation which is of definite therapeutic value. The period of radiation in most instances can be only for a few hours rather than for several days—a factor of importance if we believe that the malignant cell is most easily affected when in the process of division. The dosage must also be cut down to a smaller amount in view of the shorter period of radiation. Discomfort to the patient must be considered in lesions, especially within the mouth.

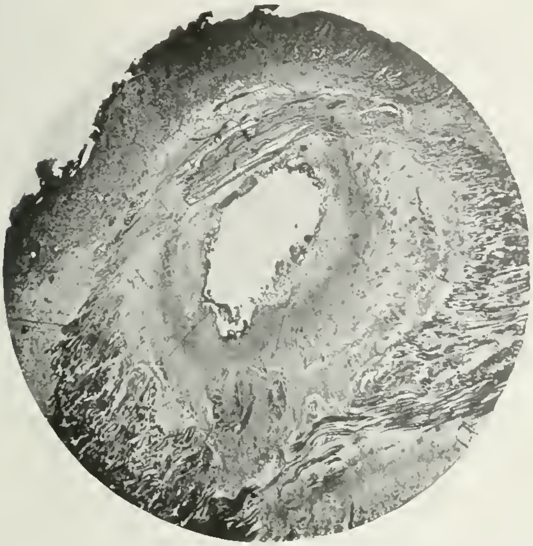

Fig. 4. Showing zone of necrosis and surrounding cellular infiltration about an emanation tube imbedded in rat tissue. (Courtesy of Dr. Halsey Bagg.)

Fig. 5. High power view of a part of Fig. 4 showing zones of necrosis and lymphocytic infiltration.

The use of filtered radium in conjunction with surgery has a certain but limited usefulness. The placing of filtered radium tubes in rubber tubing at the base of the surgical field certainly places the element in closer proximity to the seat of disease and takes account of all of the available radiation emitted by the tubes, but it is questionable if this plan is the most efficient.

With the advent of therapy by means of radium emanation a new possibility was presented—that of burying small tubes of emanation interstitially and leaving them permanently in place.

At first the amounts of emanation in the tubes and the size of the tubes themselves led to severe reactions that made the otherwise good results seem of questionable value. However, with more clinical and experimental data we feel that we have now reached a practical working standard. Radium emanation is collected in fine glass capillary tubes 0.3 x 3 mm. in size, and in such concentration that each tube contains from 0.5 mc. to 2 mc. of emanation. For most types of work about 1 mc. per tube has proven to be the most suitable amount. In some very bulky tumors stronger tubes may be used, and, likewise, in very small lesions or in delicate locations, such as near large blood vessels or nerves, tubes of 0.5 mc. or less are most applicable. These tubes can be readily sterilized by boiling and Bagg[1] has shown that the emanation is sufficiently bacteriacidal to sterilize the inside of the tube. This makes their use safe, from a surgical viewpoint, even though a tube may be broken within the tissues. These small tubes are placed in the ends of hollow trocar needles, inserted within the tumor to the desired depth and then expelled by pressing in the trocar of the needle. Since radium emanation decreases in value at the rate of approximately 15 per cent per day, it will be seen that the total radiation to be derived from a given tube can be calculated, if its original strength is known. One mc. of radium emanation buried interstitially and left in place gives a total radiation equivalent to 132 mc. hrs. It will also be seen that since the emanation decreases in value at only about 15 per cent per day a continuous radiation is kept up over a period of many days.

From the standpoint of trauma this method of introducing radium interstitially carries with it less danger than any of those previously mentioned. The tube is much smaller. The trocar needle is smaller than the needles containing the salt and is withdrawn as soon as the emanation tube is discharged, thus obviating extension of cells along its side. Even with this there is still a certain danger from trauma and it is suggested that in every instance where practicable a surface radiation with either radium or the roentgen ray be given first, similar to the manner of pre-operative radiation before surgical intervention.

Fig. 6. Microphotograph of portion of a lymph node invaded by epidermoid carcinoma, eight weeks following the introduction of radium emanation tubes. Note necrosis of tumor cells and surrounding fibrosis.

The question of necrosis about these buried emanation tubes has been mentioned as a contra-indication to their use, but where properly used we have not seen untoward results. Bagg has shown that a tube containing 0.5 mc. of radium emanation produces a zone of necrosis 5 mm. wide around it and that a tube containing 5 mc. produces but very slightly more. This fact is of great importance. The beta radiation from a given tube extends only a certain distance, no matter whether a small or large amount is used. The gamma radiation is not so limited in its action. It is therefore possible to bury the tubes in such a manner as to care for considerable of the tumor tissue by beta radiation and the remainder by a heavy prolonged cross-fire of gamma radiation, without producing gross necrosis of the entire mass. This would be necessary if beta radiation were depended on entirely, and probably explains the failure to produce satisfactory and lasting results by the use of very weak tubes—0.1 mc. to 0.5 mc. The total amount of gamma radiation produced by them is not sufficient to do more than cause a temporary regression of all the malignant cells.

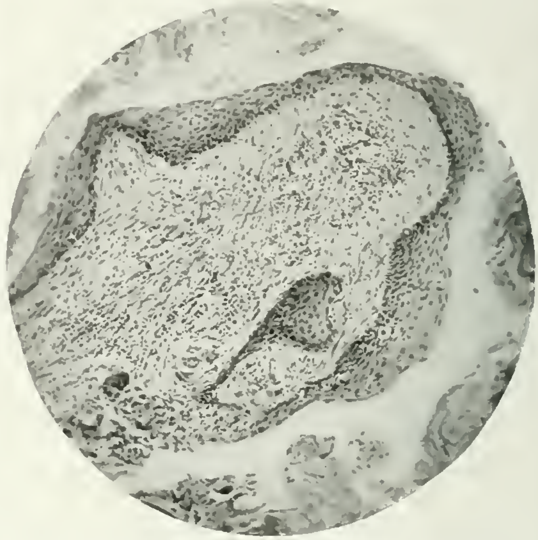

Fig. 7. Low-power view of epidermoid carcinoma in lymph node four weeks after intensive external radiation. Note extreme fibrosis.

The tissue changes taking place outside the zone of necrosis about an emanation tube are both interesting and suggestive. The tumor cells show marked degenerative changes, irregular areas of necrosis, hypertrophy of cells and hydropic degeneration with hyperchromatism of cell nuclei. In addition, there is constantly a very marked lymphocytic infiltration. This suggests that the effect of radium is not entirely a destructive process directly, but that it stimulates to a marked degree the greatest natural factor in the body's defense of cancer invasion.

In introducing the tubes, care should always be taken to obtain as equal a distribution as possible and to keep well to the periphery of the growth. It is a grave error to keep most of the radiation toward the central part of the tumor rather than at the periphery which represents the actively growing infiltrating border. In many instances it is well to implant emanation in the healthy tissue just at or as near as possible to the infiltrating base of the neoplasm. This can frequently be done by introducing the tubes through healthy tissue rather than through the growth itself. In fact, this avenue of approach is always preferable where practical. Tubes should never be introduced through an ulcerating infected surface unless drainage is free: they carry mixed infection deeper into the healthy tissues and add materially to the severity of the inflammatory reaction. Extensive sloughing may result from such a procedure.

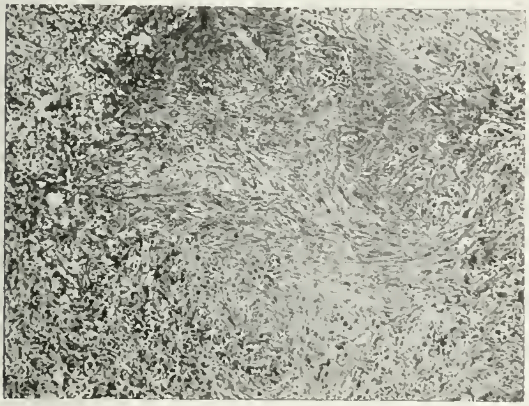

Fig. 8. Breast cancer eight weeks following interstitial radiation. Note destruction of tumor cells and fibrosis.

As to the range of applicability of this method of radiation, it seems to the writer that our greatest use of radium in the future will be in this direction. While its use over the surface must not be underestimated, it is nevertheless a fact that the supply is limited, and except for use in certain inaccessible locations, such as the body cavities, must, for the great majority of cases, give way to some other form of radiation. Naturally we turn to the roentgen ray as the logical agent for this work.

Practically all new growths which present a distinct bulk of tissue can be managed best by the interstitial embedding of radium emanation. The shape of the neoplasm governs, to a certain extent, the dosage. A globular tumor requires less than an oblong or rectangular mass of equal bulk because of the greater cross-fire. In the latter instance it is better to use more tubes of lower individual values in order to obtain a more even distribution without producing a reaction unnecessarily severe.

Fig. 9. Rectal cancer two weeks after interstitial radiation. Note destruction of tumor cells and extreme lymphocytic infiltration.

In certain locations it is almost impossible to keep surface applicators accurately in place and here again implantation of tubes obviates the difficulty.

In almost every group of malignant diseases the use of buried emanation has completely revolutionized the treatment. This is especially true of the intraoral work where surface applicators could be placed only in the anterior portion of the mouth, and even here could successfully care for only a small percentage of the cases because of the depth of neoplastic infiltration. At the Memorial Hospital we feel that the results to date have warranted us in excluding surgery entirely in the treatment of all primary intraoral lesions. A part of our results[2] published to date deal with this phase of the work in detail. In the rectal, uterine, and breast groups, also, interstitial radiation has played a part that could not have been handled otherwise. A small but important group that has shown marked response to this form of treatment is the parotid tumors. A certain number of these, because of their susceptibility to radiation, respond satisfactorily to surface treatment while others because of their bulk cannot be adequately dealt with. Others are dangerous from a surgical standpoint because of their relation to the facial nerve. Embedded emanation has been most successful in these cases. Since the intense inflammatory zone about the tube is only about 1 cm. in diameter the nerve can be approached fairly closely without damaging its function or producing symptoms of nerve irritation.

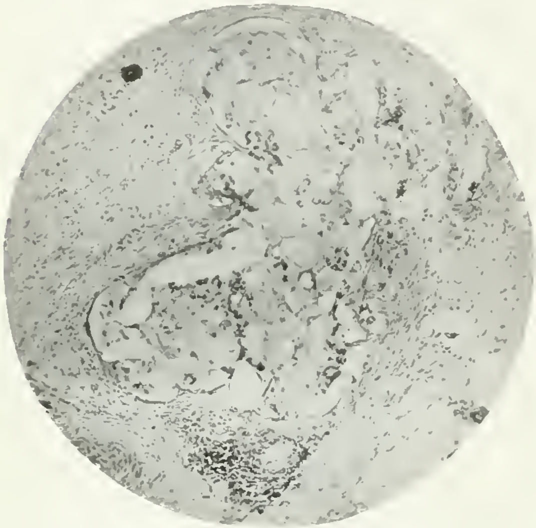

Fig. 10. Rectal cancer one month after interstitial radiation. Note necrosis and surrounding fibrosis.

In conjunction with surgery an added field of usefulness is opened for buried emanation. As previously reported[3] in detail, we use it as the method of radiation in all of our neck wounds following neck dissections. Many tumors are exposed surgically and are then found to be inoperable. Instead of closing the wound and resorting to external radiation, we are able to bury emanation accurately throughout the mass and close the wound without an added risk of suppuration. We now have a considerable series of cases of various types showing complete regression following this form of treatment and extending over periods of one to four years.

While comparatively little has been done as yet this combination of surgery and buried emanation holds important possibilities for dealing with many of the intra-abdominal new growths. With rectal cancer[4] we have found it a distinct advantage to approach some of the growths in this manner through the abdomen in conjunction with the usual treatment from below.

In connection with this subject of interstitial radiation the writer had hoped at this time to include a report of our work on the interstitial injection of an active deposit of radium but as yet the results are not sufficiently tabulated to publish.

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ROENTGEN RAYS OF SHORT WAVE-LENGTHS AND THEIR MEASUREMENT*

BY WILLIAM DUANE

Professor of Biophysics, Harvard University

CAMBRIDGE, MASSACHUSETTS

THE recent improvement in roentgen-ray therapy has emphasized the idea that we should use wave-lengths instead of voltages as estimates of penetration, etc. At its annual meeting in Cleveland, in 1914, I presented to this Society a method of measuring the average or "effective" wave-length of a roentgen-ray beam without employing a delicate and expensive x-ray spectrometer. We define the "effective" wave-length to be the wave-length of the monochromatic roentgen ray that has the same absorption as the whole beam of rays, in any particular case.[1] The method consisted in the measurement of the fraction of the radiation that passes through a given thickness of copper, or of aluminum. A curve giving the relation between this fraction and the "effective" wave-length determines the latter. The fraction of the radiation that passes through the filter may be measured either by a photographic or by an ionization method. The ionization chambers I was using at that time contained sometimes aluminum electrodes and sometimes plates of paper covered with a thin coating of graphite. The latter produces much less secondary and scattered radiation. In order to get an absolute measurement of the roentgen radiation in terms of the ionization current for a cubic centimeter of air, which served as a unit, I calibrated the ionization chambers actually used by means of one so constructed that the roentgen rays passing through it did not strike any solid body inside of it.

At the above-mentioned meeting and later before the American Physical Society I presented the curves representing the relation between the absorption and the wave-length. These curves show the wave-lengths corresponding to the amounts of radiation absorbed down to about .3 of an ångström. (We call the unit used for measuring wave-lengths the ångström.) It equals the one ten-millionth part of a millimeter.

2. In deep roentgen-ray therapy we use considerably shorter roentgen rays than .3 of an ångström, and the object of the research reported in this paper has been to extend the investigation of eight years ago to these shorter wave-lengths. Hull and Rice,[2] and Richtmeyer[3] have measured the absorption of roentgen rays by aluminum and copper down to a wave-length of .135 ångström. In the experiments I am now reporting we have measured the absorption by copper and aluminum of roentgen rays between .2 and .095 ångströms. This is the region of the spectrum used in modern deep roentgen-ray therapy.

3. Figure 1 represents the arrangement of the apparatus used in the measurements. The roentgen rays coming from the target, T, pass through a hole in a sheet of lead 1 cm. thick and in a brick wall and then through a narrow slit in a lead block, marked slit 1. The absorber or filter is placed between the tube and the wall, as indicated in the figure. After coming through slit 1 the roentgen rays strike a thin crystal plate mounted on a spectrometer table, by means of which its position and the angles it may be turned through can be measured accurately. The planes containing the molecules of the crystal reflect a part of the beam through a second slit (slit 2) into the ionization chamber. Slit 2 of the ionization chamber must, of course, be placed in the proper position to receive the reflected rays. The quadrant electrometer measures the ionization current flowing through the chamber.

In accordance with the well-known laws, discovered by Laue, Friedrich and Knipping, and by the Braggs, the crystal reflects

*Read at the Midwinter Meeting, Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, January 26–28, 1922.

only rays of certain definite wave-lengths, λ given by equation (1)

$$\lambda = 2d \sin \theta, \qquad (1)$$

where the angle, theta, is the angle between the roentgen-ray beam coming through the tube and the planes in the crystal containing its molecules. By measuring this angle, theta, we can determine from equation (1) the wave-length of the roentgen rays entering the ionization chamber. length spectra of roentgen rays that have passed through filters of 1 mm. of copper, and of 12 mm. of aluminum respectively. The curves of Figure 2 represent the data obtained in these experiments. The vertical coordinates give the ionization currents (expressed in arbitrary units) measured with the crystal in different positions, and the horizontal coordinates give the wave-lengths of the roentgen

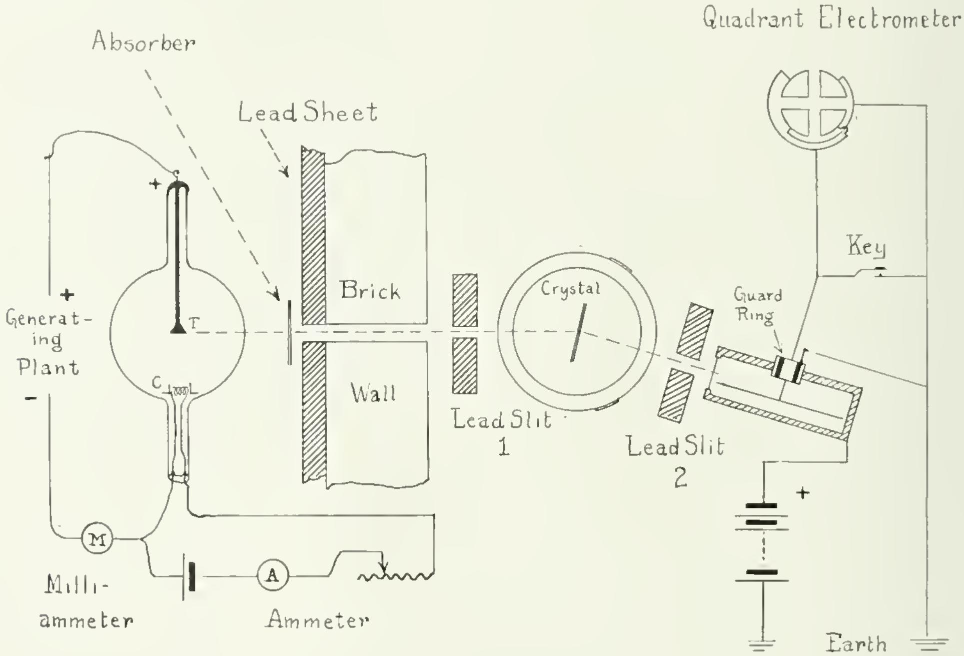

Fig. 1.

In making measurements with an x-ray spectrometer care must be taken to protect the instrument from stray radiation. It was for this purpose that the tube and generating plant were placed in one room and the spectrometer in another. In making measurements on the *absorption* of roentgen rays extreme care must be used in correcting for the natural ionization of the gas in the ionization chamber and for the ionization current due to any slight residual radiation. This correction has been made in all the experiments described below.

4. Before passing on to the methods of measuring the "effective" wave-length of a roentgen-ray beam, I shall give the results of experiments on the short wave-rays as calculated by equation (1) from the angles made by the beam of roentgen rays with the crystal planes.

It must be pointed out that the ionization currents represented by curves of this kind do not give the relative intensities of the roentgen rays at *different* wave-lengths, for various reasons, into which it is not necessary to go at this time. The ionization curves do give, however, the relative intensities of the roentgen-rays of the same wave-length in different cases.

Curve A in Figure 2 represents the x-ray spectrum with 1 mm. of copper as a filter, and Curve B, the spectrum with 12 mm. of aluminum.

In these experiments the current through the tube amounted to 1 ma. The voltage applied to the tube was constant and equal to 161,000 volts.

It appears from the figure that both ionization currents begin at wave-length .0755. This is the short wave-length limit of the spectrum determined by the voltage, v, applied to the tube,[4] in accordance with equation

$$v\lambda = 12{,}350 \qquad (2)$$

Both curves show maxima of ionization currents: Curve A for copper at wave-length .120 and curve B for aluminum at

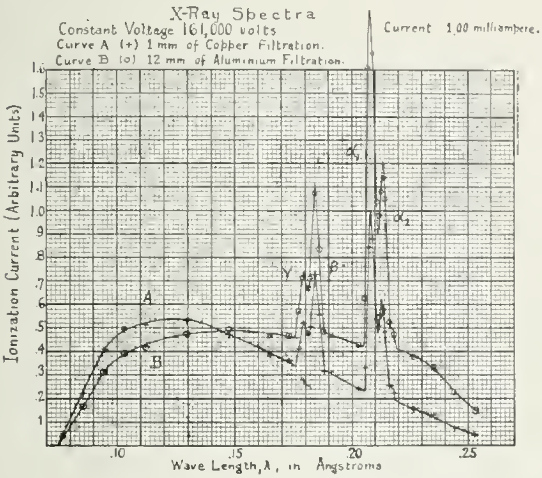

Fig. 2.

wave-length .145, the maximum for copper being slightly greater than that for aluminum.

At wave-length .141 the curves cross each other. For roentgen rays of this wave-length 1 mm. of copper absorbs exactly as much as 12 mm. of aluminum. For wave-lengths shorter than .141 the 12 mm. of aluminum absorb more radiation than the 1 mm. of copper; whereas for wave-lengths longer than .141 the 1 mm. of copper absorbs more radiation than the 12 mm. of aluminum. In other words, the relative filtering power of copper and aluminum is different for roentgen rays of different wave-lengths.

Since the aluminum lets through a much greater amount of long wave-length radiation than the copper and a much smaller amount of short wave-length radiation, copper is a much better substance to use as a filter than aluminum is, if we wish to produce a beam of roentgen rays of short wave-length. The effect appears to be very marked; for at wave-length .1 of an angström 30 per cent more radiation gets through the 1 mm. of copper than through the 12 mm. of aluminum, whereas at wave-length .2 of an ångström about 1.7 times as much radiation gets through the 12 mm. of aluminum as through the 1 mm. of copper.

The tall peaks on the curves represent the *x*-ray spectrum of the Tungsten target in the *x*-ray tube. The chief peaks (at wave-lengths .1790, .1842, .2088, .2134) correspond to the four principal lines in the Tungsten K series of roentgen rays.

Although these peaks are high, this does not mean necessarily that a large total amount of energy is radiated at these wave-lengths; for they are narrow, and it is the area underneath the curve in any region that corresponds to the intensity of radiation, rather than the height of the curve.

The radiation becomes practically zero in the neighborhood of wave-length .26, and we may regard this as the long wave-length limit of the *x*-ray spectrum for the filtration used.

5. It appears from the curves of Figure 2 that the roentgen-ray beam consists of a great variety of wave-lengths (from .0755 to .26). The fact that an *x*-ray tube does not produce a beam of roentgen rays of a single wave-length (monochromatic beam), even although the voltage applied to it may be absolutely constant (a storage battery, for instance), was pointed out in the article, published in 1915, above referred to.[4] There is, however, a certain average or "effective" wave-length, which has the same coefficient of absorption as that of the whole beam. It is this "effective" wave-length which is important to determine in many cases—for the physiological effect of the rays appears to depend upon the amount of radiation *absorbed*.

I shall now indicate how the "effective" wave-length of a roentgen-ray beam can be approximately estimated without the use of an *x*-ray spectrometer. The curves in Figure 3 represent the fraction of the radiation at different wave-lengths that passes through a given thickness of metal.

Curve A is for 1 mm. of copper and curve B is for 4 mm. of aluminum. These curves have been drawn from data obtained by actual measurements. If we determine in any particular case, the fraction of a roentgen-ray beam that passes through 1 mm. of copper, we can read off directly from the curve the wave-length of the monochromatic roentgen ray which is ab-

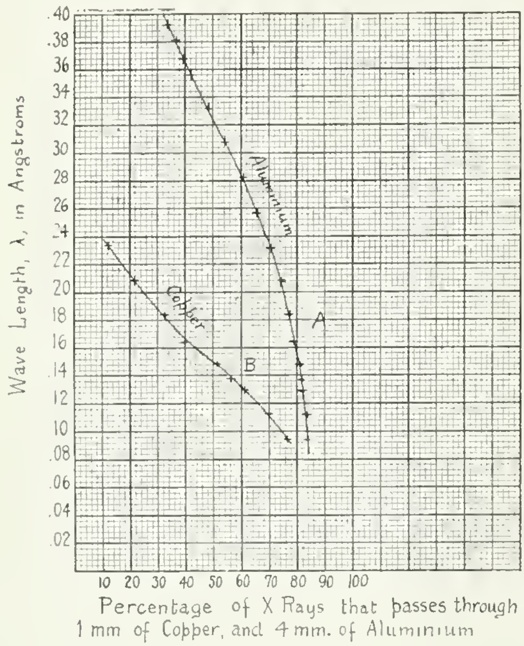

FIG. 3.

sorbed to the same extent by copper, and this wave-length is the "effective" wave-length of the whole beam.

The same process may be followed with a filter of aluminum. If the filter is 4 mm. thick, curve B will give us the "effective" wave length of the roentgen-ray beam.

The fraction of the roentgen radiation that gets through the filter in any particular case may be determined either by means of an ionization chamber, or by means of photographs. In the case of the photographic method a rough estimate may be made by determining the lengths of time required to darken two portions of a photographic plate to the same extent where one portion has been exposed to the beam of roentgen ray without the metal plate and the other portion with it. The shorter of the two lengths of time divided by the longer gives roughly the fraction of radiation passing through the plate.

A few examples of "effective" wave-lengths in particular cases may be of interest. If the voltage applied to the tube amounts to 80 or 90 thousand volts, the "effective" wave-length generally lies between .20 and .29, depending upon the filtration used and the character of the generating plant. It will be noticed that these "effective" wave-lengths average somewhat longer than the wave-lengths of the lines of the Tungsten spectrum. If the voltage amounts to 200,000 volts and is produced by an alternating generator, the roentgen ray beam that gets through a filter of .70 mm. of copper has an effective wave-length between .14 and .15 of an angström.† A roentgen ray beam of about the same effective wave-length can be produced by a *constant* voltage of 165,000 volts.

It appears from the curves in Figure 3 that a more rapid change in the fraction of rays that gets through the 4 mm. of aluminum occurs at longer wave-lengths than at shorter wave-lengths. In the case of the 1 mm. of copper, however, a rapid change occurs at shorter wave-lengths. Hence a more accurate estimate of a short "effective" wave-length can be made by using the 1 mm. of copper than by using the 4 mm. of aluminum. For longer wave-lengths, the aluminum should be used.

6. In the method of measuring effective wave-lengths described in Section 5, it is necessary to have some means of measuring the relative intensity of two beams of roentgen rays. I shall now describe a method of estimating "effective" wave-lengths by comparing two beams of roentgen rays, and determining under what conditions they produced *equal* effects. These equal effects may be photographic, ionization or fluorescent.

In Section 4 I called attention to the fact that the relative absorption of roentgen rays by copper and aluminum differed for different wave-lengths. In other words, the thickness of aluminum that has the same filtering power as that of 1 mm. of copper

† I am indebted to Dr. Wilhelm Stenström for the tests from which this estimate has been made.

depends upon the wave-length of the roentgen ray. For long roentgen rays the thickness of aluminum must be large, and for short roentgen rays, small. The curve in Figure 4 gives the thickness of aluminum that is equivalent in absorbing power to that of 1 mm. of copper for a variety of wave-lengths ranging from .095 to .40. It appears from this curve that for the long

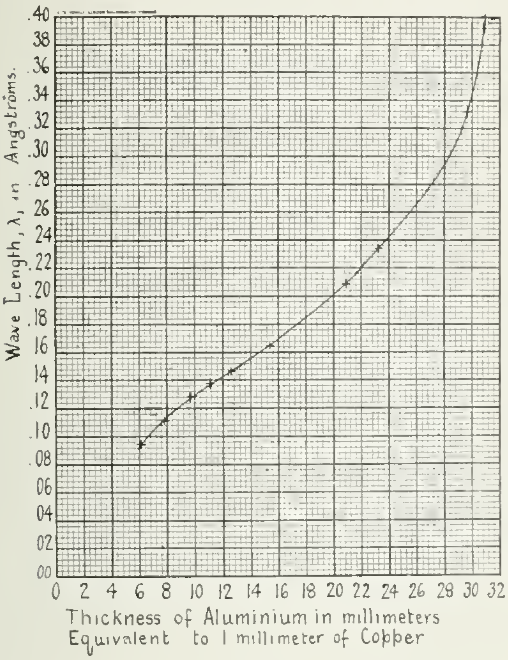

Fig. 4.

wave-lengths it takes about 31 mm. of aluminum to absorb as much as 1 mm. of copper, whereas, for short wave-lengths (about .1 ångström) 6 mm. or so of aluminum absorb as much roentgen radiation as 1 mm. of copper. If we determine by means of an ionization chamber, or by means of a photographic plate or a fluorescent screen, the thickness of aluminum that absorbs the same amount of radiation as 1 mm. of copper, we can determine from the curve of Figure 4 the "effective" wave-length of the beam of roentgen rays, —that is, the wave-length of the monochromatic roentgen-ray beam that has the same relative absorption in copper and aluminum as the whole beam.

It will be noticed that this method of estimating the "effective" wave-length resembles somewhat the use of a Benoist penetrometer. The fundamental principles of the two methods, however, are quite different from each other. The Benoist penetrometer depends upon the fact that at a certain wave-length (.485) a sharp increase in the absorption by silver occurs. In the present case there is a continuous change in the relative absorption of copper and aluminum with the wave-length. Further, in the case of the Benoist penetrometer the beam of ray for which the greatest thickness of aluminum is equivalent to the silver has the most penetration. In our method, however, the short wave-lengths correspond to the smaller thicknesses of aluminum that are equivalent to the copper.

The effective wave-length of a beam of roentgen rays decreases as it passes through the plates. In fact, the fundamental principle of filtration is based on such a decrease. Hence in estimating effective wave-lengths by this method, plates of aluminum and copper that are not too thick should be employed. For instance, in the case of short waves, we should use perhaps $\frac{1}{2}$ mm. of copper, and determine the thickness of aluminum equivalent to it; whereas, for longer waves (produced by 80 to 100,000 volts) we should use $\frac{1}{4}$ mm. of copper or less, and determine the thickness of aluminum equivalent to it. Substances other than aluminum and copper may be used in the measurement. The data for some of these will be published in another paper.

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THE AUTO ELECTRONIC DISCHARGE AND ITS APPLICATION TO THE CONSTRUCTION OF A NEW FORM OF X-RAY TUBE*

BY J. E. LILIENFELD, M.D.

LEIPSIC, GERMANY

The tubes at present in general use depend for the production of the electrons upon one of two effects, known for many decades: Either the ionization of residual gases (gas-filled tubes) or the heating of the cathode to a bright glow (thermionic or Edison-Richardson effect). The tube to be described, however, utilizes the electrons released by a phenomenon which I have only recently discovered. The main feature of the phenomenon is the releasing of the electrons on an unheated and cold cathode in the absence of any kind of ionization, either the ionization of the residual gases or an ionization through a hot spark discharge (electric arc) which pulls molecules from the electrodes and converts them into ions.

1. According to the facts observed, it is at least in a primary way the electrostatic field itself—hence the name "auto-electronic"—which liberates the electrons on the cathode.

For a clear understanding of the principle upon which this new tube is constructed, it will be necessary to first discuss certain physical experimental phenomena which have a bearing on this method of the liberation of the electrons.

CONDITIONS ESSENTIAL FOR THE PRODUCTION OF THE AUTO-ELECTRONIC PHENOMENON

The conditions which must be fulfilled, in order to realize the auto-electric discharge are:

2(*a*). The electrodes are to be sufficiently close together, up to 10 mm. or a little more. The voltage required by a certain milliamperage increases with the distance between the electrodes.

3(*b*). The cathode is to be provided with "active surfaces" having a small radius of curvature. These may be edges or points. Under identical conditions the voltage increases with this radius. It also increases if metallic surfaces connected to the cathode and situated close to the active cathodal point are introduced. This is evidently due to the deflection of the lines of electric force from the cathodal point produced by such accessory surfaces. This deflection is also the reason why when two points of identical radius of curvature, but of different angles, are compared, the more obtuse angle requires the higher voltage.

The conditions outlined in paragraphs 2 and 3 are of a geometrical nature, and speaking physically simply mean that to start the discharge a certain intensity of the electric field on the active surface is necessary. Besides these conditions there are also others of a non-geometrical nature which are essential for the production of this phenomenon. These are as follows:

4(*c*). A very high vacuum—higher, indeed than in the usual hot cathode tube—must be maintained. To this end an additional arrangement has been provided (Par. 20). A slight increase of the pressure beyond a certain value may cut the milliamperage, corresponding to a given voltage, down to 50 per cent of its proper amount, or even more.

5(*d*). Highly refractory metals, such as Wo, Ta, Mo and others, must be employed for the electrodes, because—in order to fulfill the conditions above—the electrodes, first of all the cathodes, must be heated by an electronic bombardment as high as possible during the process of evacuation. Gas absorbed at the cathodic active surfaces may interfere with the releasing of electrons and reduce the effect greatly. If such troublesome gas rests occur during

*Monatsb. der Saechs. Akad. d. Wissensch. Math.-Phys. Klasse, Leipz., Sitzung von 19 Juli, 1920, lxxii, 31. Verhandl. d. Deutsch Phys. Gesellsch., Sitzung von 25 Feb., 1920, s. 13.

*Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27-30, 1921.

exhaustion, then the regular discharge can be restored by energizing the tube with much higher tension, or by glowing the cathode intensely, or by a combination of both means. With a further increase of the gas density up to a certain limit, a further increase of the voltage is required to start the discharge. Beyond this limit, no pure electronic discharge is produced, a regular hot spark or electric arc being the only phenomenon that can be called into life by an increase of the voltage. Therefore, if evacuation is not cautiously carried out, either no discharge at all, or a regular gas discharge, or most frequently a hot spark (arc) discharge takes place between the adjacent parts of the electrodes. On the other hand, if the active metallic surfaces contain much more gas, or if the vacuum is much lower, a hot spark or arc discharge may be started with a much lower voltage. In the case of such ionic discharge, the cathode need not necessarily be pointed. The arc discharge may sometimes cease and leave a local ionization, and this may produce a local regular gas discharge, delivering *x*-rays; which, however, has nothing in common with the geometrically defined phenomenon referred to in paragraphs 2 and 3. On the contrary, the latter conditions have delayed the discovery of the auto-electronic phenomenon until now, because it was believed that there would be rather a tearing off of molecules from the metal and a starting of a hot spark discharge between the electrodes, before any release of electrons from cold cathodes by action of the electric field alone would take place.

6(*e*). The pure phenomenon is greatly facilitated by making the active parts of the anode hollow. This apparently handicaps the formation of an arc discharge and so facilitates the exhaustion, because an arc is capable of deforming the electrodes in a short time. A plane anode is less useful for the purpose and a convex is still less satisfactory.

PHYSICAL FEATURES OF THE AUTO-ELECTRONIC PHENOMENON

The characteristic properties of the phenomenon are:

7(*a*). The discharge is started by loading the active cathodic surface negatively only, so that the tubes have the character of valves.

8(*b*). The cathode is not heated by the discharge. Changing the temperature of the cathode within wide limits does not affect the phenomenon. In one of the initial experimental tubes the cathode was made hollow, so that it could be filled with liquid air. This cooling produced no effect but a slight increase in the milliamperage by some 5 to 10 per cent. which may be attributed to the fact that such cooling condenses some of the residual gases, and so improves the vacuum.

9(*c*). No change whatever is to be observed on the cathodes even by energizing the tube for several hundred hours (8). Consequently, the voltage required for a certain milliamperage is simply determined by the form given initially to the cathode (3), providing the exhaustion is sufficiently high and has been so carried out that no hot spark or arc discharge has taken place, which would result in deforming the active part of the cathode, while the tube is on the pump and during the period when the gas has not yet been sufficiently removed.

10(*d*). I have not yet been in the position to determine with accuracy the characteristic of the discharge (21). The voltage and the penetration of the *x*-rays increase definitely but not considerably with the milliamperage, to some 5 ma. With heavier current the increase of voltage, with rising milliamperage, appears to be very much slower. Correspondingly the penetration of the roentgen-radiation increases in this range very slowly with the milliamperage, so that the function characteristic of the discharge seems to contain a higher power of the voltage; probably it will prove to be an exponential function (21).

11(*e*). As far as superficial experience shows, there is a difference between different metals used as cathodes. However, the precise research of this question is still to be made.

12(*f*). The electrons are not necessarily driven from the cathode to the next adjacent point of the anode, but sometimes travel along a path of many centimeters to more distant spots of the anode, if a suitable construction of the electrodes is provided; *e.g.*, if a pointed cathode (K, Fig. 1) is placed opposite a wire (A) being the anode, the point of impact of the cathode rays may be found at any point along the wire; and if a disc (C) is provided in the thicker rear part (B) of the anode, occasionally the cathode beam strikes it, heating it to a bright glow. The velocity of the electrons is evidently accelerated to a very high degree, very close to the active part of the cathode—which amounts to the statement that a very large increase

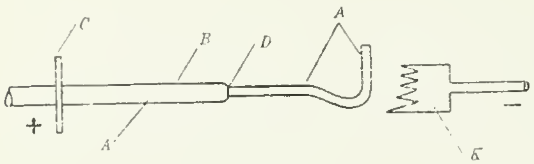

Fig. 1.

of potential takes place exceedingly close to the active cathodal surface. The residual electric force in the remaining space is of itself no longer sufficiently intense to direct the cathode beam towards the adjacent parts of the anode, once the electrons have been accelerated on the cathode.

13(*g*). Looking at the facts superficially, the sudden acceleration of the electrons along an extremely short path—practically on the surface of the cathode itself—may, from the standpoint of the theory of electromagnetism, be held responsible for a further new phenomenon which is the emission of a roentgen-radiation from the active surfaces of the cathode, while the other parts of the cathode do not emit any radiation whatever. This is proven by pinhole camera pictures of energized tubes exposed twenty times or more longer than would be required to obtain a picture of the anode. The radiation from the cathode is a weak one and specifically negligible if compared with that of the anode. Furthermore, the radiation is much softer. If a tube is operated with a 15 cm. spark gap, the regular radiation of the anode is but slightly affected by a two millimeter aluminum filter. The cathodal radiation, however, is completely absorbed by such a filter. Through so thin an aluminum layer no impression of the cathode radiation whatever can be obtained on the photographic plate.

A pinhole camera picture of a tube, consisting of a plane Pt-Ir target and a crown-shaped cathode is reproduced in Figure 2. The cathode is made of a tantalum wire of 6 mm. in diameter, drilled out into the shape of a thin-walled cylinder and cut out zigzag, making seven V-shaped points, of which the inner cutting edges are kept sharp. On the anode appears a number of focal points, one of which appears in the picture. Of the cathode the

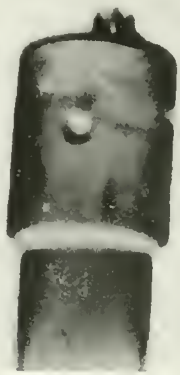

Fig. 2.

edges only can be seen. The tube was operated on a rectified direct current. A reliable highly evacuated hot cathode valve and a high tension resistance of 10 megohms of carbon-coated glass tubes was inserted in series with the tube studied, in order to exclude any inverse voltage which might have possibly arisen from some electric oscillation. The picture has been taken by exposing a glass plate, provided with an intensifying screen, to a radiation generated by 2 ma., 180 minutes at a focal distance of 25 cm., through a pinhole of 0.8 mm. The distance of the pinhole to the plate was 10 cm.

14(*h*). Another fact appearing to be closely connected to those under paragraphs 11 and 12 concerns the ponderomotive force of attraction between the electrodes. One of the electrodes—for instance the cathode—may be held at a certain distance from the anode by a spring of such dimensions that the regular electrostatic attraction does not visibly reduce the gap between the electrodes. If the spring is not too resistant, there is always a considerable pull on the cathode to be observed as soon as a discharge of about 3 ma. is started. The pull increases with the milliamperage. Another example is that of several springs mounted on the anode; such springs are apparently subject to attractive force only if they are struck by the cathode beam. As long as the cathode beam does not touch a particular spring, no expansion is to be observed, although a heavy discharge may be kept going to a different part of the same anode. This effect of anomalous attractive force has also been studied by means of an apparatus, in which the cathode was mounted upon one arm of a balance, the other arm bearing an iron core, which was under the influence of a magnetic field that could be varied from outside the tube. I have been very much interested in the measurements of the anomalous attractive force, because I feel that an exact knowledge of this effect may become a basis for determining important features of the nature of the electrons, and, broadly speaking, of electricity and matter.

THE X-RAY TUBE

15(*a*). It is obvious that the new effect may be applied for realizing any technical application of a flow of electrons. Either the electrons given off primarily by the cathode, or the secondary flow of electrons coming from the spots of impact of the primary rays on the anode, or both, may be used for any electronic device as an *x*-ray tube, an amplifier, etc.

In the present paper the application to *x*-rays only will be described. Naturally any cathode provided with active surface of a small radius of curvature and adjacent to an anode of any kind will be capable of producing *x*-rays if only the dimensions are chosen so as to make the discharge pass at the voltage required for the particular purpose. Nevertheless several constructive features must be introduced in developing the simple fundamental idea into a satisfactory practical device.

16(*b*). First of all, the shape of the cathode is to be chosen. Simple points, straight and circular edges, multiple points, mounted like points of a crown, have been tried. When a heavy milliamperage would be required especially with low voltages—multiple points will have to be used. For regular *x*-ray work, however, simple points appear to act satisfactorily, since the milliamperage increases very rapidly with the voltage (10). The points must be grounded with greatest care and precision (since the angle and their sharpness decides the hardness of the rays) on wires of a diameter of two or three millimeters. The wires are of Wo, Ta, Mo or other refractory metals,

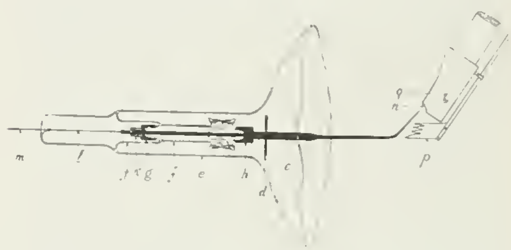

Fig. 3.

because the cathodes must be glowed out, up to a bright white glow during the process of exhaustion. The cathodic wires are mounted on holders (*c*, Fig. 3) which may consist of one of the metals mentioned or even of a less refractive material, like iron, etc. The small disc (*d*) of metal overshadows the insulating parts supporting the shaft of the cathode, in order to prevent electrons used during the process of exhaustion for the bombardment from impinging thereupon. The parts fixing the cathode properly are arranged in the neck (*e*) of the bulb. They are very elaborately designed and constructed, since an absolute fixation of the cathodic point is required to secure a constant working of the tube. Inside of the neck, another glass tube (*f*) is sealed, both ends of which act as bearings for the shaft of the cathode. The cap (*g*) of the rear part of the shaft fits tightly upon the glass tube, while the frontal cap (*h*) is tightly mounted on a quartz support (*i*), the last being fastened by means of pieces of flexible wire to the front end of the glass tube. The threaded part (*k*) of the shaft enables the glass blower to fix the cathode holder exactly upon the tube. The connection to the cathode is obtained by a flexible wire, whose outer end (*m*) is sealed into the glass. A photograph of two points of different sharpness is represented by Figure 4.

17(c). The anode of the tube may be designed for any system of cooling. That is, of course, no characteristic feature of the tube. The tubes demonstrated in this country are equipped with anodes of the water-cooled type. For the target any of the known materials may be used. The only important feature of the anode is that

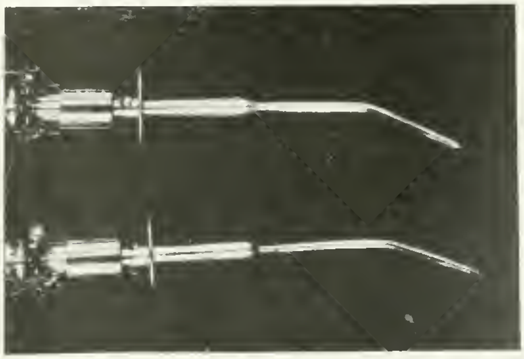

Fig. 4.

the target is hollow over the area, (n, Fig. 3), where the focal spot appears. There are two reasons for this:

(I). First, if a convex or plane target is used, the discharge has a tendency to form one or more extremely small focal spots, so that the load per unit of target's area may become too heavy even with a medium milliamperage, which would result in melting or evaporating the metal. On the contrary, if a cavity on the target is used, the sharp pencils of cathode rays are distorted by the particular shape of the electric field. With small milliamperage the focus consists of a few spots—when increasing the milliamperage, the spots become larger and more numerous, so that the area struck by the primary electrons enlarges with the current (Figs. 2 and 3), a very favorable feature. The dimensions of the anodic cavity have to be adapted to voltage and purpose. For lower voltages such as used for roentgenographic and fluoroscopic purposes, a cavity of 4 mm. depth by 5 mm. diameter appears to be sufficient. Inasmuch as there is not only impact of electrons on the points struck by the primary cathodic beam, but also on account of a great number of secondary electrons started in these points, the entire cavity acts as a focus, emitting x-rays (Fig. 5, 1). Therefore, the dimensions of the cavity are of importance, in so far as the sharpness (definition) of the pictures is concerned. The dimensions mentioned have proven—as experience shows—to be completely satisfactory.

To avoid the shadow cast by the cathodic point, the focal cavity (n, Fig. 3) is located not in the center but close to the

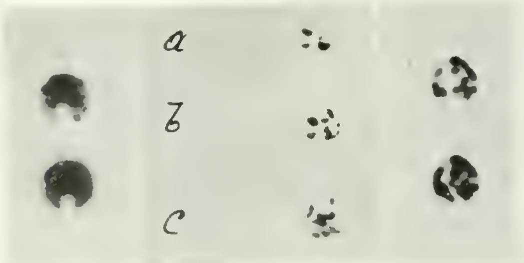

Fig. 5.

edge of the anode, so that the cavity is cut by the edge.

A cavity of much larger dimensions must be provided if the tube is to be energized by high voltages. For use in deep treatment, a diameter of 14 mm. and a depth of 16 mm. or even more may be chosen. This answers not only the purpose of distorting the initial small diameter of a more accelerated (on account of the higher voltage) cathode beam, but has the additional virtue that such a cavity may act simultaneously as a protective shield if it is designed so as to limit the intense primary x-ray beam to an angle not much larger than that required for the particular purpose.

(II). It is well-known that the hot cathode tubes emit a very considerable portion of radiation outside of the intended focal spot—from the rest of the frontal part of the target and to quite a large extent even from the stem of the anode. This radiation is due partly to a necessarily defective focusing of the cathode beam, partly to secondary electrons which are started by the primary ones at the focal point and bent inside of its double layer close to and in front of the focal point,[1] so as to strike

[1] Jahrb. f. Radioaktivität u. Elektronik, xvi, 105–189, especially 140–159.

upon the target and the stem This "stem" radiation is obnoxious, not only because it fogs the image on the sensitive recording surface, but also because its intensity is lost for the useful purpose and must, therefore, be deducted from the total radiation. By making the anode hollow the amount of this "stem" radiation is reduced to several per cent of its usual value, and practically can be neglected. It is evident that any tendency for the electron to

Fig. 6.

leave the focal cavity is inhibited by the repulsive action of the closely adjacent cathodal point, so that only few electrons escape from the cavity. Pinhole camera pictures demonstrate a very considerable amount of secondary radiation inside the cavity, while only a comparatively small intensity of "stem" radiation is to be observed

18(*d*). If a radiation of two or more degrees of hardness is to be generated then it is easy to introduce two or more pointed cathodes into the same tube (Fig. 6), and grind the different points to different angles (Fig. 4). In this case either a single cavity on the anode is to be used, so that electrons of different points may be caused to impinge nearly on the same area or there may be provided a particular cavity for each particular point (Fig. 7). Experience shows that for most radiographic and fluoroscopic purposes no more is needed than a single point. However, since two degrees of penetration are required for the general diagnostic work, a series of tubes have been constructed to meet this demand. Tubes for deep treatment are also provided with two points, the softer one

Fig. 7.

being used in the first stages of exhaustion, while provision is made to later remove this auxiliary point from the space of the discharge as well as from the angle of the radiation which is to be applied.

19(*e*). One of the characteristic features of the tube is a particular member attached to the anode for the purpose of glowing out the cathode or the cathodes by electronic bombardment during exhaustion. It is a small piece of tantalum or molybdenum foil (*p*, Fig. 3) indented on one of its edges so as to provide a number of sharp points and mounted on a 2 mm. wire, like a flag on its shaft. While evacuating the tube, the flag is facing with its indented edge the pointed end of the cathode. By loading the anode negatively, an electronic discharge is started, so that not only the pointed end, but also the shaft of the cathode, including the small disc (*d*) receives electronic impact and may be heated up to any temperature required. After sealing, the tube is inverted and by gentle tapping the flag is caused to slide back along the anode stem, where it is definitely fixed by a small metal clip (*g*) in which position it is represented on Figure 8.

20(*f*). Special attention has to be paid to the evacuation, because a higher degree of exhaustion is required than in the case of the hot cathode tubes (4). For the purpose of improving the vacuum, especially to absorb gases developed by the sealing of the tubes, a chamber (*c*, Fig. 9) can be provided in which any metals fit for the purpose may be sputtered. The chamber consists of a small bulb of 3 cm. in diameter, in which a cathodically active point is mounted, facing a plane anode of the material to be sputtered. While connected to the pump the electrodes are treated in the regular way, in order to get out as much as possible of the occluded gases. After sealing the tube, a sufficient layer of sputtered stuff is produced and since afterwards the electrodes are no longer to be used any more, they are covered with protective caps.

Fig. 8.

Fig. 9.

21(*g*). I have not yet been able to determine satisfactorily the electric properties—first of all the characteristic—of the tube; a plant delivering a constant direct current of high voltage being needed for the purpose and only little time being available, I was obliged to postpone a more detailed research of this subject, as well as of many other rather important features. But there is no doubt that a rapid increase of the milliamperage with a rising voltage takes place, probably an exponential function (10). Evidently, if worked by alternating or pulsating direct current, the discharge is limited to the peaks and the adjacent parts of the waves of the voltage to a larger extent than is the case with any other of the present tubes: surely, to a very much larger extent than with the regular hot cathode tubes, in which the milliamperage is practically independent of the voltage. Consequently, the same spark gap being supposed, not only is there obtained a considerably higher average hardness of the radiation, not only a much larger intensity of radiation per milliampere, but also a much more homogeneous quality of radiation. The degree of homogeneity can be regulated by choosing proper forms—different numbers of points, different lengths of the edges—of the cathode.

22(*b*). While the constructive features as described are essential and will probably remain typical with the tubes constructed according to the principle developed above, the same cannot be said of the external form of the tubes. Though the tube shown in Fig. 9 can be fitted in most of the usual holders, probably different types will be developed for particular purposes; a rectangular type for dental use, a straight type for radiography, and finally a special form for deep treatment purposes. Various cooling devices may also be introduced.

DISCUSSION

Dr. Levin. I would just like to ask Dr. Lilienfeld whether his tube was tested for the high voltage machine that is being used at the present time with 2½ ma., and whether it is possible to get the same conditions, because I believe if this tube were workable it would be superior to the gas tube on the one hand and the Coolidge tube on the other, because it does not require the additional filament control, etc. The doubt in my mind is whether it will always be possible to get those same conditions, or will it all of a sudden stop giving the roentgen ray and simply spark across.

Dr. Schmitz. I think about three or four years ago some research work was done by the Western Electric Co., and it was determined that a great deal of radiation was obtained from the arms of the Coolidge tube. The benefit I can see in the Lilienfeld tube is this: there is practically no radiation from the arms of the cathode and anode. Whether it is possible to use the Lilienfeld tube in therapy, I do not know. I have not seen this tube used for that purpose. I can see the advantage of using this tube for roentgenographic work, provided you are not using the Potter-Bucky diaphragm. If you use it, necessarily you do away with the radiation that is obtained from the arms of the tube. The question raised by Dr. Levin as to whether the Lilienfeld tube could be operated on high voltage is a very interesting one. If not, of course, it could not be used for therapy at all.

Dr. Lilienfeld (closing discussion). As far as Dr. Levin's question goes, I can only state that of course there is a possibility of applying the tube for deep therapy. The application of the tube for deep therapy is given, for the reason that the whole radiation is concentrated, with the exception of only very little percentage, up to the real focus point. If a tube is constructed for 100,000 volts, the discharge will start at 70,000 volts and go up to 100,000. Now, as to the question in regard to how high voltages have been used, I have to say that while I invented the tube I discovered that it was better not to use high voltages but to show that even low voltages will do the trick and will cross over the gap between the point and anode. Hence to me the most stupefying observation was that voltages of very few thousand volts would do the trick. There was no difficulty whatever in making the gap larger and of working the tube at 100,000 volts or more than that. I have no doubt that any voltage required can be adapted to this tube. You have to look at this particular invention from the historical standpoint too, because you know perfectly well that the ionization, which was the basis of the first tube, was known for sixty or even more years before definite types of gas tubes were made. The effects of hot cathode were discovered by Edison forty years ago. A great amount of detail work has been done for about thirty years, and only afterwards came the hot cathode roentgen-ray tube. Now this electronic phenomenon is very young. Only two or three years ago I had the first conception that such a thing could be realized. Of course, in these three years I was not able to do the whole development work which will be definitely required. I hope that the definite treatment tube will be made in about six or eight months. At any rate, I do not see any reason why higher voltage could not be applied for these tubes.

STEREOFLUOROSCOPY*

BY J. D. MORGAN, M.D., B.A.

Roentgenologist, Ross Pavilion, Royal Victoria Hospital

MONTREAL, CANADA

TWO *x*-ray tubes, with targets placed several inches apart, are alternately excited. These short alternating flashes produce different images on the fluorescent screen corresponding to the difference in position of the tube-targets. Owing to the persistence of each image in the eye, the result is a confused mixture of the two images. If, now, a shutter be placed in front of the eyes, and so arranged as to permit the eyes alternately to see the screen in synchronism with the flashes of the two tubes, each eye will see but one image, but the observer will be conscious of a continuous stereoscopic effect. Very early in the evolution of roentgenography, stereoscopic roentgenograms were an accomplished fact. The interest they aroused was naturally followed by attempts at stereofluoroscopy. One of the earliest to attain success was Mackenzie Davidson, of London. At a meeting of the Roentgen Society, held on December 6, 1900, he gave an exhibition of his stereoscopic fluoroscope. The shutter consisted of a rotating disc with appropriately placed slots which eclipsed each eye alternately with the sparking of the tubes. The President, Dr. MacIntyre, in thanking Mr. Davidson in the name of the Society, remarked that he thought the apparatus perfect in principle, but, in its present form it seemed to him it would be difficult to get patients to adapt themselves to the necessary position. Mr. Davidson (it will be remembered that he later became Sir James Mackenzie Davidson) himself remarked that he feared its cost, which must of necessity be high, would preclude its use from those working in hospitals with small means.

In 1911, our friend Dr. Pirie devised a much more portable apparatus which he described in the November issue of the *Archives of the Roentgen Ray* (London). His shutter, he wrote, "resembles a lady's hand-mirror in shape and size." It consisted of a perforated disc which was rotated by means of a flexible shaft connected at the other end to the main shaft of a Snook machine which latter also served to activate the tubes. Dr. Pirie made note of the important fact that "when using two tubes it is necessary to have them of the same hardness" and recommended the use of a single *x*-ray tube with two anticathodes, such, for example, as that made by Bauer. Attempts were also made in France and Germany to accomplish stereofluoroscopy. A description of a French apparatus is given by Lievre. I have not, unfortunately, been able to obtain details of this apparatus.

In America, the best known stereofluoroscope is that devised by the late Dr. Caldwell. It was fully described in the December (1918) issue of the AMERICAN JOURNAL OF ROENTGENOLOGY. The shutter has three wings which serve to cut off the vision from the eye-holes. It is driven "by making it the rotor of a motor, the field windings surrounding it and placed just beneath the face plate." To obviate the difficulty of keeping two gas tubes to an equal degree of vacuum, Caldwell made use of two self-rectifying Coolidge tubes. Dr. Williams, even prior to this, had devised an apparatus with a revolving shutter. This apparatus may still be seen at the Massachusetts General Hospital in Boston. Another recent English apparatus is one in which, again, the shutter consists of a disc which is rotated by means of a long flexible shaft, similar to the one devised by Dr. Pirie. The objection to this type of apparatus is the difficulty of retaining synchronism, owing to the "give" in the flexible shafting. In order to overcome this objection an attempt was made several years ago, by the late Dr. Robert Wilson and Mr. L. R. McDonald, my associate in this work, to construct a synchronous motor in direct contact with the revolving

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

shutter (Fig. 1). This created another difficulty, however, namely, that of weight. Mr. McDonald's apparatus, the lightest I have seen of this type, weighs about fifteen pounds. A further objection to all these types of stereofluoroscopes is that they occupy at least one hand of the operator, thus limiting his movements. Or, if the shutter be suspended, thus freeing the hands, the field of operation is limited.

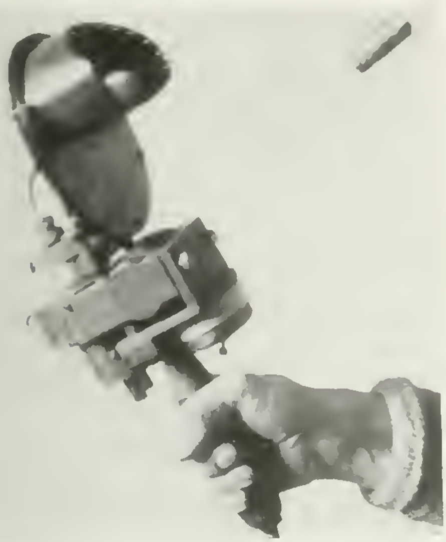

Fig. 1. Motor and shutter mounted on handle and connected by very short flexible shaft.

Yet another American stereofluoroscope is described by Dr. Heck, in the issue of the American Journal of Roentgenology for September, 1920. Dr. Heck uses two rotating shutters. He also uses two Coolidge tubes, each with its own transformer and control. The shutters are connected through suitable gearing to a solid shaft on the other end of which is a twelve-inch arm whose extremities travel close to two semicircular rods, each of which is connected to one of the Coolidge tubes. An electric motor drives this system at a speed of 900 revolutions a minute. By this means the eye gets fifteen light impressions per second. The objections to this apparatus would seem to be its size and lack of flexibility. In the July, 1921, number of the *Journal of the Roentgen Society*, London, is a description of an apparatus designed by Prof. Tyndall and Mr. Hill. Their objects have been simplicity and economy (Fig. 2). They, therefore, use but one Coolidge, or gas tube. This is mounted on a suitable insulated carriage and attached to one end of a vertical metal strip the other end of which is passed over a pin (*p*), which itself is fixed eccentrically to the face of a circular disc (*c*). "When the disc rotates the pin (*p*) forces (*m*) and the carriage to which it is attached to execute a linear oscillation through a dis-

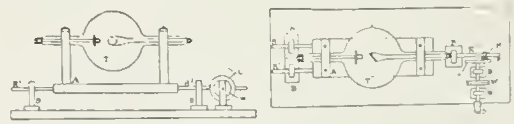

Fig. 2. Views from the side, and from above, of the tube in carrier.

tance equal to the diameter of the circle described by (*p*). This can be varied by placing the pin in any one of a series of holes at different distances from the center of the disc (*c*)." An excursion of about one inch was found to be the most efficient, and a speed of about ten revolutions a second to give satisfactory persistent pictures. Under these conditions no undue strain is placed on the tube. A rotating shutter is used (Fig. 3). My criti-

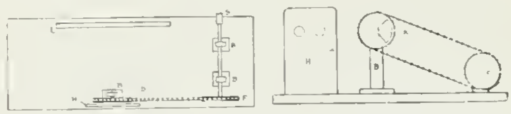

Fig. 3. Views from above, and from the side, of the rotating shutter.

cism of this apparatus, without having seen it, would be the cumbersome chain drive of the shutter and consequent lack of flexibility.

Finally, we come to the apparatus to which Mr. McDonald and myself have devoted considerable time during the past eighteen months. It differs essentially from the previous types I have described in that the shutter has a vibrating, instead of a rotating, movement. Several previous attempts have, I believe, been made to construct such a shutter, but without complete success owing to the inability to synchronize the vibrations with the lighting of the tubes. The fault has been in the use of forced vibrations. In our shutter the vibrating member is placed between two specially made electromagnets and only enough force applied to overcome inertia and air friction. It, therefore, oscillates in a natural manner. Two Coolidge tubes are used, both activated by the same transformer.

Further advantages of this apparatus are: First, its small size and lightness—it weighs only twelve ounces (Fig. 4); second, it can be strapped to the forehead

Fig. 4.

like a head-mirror (Fig. 5), thus leaving both hands of the operator free; third, when not in use it can be pushed up from in front of the eyes without removing it from the forehead; fourth, it can be fitted with an "operating-fluoroscope," thus rendering it possible to operate in a fully lighted room; fifth, it can be used equally well in any position without losing synchronism; sixth, a number of observers, each with a shutter, can "plug in" and view simultaneously the shadows stereoscopically, as they appear on the common fluorescent screen. The accompanying pictures are of our homemade apparatus.

DISCUSSION

Dr. Hickey. I had the pleasure of seeing the stereofluoroscope of Dr. Morgan in operation very shortly after it was brought out. I was much impressed with the simplicity of it. The only disappointment is that we cannot get one. Personally, I feel that the stereofluoroscope is something which the manufacturers have neglected. I have been very much interested in the manipulation of fractures under the fluoroscope in the hospital with which I am connected; practically every fracture is reduced by fluoroscopic control. The inconvenience of having to turn the patient over to judge of the position in the lateral direction so as to be sure we are not getting a misconception of the position, is something I think which could be overcome by the stereofluoroscope.

Dr. Pirie. I have had the pleasure of seeing this stereoscope working and thoroughly appreciate what a beautiful instrument it is. It is better than former stereoscopes in

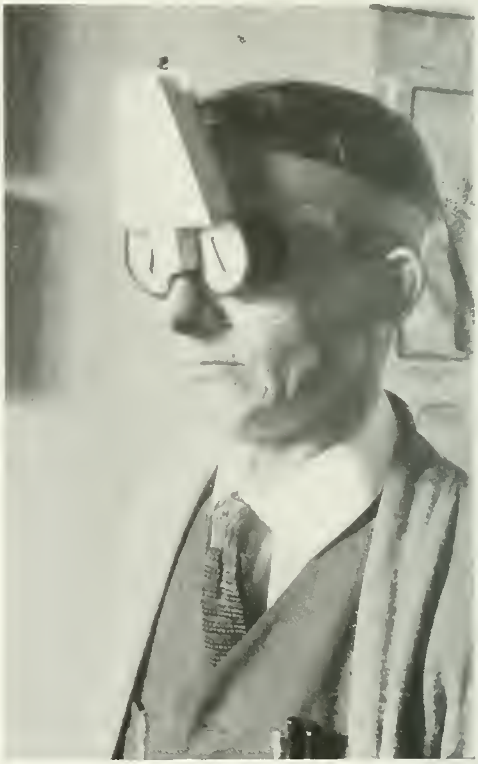

Fig. 5. The shutter can be pushed away from in front of the eyes without removing the strap.

that it is much lighter. It works perfectly and leaves your hands entirely free. I do not see that we want anything better.

The only disadvantage of the stereofluoroscope is that you have to have a special apparatus for it or you have to set it up every time you want to use it and take it away again when you want to use the single tube.

It gives a perfect stereoscopic effect and it is the best thing in stereofluoroscopy I have seen so far.

Dr. Morgan (closing discussion). I think the point brought up by Dr. Pirie regarding the difficulty of changing over from using double tubes to the use of a single tube is a good one, but any objections of this sort I feel sure will readily be overcome when once the manufacturer will have taken up the matter seriously. This is a question of mechanics, which, I think, will prove, in the end, not to be as difficult of solution as may now appear. I can see no reason why some form of apparatus cannot be constructed having two tubes for stereoscopic work, and with some arrangement by which one tube could be cut out when one wishes to do ordinary roentgenographic or roentgenoscopic work. This stereo work is only in the experimental stage. I do not know that the last word has been said regarding the design of a shutter but our hope is that with our present model we can very considerably reduce not only the great bulk and inconvenience of previous types, but also the cost. We, also, have tried to design something which could be sold independently of the rest of the apparatus so that, with one of these shutters, and a transformer already in his possession (remodelled at small cost), a doctor can readily undertake stereoscopic work.

NEW TECHNIQUE FOR THE VERTICAL EXAMINATION OF THE SPHENOIDS AND ETHMOIDS, WITH DEMONSTRATION OF SPECIAL SPHENOID FILM HOLDER*

BY GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

MUCH difficulty and dissatisfaction has been encountered in the demonstration of the sphenoids and ethmoids by vertical view; that is, in the demonstration of the horizontal plane of these sinuses, so as to project them side by side in horizontal section. Heretofore it has been necessary to either project the outlines of these sinuses through the vertex of the skull or downward within the submaxillary space and below the tissue of the neck. In either instance the position of the sinuses is so far away from the photographic film that there is much distortion and great want of definite detail. With the object of bringing the films nearer to the sphenoid and ethmoid cells to be photographed I have devised a method of placing a special film in the mouth, pushing it backward firmly against the pharynx. This gives a definite level for the projection of the outlines of these sinuses and eliminates most of the irregular extraneous shadows of overlying bones. One has then above this film only the base of the skull, and in this small area one practically obtains only the outlines of the sphenoid sinuses and the ethmoid cells surrounded by a border of teeth in the upper jaw. A preliminary report on this method of study was made by me before the American Roentgen Ray Society in discussion.[1]

Many difficulties have been involved in this procedure. In the first place it is necessary to cut the films to the exact size and shape that will fit the average mouth and pharynx. I obtained this first by finding a size that would best fit my

FIG. 1.

own mouth and which I could hold in position comfortably when pushed entirely against the posterior wall of the pharynx. This size is 2 in. by 3 in. It is square at one end and curved at the end which is pushed against the pharynx. I then found great annoyance from the secondary radiation of the tissues about the mouth which caused a great deal of fog. This was partially overcome, even as early as 1916, by the use of metal placed

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27-30, 1921, and previously at the meeting of the Section of Laryngology of the College of Physicians of Philadelphia, Mar. 10, 1921.

[1] The annual meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Chicago, Ill., Sept. 27-30, 1916. AM. J. ROENTGENOL., Aug., 1917, iv, 411.

DENTAL ROENTGENOGRAPHY IN THE LIGHT OF CLINICAL AND PATHOLOGICAL FINDINGS*

BY ALLAN SCOTT WOLFE, D.D.S.

WASHINGTON, D. C.

IN addressing you today, I am not unmindful of the honor paid my profession. I believe those of us who are specializing in oral elimination have a place in the scheme of diagnostic and preventive medicine. We should be encouraged by you gentlemen; since only by our operations and study of pathology can you be assured of a check on your roentgenographic interpretations of films taken in the mouth.

The general practitioners of medicine and dentistry, who take oral films and after a casual glance advise a patient as to the retention or elimination of teeth, are still in the majority. A great many of these men know nothing concerning the anatomy or histology of the mouth but still pretend to diagnose conditions of pathology of these parts and of the entire body.

Many expert roentgenologists are in a similar predicament. They know their anatomy and histology but not having the benefit of mouth operations, ante-mortem or post-mortem, they have gone from year to year building up certain forms of nomenclature and certain set plans of diagnosis for conditions which may or may not be found in the mouth.

Before going any further, I would like you gentlemen to remember that I am not insisting that the principles laid down in this paper are positive. I am merely giving you my findings in the elimination of oral foci and asking you to apply them at some time in your practice so that eventually we may arrive at some definite mutual conclusions.

There is a saying which tells us to strive for what is right, and not for what is expedient. This, to my way of thinking, should be the motto before us in the interpretation of the oral film. If it were a matter of expediency I would try to produce something startling for you gentlemen; as it is, I must ask your pardon for starting in on the most elementary roentgenography. It is only by so doing that I can arrive at definite conclusions.

We are told by the masters of the various arts that only by comparision can we tell the good from the bad and the true from the false. If that be so in the world of arts and letters, is it not doubly so in our work? Should we not study the anatomy of the parts just as faithfully as the pathology, comparing the two in all cases so as to get the best results? This is very seldom done, especially by the practitioner of dentistry. The reading is usually given on pathology alone, completely overlooking the anatomical variations in this particular mouth, which may have more bearing upon this individual case than the pathology shown.

Let us now get down to the basis of this paper which is a simple classification of the morbid conditions in the oral cavity.

Apical Infection	Circumscribed Areas Diffused Areas
Pyorrheal Infection	Local Systemic
Nerve Irritants	Impacted Teeth Hypercementosed Teeth Retained Cysts or Residual Infection Pulp Nodules Hidden Cavities

Added to these we have the lower border of the maxillary sinus and injury to the maxillary bones such as fractures. This constitutes a classification that can be applied to all morbid conditions and anatomical variations of the mouth as shown by the oral film.

Let us now take up some of the terminology heretofore used in describing mouth conditions: *Radio-lucent areas; radio-opaque areas; rarified areas; abscessed areas; diffused areas; infected areas; granuloma; cyst.*

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These are but a few of the terms used to explain the different shadows we find at the apex of pulpless teeth, and compared with the actual conditions in the bone they mean nothing to the operator who is supposed to eliminate them.

Let us assume now that we have gotten beyond the common errors usually made in reading the dental film, such as foramen, nostrils or large bone cells, interposed between tooth and film, and that we are reading a film of a pulpless tooth. Is it not good practice to compare this film with one taken from the opposite side of the mouth? I am assuming, of course, that the whole mouth has been *x*-rayed as one, and that two or three films are not enough on which to render an opinion. We now have an opportunity to study the bone cell and the peridental membrane of vital teeth in the same mouth with pulpless teeth. We may find this membrane thick and heavy over one tooth and not over another. Is that a sign of infection? Not necessarily. It is probably trauma caused by a high filling or a poorly fitted crown. Or again we may have a fistula discharging from a foramen located away from the apex of the tooth, leaving this apex seemingly in good condition although slightly clouded. In many cases this is called by the roentgenographer a slight infection. When we make a diagnosis of this kind it is of very little value. We must remember that infection does not show on the film. What we see is the result of infection which is destruction of tissue, both hard and soft.

There are many times when we find teeth which show no apical disturbances but which have all the clinical symptoms of infection, and when extracted by the most approved methods show decided pathological conditions in the laboratory tests. On the other hand, certain authorities report large cysts taken from the mouths of healthy patients whose teeth have never been tampered with by the dentist, and have found these cysts to be sterile.

With these few comparisons I am going to make the following statement upon which my practice is based. In all cases of systemic infection or nerve irritation accompanied by lowered resistance, it is my practice to eliminate entirely all pulpless teeth which show a break in the peridental membrane, and also nerve irritants such as shown in the classification under that head, never venturing an opinion on roentgenographic evidence alone without clinical observation.

In taking up the subject of oral elimination, I feel that no apology is necessary for my position in this matter; and since I have spent most of my life in dentistry, I have come to the conclusion that a greater percentage of dental operations are failures rather than successes and that the average operation, especially root canal work, is a liability rather than an asset to the patient. Operations done in the mouth of healthy patients may show up well for a number of years, but there comes a period of slow disintegration, and it is only a matter of systemic resistance, until the malignant conditions triumph over the benign. The operation in which the dentist took such pride yesterday, is today a filthy mass of tooth, metal and decayed food. We must now reverse the process by strengthening the benign and eliminating the malignant. I do not hold with some of the gentlemen in the profession that infected teeth are the primary cause of all human ills, but I do believe they are secondary and contributory, and that when we have systemic conditions we do help the patient by the elimination of oral foci, thereby increasing the resistance of the body.

We will now take up the condition of apical infection. As I have said before, there are only two conditions of infection that the oral surgeon finds at the apices of pulpless teeth—the encysted or encapsulated, and the diffused areas. Now let us study the cause of these two conditions.

We are hearing every day about the pendulum swinging back—that the extraction of teeth must cease—but this will not be until the present crop of diseased teeth is eradicated and the dental profession taught to conserve the pulps of teeth or be more scientific in their treatment. Of all faulty technic in any profession the treatment of pulpless teeth is probably the worst, and the more thorough the treatment the more disastrous the result. I can show you oral films of tooth roots underneath the film, yet there was still much disturbance from the secondary radiations of the tissues of the head because it was necessary to use, as in all vertical examinations, a comparatively hard ray. More recently I have overcome this by using double screens which I have cut to exactly fit this special film. The double screens are attached by means

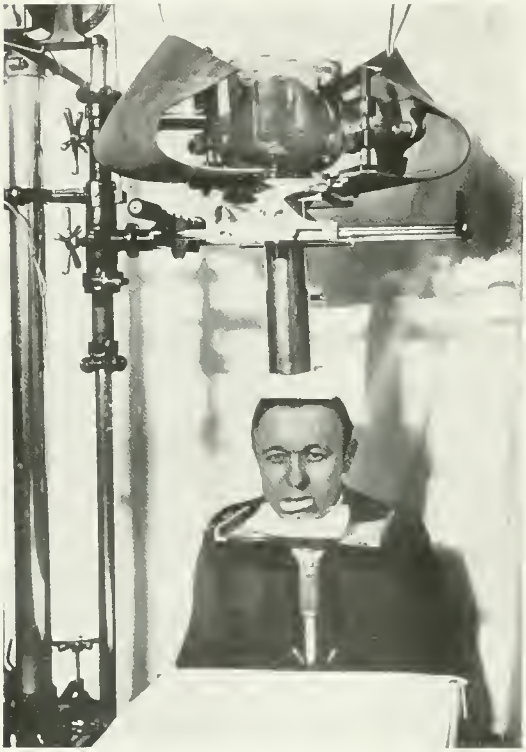

Fig. 2.

of a hinge, the lower one being attached to a layer of brass (Fig. 1-A). Special black paper envelopes are made to fit these holders and they are rendered waterproof by covering them with rubber. This double-screen technique permits the use of much softer radiation which gives rise to less scattered rays (Fig. 1-B).

This examination is made with the patient in the sitting posture (Fig. 2). The chin is rested upon a headrest. The film is then pushed back into the mouth against the pharynx and held in place by the teeth biting firmly. The distance from the target to the top of the head is 18 in., using a 3 in. cylinder and a vacuum corresponding to a 4 in. parallel spark gap, and an exposure of approximately eight seconds, with 30 ma. of current.

By this technique we can now demonstrate clearly the outline and size of these sphenoid sinuses projected side by side and this gives the operating surgeon a definite idea as to the position of the septum, for in many instances the septum is distinctly to the right or the left of the

Fig. 3.

median line. By this process one can also demonstrate a horizontal projection, or in horizontal section, the ethmoid cells. At times large ethmoid cells in the region of the sphenoids are involved by exudate which, by all other means, leads one to suspect disease of the sphenoids. With the definite demonstration of the location of exudate by this means, or even the demonstration that these various cells are normal, I am sure that a great advance can be made in the study and treatment of the diseases of the posterior accessory sinuses.

By this method I have been able to demonstrate surprisingly great variations in the outline of the sphenoid sinuses as well as the great variation in size and outline of some of the posterior ethmoid cells. It is rare that the two sphenoid

A B C D

Fig. 4.

Fig. 5.

sinuses are of equal size and it is very common to find the septum on one or other side of the median line. This technique combined with the postero-anterior and the lateral views permits one to make a very exact and definite demonstration of the sphenoid sinuses in every plane and in every direction, and therefore furnishes the most exact information for the clinician (Figs. 4 and 5).

DISCUSSION

Dr. Hickey. I would like Dr. Pfahler to give us the approximate angle when you look at the patient from the side

Dr. Heberding. I would like to ask Dr. Pfahler if he finds it necessary to use a local anesthetic to prevent agony.

Dr. Pfahler (closing). First, Dr. Hickey's question. I do not believe we can establish any definite rule about the side angles—about the direction you send rays down—because you must judge where the sphenoid is according to the shape of the head. In a general way, it is in a plane 2½ cm. anterior to the external auditory meatus. Therefore, you find that point on a level with the auditory meatus, then project the central ray toward the mouth and you get the sphenoid on the film. It is just keeping in mind where your film is and realizing the position of the sphenoid, and then you project downward and forward, as shown in final illustration.

As to the anesthetic, no. Neither have I had any objection on the part of the patients, which is surprising. The film is dipped into ice water just before inserting, and I have never had any one gag or push it out. It takes only a few seconds. I have been using 4 to 4½ in. spark gap, 30 ma., about eight seconds, exposure at 20 in. distance, or about 16 in. above the top of the head. I do not believe the majority of you will need to use that much exposure. I am probably using a little weaker developer. I use a 3 in. cylinder for my diaphragm.

As to the manufacturer, there is no special manufacturer. This was made by my own personal mechanic, Thomas Gallen, 1939 Wood St., Philadelphia, Pa.

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As to root canal treatment, do not misunderstand me. I believe that simple straight-rooted teeth can be treated and saved for a great many years without harm to the patient, but I do not believe in the retreatment of teeth; and in view of these facts, when the patient presents, if we err, let it be upon the right side and over-eliminate rather than under-eliminate.

The encysted area is nothing more than a slow-growing mass at the apices of pulpless teeth—a bone cavity encapsulated by the resistive forces of nature, the contents of which may be granuloma or cyst, sterile or infected; it makes very little difference. It should be removed, after extraction, with a dull curette, otherwise, without the elimination of this, the extraction of teeth is useless.

In cases of diffused areas the roentgenogram shows no limiting wall, but a feathery shadow, extending from the root ends into healthy bone. In the mouth, this bone presents a necrotic condition with little vascularity until normal bone is reached. A sharp curette should be used to remove this bone, not only to get rid of the infection but also to stimulate cell activity. This is nothing more than a chronic condition of devitalized bone, permeating the trabecula to an unknown extent. One who has made numbers of root resections and Novitisky's operations will recognize the difference between this condition and the encysted areas where we have a healthy condition of the bone.

As to the cause of the diffused area I have my own records and the past history of the patient to rely upon; also an intimate knowledge of the methods used by various dentists who have practiced upon such patients. From these records I am convinced that the diffused area is partially due to arsenical poisoning. Why the dental profession has tolerated the use of arsenic as a devitalizing agent for so long a period, I cannot understand. It is a corrosive poison, the action of which does not stop at the apex of the tooth but keeps on going through the trabecula until we have liquefaction of bone. This is really one of the greatest causes of oral infection and the simple extraction of teeth is not enough to eradicate it entirely. I do not think that we have this diffused area in all cases where arsenic has been used, but I believe it accompanies lowered resistance and anemia; in other words, if the destruction of bone is too great, diffusion will result. Another cause of this condition is teeth devitalized through trauma in young patients, or those with very low resistance. We very often find large diffused areas in apparently good teeth of which the patient can give us no history.

PYORRHEAL INFECTION

We are told that pyorrhea is the liquefaction of bone due to local and systemic conditions. Here again it remains for the oral surgeon, in doing research work, to apply or have applied all known procedure in the treatment of this condition, checking up from time to time with the roentgenogram, smears from the mouth, blood tests and urinalysis. When this has been honestly done, it will be found that if the disturbance at the crest of the alveolar process comes from lack of contact, contour and poor occlusion, that is, from purely local conditions, regeneration will take place when proper remedies are applied. On the other hnad, when conditions are systemic, and the cancellated bone surrounding the tooth is pus-soaked, this condition occurring all over the mouth irrespective of contour or contact, then we have the true systemic condition of pyorrhea, which treatment, up to the present time, has never been able to conquer. Any type of treatment is merely temporizing; and it is only a short space of time until wholesale extraction is resorted to, in order to relieve the patient of a filthy condition which, to my mind, is only a sympton of some unknown systemic condition.

What is the duty of the roentgenologist in these two cases? For type one, where the loss of process is due to the impactions of food, poor contact and occlusion, it is the duty of the roentgenographer to advise complete restoration of the dental arch supplying all teeth that are lost and replacing all fillings that are faulty. Also in this class we may have just the opposite condition—the third molar, erupting without enough room, will distort and buckle the arch, thereby causing a condition of pyorrhea. I have seen many cases where the early extraction of the third molar would have meant the saving of the entire denture. In the treatment of type two, I have had nothing but failure, and have seen the same results from the work of the most skillful of operators. The patient's judgment cannot be considered in this matter, as he is over-enthusiastic at the apparent results obtained in the first few treatments, and, wishing to retain his teeth, the reports he gives are untrustworthy. If the physical diagnosis shows any alarming condition the infected teeth had better be eliminated. Remember, we are now speaking of the patient who comes to you for some systemic disturbance accompanied by lowered resistance, which I understand constitutes the bulk of your work.

NERVE IRRITATION

The condition of nerve irritants from impactions of teeth, hypercementosed roots, retained cysts, pulp nodules and and hidden cavities should now be considered. For years, patients have been told that impacted teeth caused no trouble. Since the appearance of the *x*-ray, the dentist who is afraid to eliminate this form of nerve irritant has had a hard time convincing both diagnostician and patient that these impactions were harmless. In the light of recent investigation we know that excess irritation, such as that of the third molar, with the crown impinging against the gingiva of the second molar causing peripheral irritation, and the roots depressing the inferior dental nerve and vessels, causing a dilatation of the erectile tissues of the turbinated bones through the sphenomaxillary ganglion, are conditions referred back to the face, neck and shoulders as different forms of neuralgia and neuritis. The same condition holds in hypercementosis and retained cysts, especially near the mental foramen or any nerve trunk. It will be noted that the bone cells around the cyst or impaction have lost their form and become flattened. This is caused by the gentle pressure exerted upon the cell while the cyst is forming or the tooth growing. In many instances, especially in the lower jaw, this pressure continues through gravity down to the nerve trunk causing a definite neuralgic condition. These conditions cause as much, if not more trouble, than infection on root ends, but of a different type. So I believe that the tooth, cyst, or hypercementosed condition, in attempting to find an outlet, natural or otherwise, presses against the nerve trunk or periphery causing referred pains that are purely mechanical and have nothing to do with infection or infiltration of pus. It is in these cases that we have the so-called "quick cures" following elimination of the irritant. In cases of infection it is months before the benign forces of the body overcome the malignant and we have resolution or, if infection be too great and resistance not high enough, we have dissolution. It is for these reasons that I say the old-fashioned extraction of teeth is one thing and the modern surgical elimination of focal infection something quite different. It is because we have had the old-fashioned method in the past that we are now having the retained cyst to contend with. This is a condition where the granuloma or cyst is left intact in the bone cavity and continues to increase in size; and for that reason, spaces where teeth have been extracted and edentulous mouths, should be subjected to as close a scrutiny as if the teeth were present. In many instances the diffused area is present after extraction of teeth, but if resistance be high this condition is absorbed much more readily than the encapsulated area. Treatment of this condition is by thorough curettage and packing of cavities, care being taken that healing is not by first intention.

Neuralgic conditions caused by hypercementosed roots, sometimes misnamed exostosis, and impacted teeth can be very often diagnosed by deep injections of novocaine. In many cases after *x*-ray diagnosis has disclosed the presence of an impaction in cases of trifacial neuralgia or "tic," nerve-blocking has given instant relief and the subsequent elimination of this particular form of nerve-irritant has effected a cure.

The question of pulp nodules is one that I approach with a great deal of hesitancy. Many cases of neuralgia which I have felt sure were traceable to this form of irritant, have turned out to be something entirely different. The roentgenogram does not give a positive diagnosis of pulp nodules, for in the examination of extracted teeth I have found just as many pulp nodules which did not show up in the film. While I do not care to commit myself upon this very important phase of diagnosis, I believe that the only condition where pulp nodules are the cause of pronounced pain is where the pulp is becoming devitalized through decay, or under a large filling, and that the deposition of lime salts, which we find in perfect teeth and call pulp nodules, is a normal condition which does not justify extraction or elimination of the pulp.

Another reason for *x*-raying the full denture in cases of neuralgic conditions is the hidden cavity, usually beyond the gingiva of the molar teeth, which, undiscovered by the dentist and constantly irritated, it sends its complaint to the nerve centers. This simple condition causes as much trouble as anything we find in the mouth and can usually be detected with the oral film, although at times it may be read as a cement filling. It is impossible for the patient to localize this trouble in any certain tooth, and to my way of thinking it demands as much thought and work as pathological conditions.

MAXILLARY SINUS

In taking up the maxillary sinus I feel that I am straying somewhat from the field of the oral film, as in no case should a reading be made of the antrum from anything but full head plates. Here again it is a question of comparison in interpretation.

The average dentist or oral surgeon has neither the facilities for taking such films nor the ability to read them, but he must be taken into consideration in the elimination of antrum conditions. Many of these cases are mainly catarrhal and become infected from nasal conditions remaining wholly dependent upon the rhinologist for treatment. In my opinion there are fully as many cases infected chiefly from just a dental cause. Therefore, in diagnosing these conditions, smaller films should be taken of the lower border of the antrum, and if there are any pulpless teeth entering into it or near the floor they should be eliminated in conjunction with the treatment of the rhinologist, for it is a rule in oral surgery that no devitalized tooth projecting into the antrum should be treated.

I realize that the curvature of the palate makes it very difficult to secure an oral film of the antrum which is in any way positive, but it is my opinion that operations on it should be at the lowest point for drainage, especially when pulpless teeth are involved. After a diagnosis of the infected sinus has been settled upon, the use of the No. 2 oral film, of the lower border of the antrum, without regard to tooth roots, gives one the best landmarks to follow in operating.

This subject of the maxillary sinus is one which has not been given as much consideration by the profession as it deserves. We might term "No Man's Land," from the floor of the antrum to the apices of the teeth. The extraction of teeth has not entered the antrum from the mouth and the rhinologist has neglected it from the nose; hence it remains for the oral surgeon to clean this tract up with a definite surgical procedure in which he can be greatly helped by the roentgenologist.

Taking up the subject of fractures, I have only one thing to say from the standpoint of the oral surgeon, and that is "never advise leaving a tooth, fractured root or piece of bone in the line of fracture."

In reading this paper I am assuming that the roentgenologist is not only taking films or plates of the conditions I have set forth, but is giving his opinion before action is taken by diagnostician, or surgeon. Consequently, he should be very careful to limit the number of teeth extracted at one sitting. A patient of low resistance should not have more than three or four teeth extracted at one time, thereby showing the system the benefit of antibodies instead of being overwhelmed by the mouth infections. I know of at least 2 cases where death has followed wholesale extraction. Again, if there are several vital normal teeth in the mouth, it is well to save them, for clasped temporary plates give the patient the benefit of what we term denture experience, after which they become used to full plates more readily.

In closing I wish to say that any of the various subtitles that I have presented could have consumed a whole evening's discussion, and that it will be readily seen that this paper is nothing more than a review of work done in my practice and in clinics. Judged by your standards it will probably not be called scientific, but I am asking you to believe that it is an absolutely honest presentation of what I have found in the mouth.

DISCUSSION

Dr. Darling. It is a great pleasure to me to be able to discuss Dr. Wolfe's paper. He has given us the benefit of his twenty-five years' clinical experience. We want to do what is right medically by the patients and we have a problem to meet in what the dentist will do after he gets our findings and after he has the patient entirely under his care.

Dr. Wolfe is not what you would call a dentist. He is an oral surgeon. Now the oral surgeon is interested in eliminating the focus of infection in the same manner as the medical man is. He has a few of the things which medical men have not got and we must learn to speak the same language, and it seems to be quite a difficult task.

In roentgen-ray interpretation we are mostly interested to know whether to extract or not. The dentist lays more stress on the clinical examination, but all clinical examinations are doubtful and you use the *x*-ray as the deciding factor; it is effective in many cases. Whether it shows granulomata or abscess, walled off or diffuse, we are not so much interested in, as whether it is the focus of infection. The oral surgeon wants to know the character of the lesion he is expected to remove; he wants to know the extent. We should have this in mind. Research seems to have shown that a tooth once infected is always infected. Even teeth that are not infected in the beginning, after cleaning out the pulp shreds by sodium-potassium or other root canal explosions (which they really are), soon become infected; also after the arsenical treatment which Dr. Wolfe has mentioned. Novitisky claims that a dead tooth after six months is an infected tooth. In fact, the dead tooth is now the battle-ground between the doctor and the dentist. They are pulpless teeth, and there is a great attempt to show they are living teeth, which they are not. The nutritional exchange for cell metabolism probably does not take place beyond the cementum.

Dr. Wolfe eliminates all pulpless teeth which show a break in the peridental membrane. With reference to causes of systemic infection and lowered resistance, the dentist attempts to determine the lowered resistance in a few minutes in a dentist's chair, which Grieves points out takes all the brains of the medical profession to arrive at the diagnosis. The dentist settles it in his own chair very often, and determines whether the tooth should be extracted or not.

I would like to hear Dr. Wolfe say that the more thoroughly a tooth is treated the more disastrous the results. I would give a great deal to be present in a New York dental society meeting and hear him make that statement.

I am going to take slight issue with Dr. Wolfe to get him to explain further about retained cysts. I do not feel that the curettage in all cases is a necessary routine. I understand that to be the practice of oral surgeons, but I cannot agree with them. In the seven or eight years that I have been interested in this work, I have found only one such encysted area. I feel that curettage which breaks down the walled off area that has been established by the repair should be left intact and that there is sufficient drainage brought about by the removal of the tooth. Later, after healing, in those few cases where a cyst remains, another operation may be undertaken. I want to emphasize what he points out as important things for the roentgenologist to note in his report, namely, hidden cavities. I would add to that, shell crowns which are large and irritating, and irritating fillings which have been thrown in without being filed off.

In the following year you are going to see around the country a very strenuous comeback on the matter of bone restoration and repair. Bone restoration is, in my opinion, only sclerosis of the bone. The root canal treatment has managed to introduce a few staphylococci which have been able to produce chronic osteitis with sclerosis. Oral surgeons have not proven bone restoration either roentgenographically or by research. They are going to bring that back hard as a reason for treating infected areas around the teeth. I would like to hear Dr. Wolfe take that up.

I want to say in closing, that we must strive to speak the same language. We should not only strive but we should yearn, for the benefit of the patient, to speak the same language.

Dr. Scott. I would like the privilege of presenting two rather unusual cases. The first was a woman fifty-five years old, residing in Niagara Falls, with tonic contraction of the muscles of the lower jaw. She had a filthy mouth and the contraction was to such an extent that it was impossible to get a film behind the teeth. Examination was made through the back of the neck and it was found that all of the teeth were surrounded by abscess cavities. The only teeth remaining were the central and lateral incisors and the canines on both the upper and lower jaw. She was advised to have the teeth extracted and was sent to the hospital for that purpose and the teeth were extracted. Promptly following, she recovered full function of the muscles of the jaw and was able to use her jaw for its natural purposes. Apparently she was making a complete recovery. About three days after the extraction, she suddenly toppled over dead. The physician thought death was the result of embolism.

Strange as it may seem, within a period of three or four weeks following this case, another case presented itself—sent in by a physician from the country. This woman was apparently in perfect health; she was about thirty-five years of age, and had an absolute tonic contraction of the muscles of the jaw to such an extent that it was impossible to pry open the teeth in the slightest degree. She had apparently a full set of perfectly normal healthy looking teeth, so far as inspection would show. It was impossible to get anything in the shape of a film between her teeth. This woman gave a history of the condition coming on suddenly during the night without any previous evidence of illness. Examination was made in the lateral, oblique, and posterior-anterior positions, and two of her teeth were found infected. After removal she promptly recovered normal use of her jaw. About three weeks later the dentist to whom she was sent for the removal of her teeth telephoned me that the woman again came in and had complete tonic contraction of the muscles of the jaw, as extensive, or more so, than in the first instance. This time we gave her an anesthetic and made a complete examination of the teeth. All the teeth of the upper left jaw had apical abscesses. Before making the examination of the teeth we also made sinus plates, which were negative. The affected teeth were later removed and the patient made a prompt recovery. Strange to say, the day before I came here the dentist telephoned me that this woman came into his office with a recurrence of the condition.

The question which presents itself to me is, how much of this condition was due to irritation as a result of absorption and how much was due to neurosis? In other words, in the latter case in particular, was it a case of simple hysteria? In each recurrence the contraction was absolute and after removal of the infected teeth the patient was apparently normal for a period varying from four to six weeks.

Since reporting the above cases I have again examined the latter patient under anesthesia and found the remaining teeth to be entirely sound, the condition of tonic contraction of the muscles of the jaw, however, promptly recurred after recovery from the anesthesia.

Dr. Edmonson. The tooth is about the smallest roentgen-ray made, but it is one of the most important things in roentgenography. I should like to ask Dr. Wolfe if he is able, with any definite accuracy, to ascertain whether or not a tooth is devitalized from a roentgen-ray examination. I would like to ask him the limitations in extraction from the standpoint of health and disease. In my town the dentists blacklisted me on account of my attitude, but I call it conservatism. I cannot help believing that every tooth and every condition should be thoroughly investigated and that it is good medicine to investigate the systemic condition before sacrificing a tooth. Of course, if you have diffuse infection locally and general systemic infection, you are justified in extraction, but I do not believe in promiscuous pulling of teeth.

Another thing I would like to ask Dr. Wolfe is in regard to his judgment relative to the resistance of a patient. I have known some fatal cases where a good many teeth were pulled at one sitting. I know of a dentist who pulls them out by the bucket-ful every day. I had a patient whose teeth had to be extracted and I advised her to go into a hospital and have them pulled one or two at a time. Her blood-pressure was 240. The dentist got by with it and pulled one-half of her teeth one day and the other half the next. It so happens she is still living.

Dr. Crane. I believe that physicians and dentists are making a horrible mistake so far as the ultimate good of the patient is concerned. We must not antagonize or criticize each other but must get together like fellow members of the healing art, and we will have to use some sort of language that each can understand.

My standpoint on films is that no man is capable of making any sort of diagnosis simply from the examination of the film. Examination of the film plus the clinical examination allows us to arrive at a comparatively satisfactory diagnosis. You who are in the roentgenogram branch of the profession have people referred to you for certain plates and films, and when they come to you from a physician for examination of the abdomen, thoracic viscera, or for the osseous structure, they come after a clinical examination. You base your reading of the roentgenogram largely upon the foreknowledge that you have of the clinical examination or the object for which the patient has been sent to you.

When you make examination of the teeth, in most cases they are sent to you by the internist or physician, and if you try or attempt to make a conclusive diagnosis from reading the shadows of the teeth, you are doing something which no intelligent dentist would attempt to do, because we find many conditions in the mouth which are infective and which may be as great contributing factors as the most apparent thing in the roentgen-ray film, and which give absolutely no roentgen impression. So that in order to arrive at an intelligent diagnosis, it is necessary not only to have a good set of dental films but to have a thorough clinical examination. Clinical examination without the film is not of great value. The film without the clinical examination is not of great value. Taken together they allow us to arrive at a satisfactory diagnosis of mouth conditions.

With regard to extraction and non-extraction of teeth in which the pulps have been removed, it would seem to me that the only rational way to approach that subject at all is to say that any teeth which are the seat of pathology and which cannot be cured, should be extracted. Of course, dentists differ as to what pathology can be cured or eliminated without extraction, but where we have no evidence of infection either clinically or roentgenologically, the man who mutilates a patient needlessly by extracting teeth, whether in his opinion the patient is subnormal or not, is taking a grave responsibility on his hands. Just today I have examined films of some very poorly treated teeth, in so far as the roentgen evidence of root canal filling is concerned, which have a history of having been treated ten or fifteen years ago. The line of pericementum is as intact and normal as any found on vital teeth. There is no clinical evidence whatever in the patient's mouth of any infective process or pathology about those teeth. If those teeth were of great dental importance to the patient and if I were called in consultation even if the patient had a serious systemic infection, I would not advise the extraction of those teeth, because I am firmly convinced that they could not be a contributing factor in the systemic infection.

Dr. Wolfe (closing). In response to Dr. Darling's question as to curettage, I cannot agree with the doctor. When we speak of curettage we must again go back to the terminology used in the paper. The encysted area demands blunt dissection of soft tissue only. The diffuse area which, as I have said before, is nothing but devitalized bone, and needs definite curettage with sharp curettes. The one thing that pleases the oral surgeon is to extract teeth with granuloma, or whatever you choose to term it, clinging to the root. He knows that it should not be there and would not willingly push it back into the cavity. If drainage is complete at all times, this would probably absorb, but in many cases healing is by first intention, the abscessed area is retained and becomes what we term "residual infection."

As far as bone restoration is concerned, I do not believe that it is restored in the presence of infection. A good deal of it is a deposit of lime salts. If you will use a correal trephine, you will probably find streptococcic infection at the apices of most of the treated teeth, especially where an escharotic drug has been used.

With reference to sacrificing teeth, I would not extract simply because a tooth is pulpless but would depend upon the condition of the lamina dura. Teeth are very valuable, and I do not believe in their needless extraction, but I do believe that in cases of systemic infection or nerve irritation that elimination should be just as complete in the mouth as we can make it, handing over to the physician a patient who is free from all oral sepsis.

I am afraid I will have to disagree with Dr. Crane. If the patient were dying—and we have such cases in pernicious anemia—I would certainly extract any or all the teeth if I thought that in any way the patient would be benefited,—looking at it purely from the viewpoint of the physician.

I wish to say that I save just as many teeth as I can and am more proud of the teeth I save than those I extract.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY
LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922
Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

HEINRICH ERNST ALBERS-SCHÖNBERG

On June 4, 1921, Heinrich Ernst Albers-Schönberg, for some time an honorary member of the American Roentgen Ray Society, died, after years of almost constant suffering and after several months of well-nigh intolerable pain.

He was born in Hamburg on January 21, 1865, the son of August Heinrich Albers-Schönberg and of Amélie, née Des Arts. He received his medical degree at the University of Leipsic in March, 1891. After first acting as assistant in the gynecological department of the Hamburg-Eppendorf Hospital, and finally as assistant to the surgeon, Dr. Sick, he began the private practice of general medicine in Hamburg in 1895. In February, 1897, he established, together with Dr. Deycke, an institute for roentgenology and shortly after that devoted himself entirely to this specialty.

In the same year he founded the *Fortschritte auf dem Gebiete der Röntgenstrahlen*, of which he remained the editor almost up to the time of his death. The second issue of Volume XXVIII which came off the press on June 9, 1921, had still been under his editorship.

The number of his contributions to roentgenology, ranging from short papers to a complete textbook, is approximately one hundred and forty. But before the days of roentgenology he had published eight papers on other medical subjects. Most of his contributions are instructive and important. Some are epoch-making, as, for instance, the compression diaphragm and the development of the technique for the demonstration of urinary calculi, the recognition of the effect of roentgen rays on the generative organs, and, following in the footsteps of Foveau de Courmelles, the introduction into Germany of deep roentgen therapy. One of his early papers

Heinrich Ernst Albers-Schönberg.

on the therapy of gynecological lesions appeared in the *Transactions of the American Roentgen Ray Society* for 1908.

His contributions are all the more important because, progressive and enthusiastic though he was, he possessed cool judgment and thorough scientific and clinical training. He was a keen observer, punctiliously truthful in his statements, and not afraid to admit an error or retract an assertion if later experience proved him mistaken.

Having experienced early the disastrous results of work with roentgen rays, he constantly preached the need of ample protection. His laboratory at the St. George Hospital in Hamburg was one of the first where protective devices were installed. The rules and regulations established there for the proper protection of patients, physicians, nurses, assistants and all other workers are a model in their completeness.

Ever since he devoted himself to roentgenology he labored assiduously for its elevation to the rank of a medical specialty. It is not belittling the work of others if one ascribes this happy result largely to his organizing genius, his profound medical knowledge and his true scientific spirit. Thanks to his efforts roentgenology has become an obligatory subject in undergraduate work in German medical schools. In recognition of his attainments he was appointed Faculty Professor of Roentgenology at the newly founded University of Hamburg, which was the first appointment of this kind in Germany.

It is difficult for the writer to speak of his personality without resorting to superlatives. His kindness, his sterling character, his readiness to help and encourage the beginner as well as the veteran, were unbounded. His cheerful disposition, even amidst intense suffering, could not be broken. Visitors who saw him in 1920 report that, although he must have suffered great torture from his cancerous growths, he never complained and never let anyone feel what he suffered. It was characteristic of the man that, even in the last letters which he could but dictate, he never complained of his own sufferings and was still ready to discuss roentgenological problems. His interest in these problems and his devotion to science remained alive till the end; this is strikingly shown by his ante-mortem request that his autopsy record be published in the *Fortschritte.*

Those who had the good fortune of knowing him, will never forget him. One visit only was enough to impress his personality upon the visitor. In many ways he reminds the writer of our own lamented Walter Dodd: serene in the face of the inevitable, progressive but not hasty, enthusiastic but not hot-headed, a worshipper of the truth, a lover of all men, a hater of none, not even of his enemies. As Forssell has so fittingly said: "His memory will live, honored and revered, as long as the history of roentgenology lives."

L. Jaches.

ANNUAL MEETING

If one may judge by the reports already on hand, the forthcoming meeting at Los Angeles will be one which no one can afford to miss. If you have not responded to Dr. Watkins' letter concerning reservations for space for lantern slides and other scientific exhibits, please do so at once. While the space available is large, the committee desires to know in advance just how much space to provide.

CANADIAN RADIOLOGICAL SOCIETY

Invitation to Convention

The Third Annual Convention of the Canadian Radiological Society will be held in Winnipeg in conjunction with the Dominion Medical Convention, June 20, 21, 22 and 23. The officers and members of the Canadian Society extend a most cordial invitation to American Radiologists to attend this meeting. At the last convention the Society was honored by the presence of a very representative body of members of your Society, and we shall look forward to welcoming them and others to the Winnipeg meeting.

It is requested that those who contemplate attending, communicate at their earliest pleasure with Dr. L. K. Poyntz, Secretary, 1460 Dallas Road, Victoria, B. C., Canada.

CORRESPONDENCE

Dear Sir:—

In view of the fact that the roentgen-ray and radium treatment of ear conditions appears to be somewhat in the limelight, it is important that previous experiences and experiments be quoted. The following-seems to show that experimental investigations on animals have not been made concerning middle-ear infections of the current types. I should like to call attention again to the necessity of such investigations. The following facts seem to be very little known.

Dr. Victor Urbantschitsch, in his "Text-book of Otology," 1910, p. 133, says: "There exist some noteworthy experiments concerning the influence of roentgenization on the diseased middle ear in confined middle-ear suppurations. Schwarz successfully influenced the profuse secretion in a case of tenacious middle-ear suppuration. As Schwarz states, the treatment must be carried on for a long time. It is not necessary to introduce an ear speculum. The whole region of the ear can be rayed, with protection of the face, with fourteen days' intermission and 2 Kalom light power. Joulin (Chronic middle-ear catarrh and otosclerosis. *Arch. d'électic. med.*, 1908, p. 231) cites 10 cases of otosclerosis in which he had remarkable results with roentgenization. Schwarz succeeded in one case among 3 to get almost normal hearing in a sixteen-year-old boy after 6 radiations one month apart. Two qualities of the *x*-ray must be considered, namely, the shrinking effect upon newly formed, especially keloid connective tissue, and further, the arrest of bone formation which has been proved experimentally. According to the experiences so far gathered, it seems that the roentgenization has no damaging influence upon the labyrinthine structures. At least, long-continued treatment with roentgen rays as well as experiments on animals has shown no damaging effects. Contrary to this, a degeneration of Corti's organ can follow treatment with radium.

"Ewald (*Ztschr. f. Physiol.*, 1905, p. 10) found, after application of small glass balls with radium in the ear capsule of pigeons, typical labyrinthine symptoms a few days later, especially turning of the head. Ewald assumes that these symptoms are caused by a paralysis of the ciliated sense-epithelium in the vestibular apparatus. Marx (*Ztschr. f. Physiol.*, lix, p. 102) used radium on the opened ear capsule of pigeons and guinea pigs and found an isolated simple atrophy of Corti's organ. The symptoms in pigeons developed only after six months. The duration of raying had no demonstrable influence upon the latent period." Emil Amberg.

February 4, 1922.

PROGRAM OF THE SEVENTH ANNUAL MEETING AMERICAN RADIUM SOCIETY

ST. LOUIS, MO., MAY 22, 23, 1922.

The Seventh Annual Meeting of the American Radium Sodiety will be held at St. Louis, Mo., Monday and Tuesday, May 22nd and 23rd, 1922. The headquarters and place of meeting will be at the Planters Hotel.

The program is as follows:

MONDAY, MAY 22, 1922

Morning Session

(Begins promptly at 9.30)

A. Executive Session.

B. Scientific Session.

1. "Lymphosarcoma and other Glandular Enlargements of the Neck: Their Radiation Treatment." Edward H. Skinner, m.d., Kansas City. Discussion to be opened by Albert Soiland, m.d., Los Angeles.

2. "Experience with Radium in the Treatment of Bone Tumors." Joseph C. Bloodgood, m.d., Baltimore. Discussion to be opened by William S. Stone, m.d., New York. (By invitation.)

3. "Treatment of Carcinoma of the Esophagus by Radiation." Walter Mills, m.d., and John Kimbrough, m.d., St. Louis. (By invitation.) Discussion to be opened by Charles F. Bowen, m.d., Columbus, Ohio.

4. "Statistics and Technique in the Treatment of Carcinoma of the Rectum by Radiation." Harry H. Bowing, m.d., Rochester, Minn. Discussion to be opened by Douglas Quick, m.d., New York.

5. "Technique and Ante-Operative Radiation for Carcinoma of the Breast." Russell H. Boggs, m.d., Pittsburgh.

6. "Statistics and Technique in the Treatment of Carcinoma of the Breast by Radiation, from the Standpoint of the Surgeon." Burton J. Lee, m.d., New York. (By invitation.)

Discussion on these two papers to be opened by B. R. Kirkendall, m.d., Columbus, Ohio.

Afternoon Session

7. "Statistics and Technique in the Treatment of Carcinoma of the Uterus and Pelvis with the Combined Use of Radium and X-Rays." Henry Schmitz, m.d., Chicago.

8. "Statistics and Technique in the Treatment of Malignant Disease of the Uterus and Pelvis by Moderate Quantities of Radium." John G. Clark, m.d., Philadelphia.

9. "Results of Treatment of Carcinoma of the Cervix, with Statistics and Technique." Curtis F. Burnam, m.d., Baltimore.

10. "Statistics and Technique in the Treatment of Certain Benign Uterine Conditions by Radium." Leda J. Stacy, m.d., Rochester, Minn.

11. "Statistics and Technique in the Treatment of Uterine Fibroids by Radiation." James A. Corscaden, m.d., New York.

Discussion on this symposium to be opened by James T. Case, m.d., Battle Creek, Mich.

12. "Radium Therapy in Cancer of the Prostate." Herman C. Bumpus, m.d., Rochester, Minn. (By invitation.)

13. "Statistics and Technique in the Treatment of Carcinoma of the Bladder by Radiation." Benjamin S. Barringer, m.d., New York. Discussion on these two papers to be opened by George E. Pfahler, m.d., Philadelphia.

MONDAY EVENING

Annual Dinner. Address by the President, George E. Pfahler, m.d., "Protection in Radiology."

TUESDAY, MAY 23, 1922

Morning Session

A. Short Executive Session.
B. Scientific Session.

14. "Statistics of the Intra-Oral Group of Carcinomas." Douglas Quick, m.d., New York. Discussion to be opened by Rex Duncan, m.d., Los Angeles. (By invitation.)

15. "The Treatment of Infected Tonsils by Radium." C. Augustus Simpson, m.d., Washington. (By invitation.) Discussion to be opened by Carl F. Robinson, Barre, Vt.

16. "Radium Treatment of Nasal Polyps." H. R. Lyons, m.d., Rochester, Minn. Discussion to be opened by C. Everett Field, m.d., New York.

17. "Statistics and Technique in the Treatment of Malignant Disease of the Antrum by Radium." D. Crosby Greene, m.d., Boston. (By invitation.) Discussion to be opened by Henry K. Pancoast, m.d., Philadelphia.

18. "Statistics and Technique in the Treatment of Malignant Neoplasms of the Larynx." Douglas Quick, m.d., New York. Discussion to be opened by John M. Lee., m.d., Rochester, N.Y.

19. "Technique in the Application of Radium Needles." William L. Clark, m.d., Philadelphia. Discussion to be opened by Charles F. Bowen, m.d., Columbus, Ohio.

Afternoon Session

20. "Statistics and Technique in the Treatment of Malignant Disease of the Skin by Radiation." Frank E. Simpson, m.d., Chicago.

21. "Statistics and Technique in the Treatment of Malignancy of the Skin by Radiation." Howard Morrow, m.d., and Laurence R. Taussig, m.d., San Francisco. (By invitation.)

22. "The Treatment of Superficial Cancer, with Statistics and Technique." D. T. Quigley, m.d., Omaha.

Discussion on this symposium to be opened by Rollin H. Stevens, m.d., Detroit.

23. "Comparative Measurements between Radium and *X*-Rays Concerning Energy Absorbed at Depth." Harvey R. Gaylord, m.d., and Dr. Carl W. Stenstrom, Buffalo. (By invitation.)

24. "On Ionization Measurements." Gioacchino Failla, e. e., New York.

Discussion on these two papers to be opened by Charles H. Viol, Ph. D., Pittsburgh.

25. "Proposed Collective Investigations of Certain Aspects of the Treatment of Malignant Disease." Robert B. Greenough, m.d., Boston. (By invitation.)

26. "The Present Field for the Use of Radium and the *X*-Ray in the Treatment of Malignant Neoplastic Disease." William S. Stone, m.d., New York. (By invitation.) Discussion on these two papers to be opened by Edward C. Ernst, m.d., St. Louis.

27. "The Biological Effects of Radio-Active Substances and *X*-Rays on Cell and Tissue Structures." Leo Loeb, m.d., St. Louis. (By invitation.)

28. "Two Important Points Regarding Cancer Immunity from the Radium Therapist's Standpoint." Carroll Chase, m.d., New York.

Discussion on these two papers to be opened by Isaac Levin, m.d., New York.

DEMONSTRATIONS OF APPARATUS, APPLICATORS AND TECHNIQUE

1. Carroll Chase, m.d., New York: Illustrating New Chart for Use in Radium Therapy.
2. Dr. Carl W. Stenstrom, Buffalo: A New Device for Retubing Radium Emanation.
3. Albert Soiland, m.d., Los Angeles: Lantern Slide Demonstration: The Protection of our Operators from Unnecessary Radium Radiation.
4. Sinclair Tousey, m.d., New York: Estimation of the Safe Dose of Different Radium Preparations by Photographic Measurements.
5. Henry K. Pancoast, m.d., Philadelphia: A Radium Needle Holder for Laryngeal Growths.

TRANSLATIONS & ABSTRACTS

Barjon. Radiodiagnosis of Pleural Symphysis. (*Paris méd.*, February, 1921, ii, 6.)

By symphysis is meant the adhesion of the two laminae of the pleura to each other, which leads to a certain amount of fixation of the lung and thoracic cavity, either total or partial. It is the cicatrix resulting from inflammation of the pleura or lung, and the process of inflammation may be still active or extinct. It is found in the most varied inflammatory and neoplastic conditions, but is itself silent, giving rise to no clinical manifestations. In physical diagnosis it gives rise to diminished resonance and vocal fremitus and lessened to breathing. If the subjacent lung be healthy there will be no reason to suspect pleural adhesion; while if it be diseased the signs of the affected lung tissue mask its presence. In extreme cases of adhesion and cicatricial retraction the thorax is deformed and retracted, with or without deviation of the heart.

Pleural symphysis is often looked upon as a conservative effort of nature rather than as a disease, for it may, for example, prevent the perforation of a cavity. Chiefly in connection with the operation of artificial pneumothorax is it advantageous to know whether the pleural laminae are adherent, for this constitutes a contraindication. Hence the use of radiography before this operation. In the routine use of the rays in the diagnosis of tuberculosis it is also of importance to note the presence or absence of adhesions. In radiographic diagnosis the bases of the lungs are most readily studied for the presence of adhesions. If these are present the sinuses will be effaced while the diaphragm may be fixed.

The author has studied twenty-four cases of adhesions from this double viewpoint. The costo-diaphragmatic sinuses may be completely or only partially obliterated, or normal. In the first case there is seen on the plate total opacity of this portion of the pleural cavity. There may be a certain amount of exudate as a result of the inflammation which has produced the adhesion. This little by little will push back the pulmonary lamina until it is completely dislodged, as a result of which the sinus is the seat of total opacity with loss of its contours. At times the diaphragm loses its convexity, for fixation of the external border to the parieties of the chest has deprived it of mobility. Nearly always in such cases the lung preserves towards its base a certain luminosity, and a clear band is defined immediately above the diaphragm. The opacity of the sinus is due to the fact that the lung has been dislodged from it. It is necessary in these cases to exclude the possibility that the opacity could be due to a lesion of the base of the lung. In pleural exudation the shadow is much more compact and homogeneous with complete obliteration of contours.

If the sinuses appear perfectly normal on the screen we cannot exclude the presence of adhesions, for in twenty-five radioscopies of apparently normal individuals symphysis was later shown to have been present in ten. A positive result on the other hand is conclusive. The importance of immobility of the diaphragm for the diagnosis of symphysis is not great, because this condition occurs under a variety of circumstances. In twenty cases of symphysis the diaphragm was immobilized in but three. The author concludes that the disappearance of the image of the sinus has great and at times pathognomonic value, especially when the symphysis is partial; although negative image does not imply absence of symphysis. The author emphatically denies that with a clear base, normal sinus and mobile diaphragm one may be certain of the success of an artificial pneumothorax: cases undoubtedly exist in which symphysis is present despite these findings.

Bonn (Rostock). Roentgen Diagnosis of Acute Mediastinal Abscess. (*Deutsche Ztschr. f. Chir.*, 1920, clviii, 3–4.)

In a paper on the operative treatment of acute mediastinal abscess in which five cases of different types are reported, the author states that while roentgen diagnosis is certain in chronic mediastinal abscess the same cannot be said of the acute type. This he explains by the fact that in tuberculous abscess the shadow is more extensive and better defined, the membrane being thicker. Nevertheless data of value may be obtained in the acute form, although there is no certainty in any recourse save puncture. In one case of the author's there was an indefinite shadow in the region of the third right rib, very difficult to demark from the heart shadow. In another case there was at the height of the aortic arch a round shadow on either side of the vertebral column which was evidently not the shadow of the aorta and aroused suspicion of a small abscess in the posterior mediastinum. In a third case there was a sign of fluid in the right thoracic region the diagnosis varying between interlobar abscess and suppurative mediastinitis.

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X-RAY EVIDENCE OF ABDOMINAL SMALL INTESTINAL STATES EMBODYING AN HYPOTHESIS OF THE TRANSMISSION OF GASTRO-INTESTINAL TENSION*

BY R. WALTER MILLS, M.D.

ST. LOUIS, MISSOURI

THERE seems to have been no considerable effort made to investigate small intestinal normal or abnormal conditions by means of the *x*-ray, this with the exception of lesions of the duodenum which are not included in this presentation. Certain observations as to fundamentals in small intestinal motility have been recorded. The outlines suggesting gross obstruction are recognized. The strikingly apparent dilated and ribbed loops of the obstructed small intestine made visible on the plate by gas and fluid or apparent after barium ingestion have been described (Fig. 11). Several authors have written of the very valuable information derived by the *x*-ray in pathological jejunal and ileal obstructive states of various etiology including congenital bands with resulting kinks (Fig. 12). It is remarkable that so little has been done towards investigating disturbances of the small intestine, the most essential and indispensable part of the alimentary tract. With the exception of gastrojejunal ulcer there does not appear to have been any conception that direct evidence of involvement of the small intestine might be obtained as in the instance of stomach and colon or any effort made to elicit evidence of impairments of its function other than in the instance of ileocecal valve incompetence and ileal stasis. Even the atypical segmentated shadows of the organically involved small intestine have been regarded only as evidence of slight local obstruction.

For the past ten years it has been my custom to write a formal report of each *x*-ray examination, partly for purposes of cross-filing. Any *x*-ray findings not understood were systematically recorded in this report. Among other captions in this cross-file was that of atypical small intestinal loops. I was thus forced to observe and make note of any small intestinal forms that were at all unusual. It gradually became apparent that certain of these forms were associated with certain conditions (Tables I and II); for instance that in colonic obstruction a certain form of small intestine suggesting overdistension was generally present. This naturally led to the idea of recoil or relative stasis which conception once entertained was found to be supported by collateral evidence on every hand; the same for organic conditions. These atypical small intestinal outlines were first noticed and recorded in 1916. In the subsequent five years they have been observed approximately 600 times in the *x*-ray examination of 6,000 persons, naturally with growing frequency as they became better appreciated. For

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Material from the private Laboratory of Dr. H. W. Soper and myself and the X-Ray laboratory of Washington University Medical Department. My thanks are due to the many colleagues who have favored me with material.

instance in the past six months 205 times in the examination of 750 patients (Table III).

A factor that was fortuitous was that in efforts to determine the exact time of complete gastric emptying for a special study of gastric motility a large series of cases were plated with the patient standing which naturally gave a filled small intestine without considerable pressure artefacts such as result when the plate is taken with the patient prone as is generally done; such plates being consequently non-informative as to the evidence to be mentioned. It is this accidental factor more than all others that accounts for my own findings which have not been apparent because not available to others whose plates were taken with the patient prone.

The subject is difficult to present in abstract form as to functional disturbances because complicated and resting on certain unrecognized principles, perhaps more safely hypotheses, evidence supporting which it may be frankly admitted is as yet to a degree inferential and will only be possible of proof or disproof by prolonged observation. It is thus realized that suggestions to be offered are not proved and so radical that I have hesitancy in presenting them without further investigation. They seem however so appealing and supported by so much evidence that they are submitted to you for consideration and it is hoped will result in your investigation of them.

Since the plate itself is the most effective means of demonstration a statement in proposition form will be given of matter to be presented so far as possible each point illustrated by a print or two with accompanying descriptive legend. It has been disconcerting that my efforts to demonstrate these atypical small intestinal forms to others have not been particularly successful. Roentgenologists of widest experience in gastro-intestinal work were unable to appreciate or differentiate outlines that to me seemed perfectly apparent and that I have every reason to believe we are utilizing daily with diagnostic helpfulness. I must conclude that appreciation of such evidence is a matter of experience and education; that one must become as it were sensitized to changes in outlines that at first are not apparent. Each of us has had a similar experience in our gradual education in the matter of duodenal cap deformity, appreciation of gall-stone shadows, and so on.

We have little knowledge of factors governing small intestinal motility. A few seemingly well-founded observations and ideas are current in the literature: That the stomach is the chief regulator of the rate of small intestinal motility; that the rate of motility in the jejunum is very rapid, periodic and segmental, and that ileal motility largely lacks these characteristics; that the rate of motility progressively decreases from the duodenum to the ileocecal valve. Certain conceptions of a small intestinal segmenting peristalsis founded chiefly on observations on animals have been presented. Such action seems not so evident at least difficult of observation in man. The function of the ileocecal mechanism has been differently understood. One teaching is that it essentially prevents a too rapid flow of small intestinal contents into the cecum. The other is that it prevents the reflux of cecal contents into the ileum. My own idea is that it more particularly functions in the latter manner, though as has been taught it doubtless has a dual function, the valvular mechanism preventing reflux and the muscular action in the terminal ileum moderating proximal flow.

The small intestine bears the same relation to habitus as does the stomach and colon as to form, position, tonus, and motility. In sthenic types the arrangement of the whole is higher, the coils are more discrete, of different arrangement, a demonstrably greater degree of tonus and a more rapid rate of motility than in asthenic and hyposthenic subjects. There are suggestions that intra small intestinal tension is greater in sthenic types. Under normal conditions the appearance of the small intestine on the plate is characteristic judged on the basis of physical type (Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10).

X-ray evidence of organic small intestinal lesions may be summarized in a word. Any organic process involving the small intestinal wall either primarily or secondarily will modify the *x*-ray shadow of the contents of the part involved and thus

Fig. 1. Normal small intestine of subject of hypersthenic habitus. Compare with following photo. Small intestine generally high in position showing no tendency to massing in the lower abdomen, its loops discrete and of a high degree of tonus, its motility rapid.

Fig. 2. Photo of woman of hypersthenic habitus. Compare with type of small intestine shown in preceding figure. Physical characteristics are great body weight, short deep thorax, very obtuse intercostal angle, long abdomen, relatively narrow pelvis, high degree of visceral tonus and rapid alimentary motility.

Fig. 3. Normal small intestine of subject of sthenic habitus. Compare with following photo. Characteristic peculiarities essentially those of the hypersthenic (Fig. 1) but less marked. The small intestine is somewhat lower, the loops less separated, of slightly less degree of tonus and less rapid motility.

Fig. 4. Photo of woman of sthenic habitus. Compare with type of small intestine shown in preceding figure. Peculiarities are those of hypersthenic but less marked in degree. Thorax of moderate length with wide but not obtuse intercostal angle, abdomen moderately long, body weight above the average.

render direct diagnostic evidence of its presence; if not as strikingly as in the instance of stomach and colon or yet as suggestively as to the nature of the lesion, none the less positively as to an organic pathological process being present (Figs. 13, 14, 15, 16, 17 and 18).

The following principles concerned in abnormal functional small intestinal conditions may be offered. The first of these is thoroughly recognized and accepted by all of us, the others are not and must as yet be considered hypothetical.

1. When there is organic alimentary obstruction there will be dilatation and motor delay proximal to it, their degree determined by that of the obstruction and the resulting proximal dilatation or hypertrophy. Duodenal ulcer obstruction and its results on stomach form and motility is the commonest instance. To repeat we are all perfectly familiar with this principle, illustration is hardly necessary. It is unrecognized however and of greatest interest that in other portions of the alimentary tract impaired motility and dilatation resulting from obstruction may often be recognized in lesser degree far proximal to the obstructive point and immediately proximal area of frankly apparent motor delay. To illustrate: obstructive carcinoma of the colon results as we all recognize in an immediately proximal dilatation and colonic motor delay, but it seems also that this dilatation is reflected proximally in diminishing degree throughout the entire colon, is especially noticeable in the appendix and is apparent in the form of the small intestine suggesting distension as a result of recoil or relative stasis and may perhaps be reflected as far as the stomach. In addition there is usually present small intestinal gas which while not to be regarded *per se* as pathological, nevertheless usually is and does not seem to occur under what may be termed admirable conditions (Figs. 19, 20, 21, and 22).

It is indeed a question whether delayed progress in the small intestine may not result in impaired gastric motility. It is conceivable that such might occur as the result of inhibition of those stimuli that result in expulsive activity on the part of the stomach as does occur in much greater degree in acute small intestinal obstruction. My attention was attracted to this possibility some years ago in attempting a study of causes of delayed gastric emptying. In that study certain conditions such as chronic appendicitis and gall-bladder disease were found suggestively associated with slow gastric emptying. Thus 15.4 per cent of a considerable series of cases of chronic appendicitis and 34 per cent of a series of gall-bladder disease showed six hour residues on a standard contrast meal; rather a course test considering variability in the time of complete gastric emptying in different types of individuals. The cause of this was not apparent and the study thrown aside in the hope the reason would later be found. The present effort is partly the result of attempts to reach a solution of the problem. Certainly on clinical grounds the explanation of the functional dyspepsias associated with organic surgical and possibly functional nonsurgical conditions, such as constipation, partly on the basis of slow gastric motility would seem attractive. This might result through inhibition secondary to distal small intestinal motor delay or inhibition of proximal (gastric) motility as in gall-bladder disease. One might even conjecture that biliary motility was influenced in some such fashion, i.e., that slow biliary flow was secondary to small intestinal hypomotility in turn the resultant of colonic stasis. Clinically again there are suggestive things. For instance the insistence of certain persons on the cure of their "biliousness," whose explanation no physician may attempt, by means of purgatives which we are thoroughly assured are not cholagogue but which apparently amply serve the end desired from the patient's standpoint.

2. Evidence strongly suggests that the same far reaching proximal recoil occurs in somewhat less degree in functional stasis of the colon as in marked colonic constipation. The *x*-ray apparently shows that not only is there resulting motor delay throughout the entire colon but also secondarily in lesser degree in the small intestine. Such evidence of small intestinal recoil through the form of the small intestinal

Fig. 5. Normal small intestine of subject of hypostheni habitus. Compare with following photo. Small intestine in toto is somewhat low in position, its various portions massed to a degree and the tonus moderate only, the rate of motility slower than in either of the preceding types.

Fig. 6. Photo of woman of hyposthenic habitus. Compare with type of small intestine shown in preceding figure. An average type tending rather to the asthenic than the sthenic. Body weight is rather below the average, thorax moderately long, not deep and with slightly acute intercostal angle. Abdomen somewhat short.

Fig. 7. Normal small intestine of subject of asthenic habitus. Compare with following photo. On the whole position is low, loops show tendency to massing, especially true of ileum. Tonus poor and motility slowest of any type. Differentiation of jejunum and ileum usually more marked in this type.

Fig. 8. Photo of woman of asthenic habitus. Compare with type of small intestine shown in preceding figure. Characterized by general frailty, light body weight, very long gracile shallow thorax with acute intercostal angle. Short abdomen longitudinally, wide pelvis.

Fig. 9. Extreme degree of hypertonicity of small intestine seen characteristically in subjects of markedly sthenic habitus and a high degree of tonicity, common as to visceral tonicity in general.

Fig. 10. Extreme hypotonicity of small intestine as seen in markedly asthenic and debilitated persons. Gas-filled loops probably result of hypotonicity not necessarily pathological but do not express admirable conditions. Small intestine as here shown not distinguishable from that of pathological causation except through consideration of other factors, especially habitus.

Fig. 11. Characteristic and well-recognized evidence of gross small intestinal obstruction. Dilated herringbone or ribbed pattern of gas, fluid and barium filled, obstructed and dilated small intestine. Case one of gross obstruction by dense adhesions within sac of

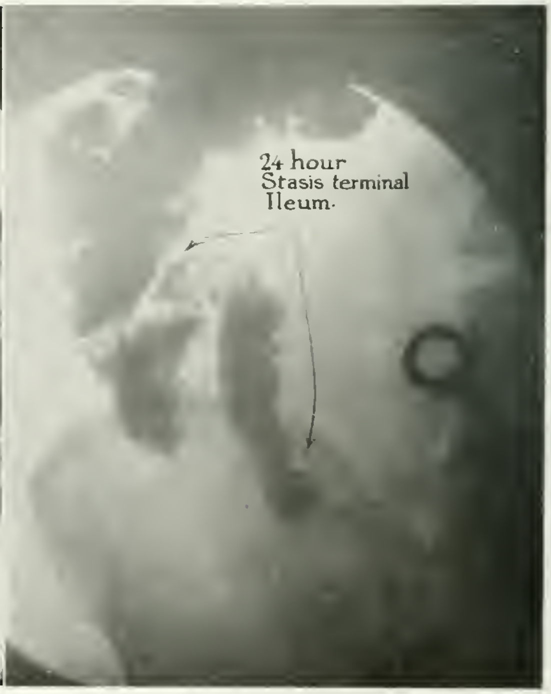

Fig. 12. Stasis in terminal ileum at 24 hours as the result of adhesions secondary to appendicitis with rather extensive peritonitis. Condition probably the expression of crippling of motor mechanism of terminal ileum rather than of obstruction or incompetence of

FIG. 13. Organic lesion involving small intestine. Here general carcinosis secondary to carcinoma of pancreas. Post-mortem and microscopical confirmation. Characteristic discrete atypical loops of small intestine disorderly arranged showing multiple serrations probably result of locally excited spasms. Outline highly diagnostic of organic lesion but not differentiating as to specific nature.

FIG. 14. Organic lesion involving small intestine. Tubercular peritonitis. Peritoneum 1 cm. thick. Tubercular exudate with universally adherent and matted intestines. Peritoneum studded with tubercles. Operative and microscopical confirmation. Splashy leaf-like pattern indicates organic lesion; elevation of small intestine in toto; suggests ascites.

FIG. 15. Organic lesion involving small intestine. Atypical patchy irregular discrete loops of small intestine. Fairly characteristic of and here the result of inflammatory exudate due to rather extensive local peritonitis secondary to acute appendicitis. X-ray evidence of highest diagnostic value. Operative confirmation.

FIG. 16. Slight local small intestinal obstruction due to a few carcinomatous nodules at root of small intestinal mesentery. The local puddling with fluid level is apparent and characteristic of slight obstruction. Operative confirmation.

loops as resulting from constipation naturally does not differ from that indicating the secondary effect attributable to slight or moderate colonic obstructive states. It has been taught that there is no constipation of the small intestine; there is not on the same time ratio, but recall the comparatively rapid motility of the small intestine. Interestingly the fact that it is thus less evident suggests too a greater peristaltic energy on the part of the small intestine with consequent greater tension within it. The ileum can drive its contents into an over-filled even obstructed cecum without great delay; a suggestive idea of many leads and bearings, especially as to whether colonic contents regurgitate or reflux into the terminal ileum under natural conditions as in the case of the barium enema[1] (Figs. 23 and 24).

3. Any alimentary sphincter that is subjected to increased intravisceral tension originating either immediately proximal or distal to it tends to give way and if this tension is sufficiently great the sphincter becomes divulsed and incompetent, dilates in common with the contiguous dilated gut with resulting disturbance of proximal and distal motility. An illustration of the first condition is afforded in the gapping incompetent pylorus occurring in certain cancers of the stomach, the expression of its divulsion resulting from increased intragastric tension in turn the product of decreased intragastric capacity, lessened elasticity of the stomach walls and stomach elevation *in toto*, favoring over-rapid emptying through gravity. This latter statement made advisedly (Fig. 25). Obstruction of the distal duodenum resulting in dilatation of the duodenum proximal to it and of the pylorus and of the stomach in common, is an illustration of the second (Fig. 26). In the first instance that of the gapping incompetent pylorus resulting from contracting cancer of the stomach, distal motility is abnormal—over-rapid largely because the controlling sphincteric action of the pylorus is lost as a result of the factors mentioned. In the second instance that of an obstruction of the distal duodenum with secondary divulsion of the pylorus, proximal motility of not only the duodenum but the stomach as well is interfered with. The pylorus being divulsed duodenum and stomach become one ventricle. Less spectacularly but just as truly, the same dynamics obtain in the instance of every other alimentary sphincter, the cardia, ileocecal mechanism and rectosigmoid (Figs. 27, 28, 29 and 23).

Ileocecal valve incompetence is as has been contended not essentially a thing of the moment effected by barium enema pressure, but instead the reflux of the enema into the terminal ileum expresses its actual acquired and constant relative incompetence, the result of persistent increased intracolonic tension beyond from various causes, most commonly constipation usually contributed to by an inherently low degree of sphincteric tonus as occurring in asthenic states. It is a result and not a cause. The whole subject of ileocecal valve incompetence and ileal stasis as written of by clinicians and roentgenologists is full of suggestions of acquired patulence and secondary small intestinal recoil without the situation apparently being appreciated. Incidentally reflux through the ileocecal valve of the barium enema does not necessarily mean that the same thing occurs under natural conditions, though it usually indicates an acquired patulency. The result is but the expression of the balance between the artificial pressure exerted and the resistance offered. Even under perfectly normal conditions the small intestinal column must feel the resistance of the cecal contents ahead at those times when the sphincter mechanism in the terminal ileum is open. It is only when distal resistance is abnormally great through abnormal conditions and a certain maximum pressure is exceeded that the valve gives way. The whole present conception of abnormal intra-alimentary tension transmission points to one function of the sphincters being that of protectors or guards against pernicious transmission of tensions in addition to the usually appreciated action of favorably retarding motility that the ends of digestion and absorption may be served. The function of the pelvirectal sphincter is to prevent the forming stool

[1] I have since learned that Case has definitely determined this to occur.

FIG. 17. Organic lesion involving small intestine manifested by extreme and atypical hypertonicity, here secondary to general miliary peritoneal tuberculosis. Operative confirmation. X-ray evidence suggests irritation due to organic lesion through curious corkscrew or scroll-like atypical spastic loops of small intestine. Evidence diagnostic but not definitely differentiating. (Compare with following figure.)

FIG. 18. Hypertonic small intestine disharmonic on basis of individual's type (asthenic) suggesting result of secondary irritation by organic factor, here general lower abdominal peritoneal irritation (peritonitis ?) secondary to pelvic condition. Note discrete really atypical loops of lower shadows suggesting plastic exudate. X-ray evidence suggestive but not conclusive or differentiating.

FIG. 19. Illustrating evidence of transmitted intracolonic hypertension. Marked dilatation of appendix which hangs over pelvic brim, the result of obstructive lesion, carcinoma of ascending colon, possibly secondary to diverticulitis, though cecal diverticula—an unusual location—possibly secondary to hypertension in proximal colon. Post mortem. Condition results in small intestinal stasis. See following figure—same case.

FIG. 20. Small intestinal recoil and stasis from proximal colonic obstruction (carcinoma) shown in dilated atypical loops of small intestine not to be differentiated from result of moderate organic obstruction of distal small intestine, though such not here present. Post mortem. See preceding figure—same case.

Fig. 21. Illustrating evidence of transmission of intestinal hypertension proximal to organic obstructive lesion, here carcinoma of ileac colon. Proximal colonic hypertension suggested in degree of dilatation in descending and distal transverse colon and in form of appendix suggesting slight dilatation probably limited by degree of proximal appendicular sclerosis. Operative confirmation. See following figure—same case.

Fig. 22. Evidence of small intestinal recoil due to obstructive lesion (carcinoma distal colon). X-ray evidence through marked local puddling and overfilling with over-fluid contents of small intestinal loops. Same case as preceding figure. Operative confirmation.

Fig. 23. Colon of extreme constipation with patulence of rectosigmoid sphincter as described by Soper, the result of fecal divulsion. Compare with succeeding figure showing atypical small intestine of same case. Direct course of rectum and pelvic colon and absence of functioning rectosigmoid characteristic.

Fig. 24. Atypical small intestinal loops. Contention that here expressive of small intestinal recoil due to extreme constipation through degree of acquired patulence of ileocecal valve. Patient suffers from profound auto-intoxication. Calomel user. Same case as preceding figure.

FIG. 25. Marked divulsion and insufficiency of cardia and pylorus, "gapping pylorus," characteristic of and here result of general contracting carcinoma of stomach lessening gastric capacity and causing gastric hypomotility through such, together with resulting elevation. Operative confirmation. Post mortem.

FIG. 26. Organic obstructive lesion involving duodenum at juncture of second and third portions and resulting in dilatation of duodenum proximal and of the stomach in common with permanent and marked divulsion—practically obliteration—of the pyloric sphincter. No operative confirmation nor post mortem. Palpable mass later developed corresponding to site of defect. Possibly carcinoma. Possibly lues. (Wassermann four plus.) Patient died shortly afterwards.

FIG. 27. Remarkable permanent divulsion and incompetence of cardia due to decreased abdominal capacity in aged cripple with most marked kyphosis. As the result of the obliteration of the abdominal cavity in large measure through mal statics intragastric tension has been increased through external pressure until the cardia has been forced and rendered incompetent with permanent food content remaining in esophagus. No organic lesion present.

FIG. 28. Permanent divulsion of ileocecal mechanism as the result of exudative colitis. The mechanism of the terminal ileum has been permanently divulsed and rendered incompetent through recoil resulting from distal resistance offered by the rigid colon beyond.

from entering the rectum which is normally empty excepting just before defecation, the urge to which is excited by the descent and presence of feces in it. As has been determined by my associate, Soper,

FIG. 29. "Incompetence of rectosigmoid apparatus" (Soper) divulsed and rendered permanently patulent through colonic stasis with permanent retention of fecal matter in the rectum and pelvic colon doubtless contributed to by the use of purgatives. Also shows location of diverticula at points of maximum intracolonic tension, i.e., in abrupt curves of ileac colon and just proximal to resistance factor—retained rectal fecal column.

through sigmoidoscopic studies, the majority of cases of constipation are concerned either with loss of contractility of the pelvirectal sphincter or its overtonicity (Figs. 29, 23, 30 and 31). In the first case secondary to its divulsion through constant rectal accumulation of feces, in turn caused by ill habits and habituation of the rectum to such fecal presence and by the constant abuse of purgatives exposing the sphincter to frequent unnatural strain. In the second spasticity of the pelvirectal sphincter and contiguous pelvic colon result in proximal fecal retention.

4. Any acquired local lack of resilience in the gut wall as from an inflammatory or other pathological condition will lead to recoil and relative proximal stasis. A sclerosing duodenal ulcer even if it does not actually involve and result in fixed contracture of the pyloric sphincter is frequently associated with a slight or moderate delay in gastric motility—a six hour residue and a degree of gastric dilatation. This may be an expression of final fatigue on the part of the stomach walls from the ulcer resistance offered in the cap, whose function would thus be suggested as that of a shock absorber for gastric peristaltic impulse.[2] In such a duodenal ulcer the pylorus itself is often shown by the plate to be actually open and roentgenoscopically to be incompetent, divulsed by the increased intragastric tension instead of in spasm, usually considered the causative factor in the delayed gastric emptying (Fig. 32). It may even be that the secondary indications, the

FIG. 30. Marked hypertonicity, "spasm of rectosigmoid apparatus" and pelvic colon—according to Soper an essential cause of constipation in colons of essentially a high degree of tonus.

indirect signs of non-obstructive duodenal ulcer, can be accounted for on the basis of

[2] The size and form of the duodenal cap indicates the extent to which it is subjected to pressure—plus its form and direction and the influence of the essential degree of visceral tonus of that person. Where the pylorus is patulous and the cap vertical it will as a rule be large. In heavy hypersthenic persons with high hypertonic stomachs the cap is non-retentive because its downward direction favors non-retention through gravity. It will consequently be small and not apparently greatly differentiated.

abnormal distal resistance. The hyperperistalsis as the direct response; the initial hypermotility as the resultant of hyperperistalsis thus excited plus the incompetence of the pylorus to a degree divulsed through

FIG. 31. Spasm of pelvirectal apparatus, a common cause of constipation in spastic colons (Soper). Exact point of pelvirectal contracture here not shown as it is posterior and technically very difficult of x-ray demonstration.

increase in intragastric tension. A stomach not regularly distended tends to contract as in starvation or when the patient is on a soft diet. The gastric hypertonus may thus represent lack of gastric distension, the product of hyperperistalsis and initial hypermotility. A cecum whose elasticity has become impaired as a secondary result of an old appendicular inflammatory process or which offers increased resistance through malposition or even a retrocecal appendix will practically always be associated with an atypical form of small intestine indicating relative stasis as the result of recoil from the increased cecal resistance beyond (Figs. 33 and 34). Clinical medicine furnishes a number of illustrations of the untoward results of abnormal modifications of intravisceral tension of great practical importance: The dilatation of the bile-ducts on the removal of the gall-bladder, the biliary tension equalizer; the occurrence of hydronephrosis in conditions in which the elasticity of the urinary bladder is impaired. According to Matas, in arteriovenous aneurysm not only the vein is dilated but the artery also as far back as the heart as a result of the abnormal resistance encountered by the arterial current at the point of anastomosis. Circulatory results of valvular heart disease furnish many illustrations.

5. Rarely but to be mentioned as a possible principle, lesions lessening the recoil absorbing power of at least certain proximal portions of the alimentary tract determine a greater motility distal to it. A non-ulcerative localized tumor of the body of the stomach with intact expulsive antral mechanism will result in divulsion of the pylorus and resulting dilatation of the proximal duodenum and in small intestinal hypermotility, because the power

FIG. 32. Permanent divulsion and incompetence of pylorus, the result of distal resistance due to sclerosed duodenal ulcer definitely beyond pylorus. Condition possibly suggests cause of duodenal ulcer secondary indications, hypermotility, hyperperistalsis, and hypertonus through resistance offered and physiological response to it.

to absorb peristaltic shock on the part of the stomach has been impaired through loss of elasticity (Fig. 35). The lax pylorus characteristic of gastric ulcer of the pars media is perhaps the result of slight divulsion through similar conditions (Fig. 36).

6. It has been assumed that tension within the alimentary tube if not a constant throughout still may be proximally influenced by changes in distal tension. Conditions favoring transmission of pressure are fairly obvious in the small intestine especially in the ileum; very much less so in the colon, particularly in parts filled with heavy fecal matter. There seems however a factor that makes this quite possible. This factor is the existence of an undescribed slowly progressing peripheral colonic motility about the central fecal column in cylindrical fashion which seems to me to be the essential motility of the colon, certainly of the transverse colon. *X*-ray plates commonly indicate this peripheral motility which is perhaps largely the resultant of intermittent cecal pressure and allows of direct and immediate contact of oncoming matter with the colonic wall for purposes of absorption, an action much furthered by the haustration of the colon. The haustra act as resistance units to this peripheral current, as stations for delay and deliberate absorption from their contents and prevent the dislocation and progression of the column *en masse* as occurs in the infrequent great colonic movements suggestively during which haustration is abolished and the parts of the colon concerned become a cylinder. This type of motility results in peripheral stratified accretion to the haustral contents through inspissation to the formation of scybalae. Scybalae are thus largely the product of gradual surface accumulation. This peripheral current probably makes possible an approach to a common intracolonic pressure on account of its comparative fluidity and allows for the proximal transmission of increased distal tension judging by analogy and *x*-ray evidence (Figs. 37, 38, 39 and 40). There is as mentioned previously much to suggest that colonic tension may thus be transmitted in part on this peripheral current not only throughout the colon but through the ileocecal valve, under normal conditions during periods when it is open, and under abnormal conditions of increased intracolonic tension to its gradually acquired partial or even complete incompetence with secondary recoil and relative stasis in the small intestine. The ileocecal valve may so be forced and become permanently incompetent in the same way that the cardia is divulsed and rendered incompetent in contracting carcinoma of the stomach to the persistence of a constant esophageal content (Fig. 41).

This conception of tension transmission may help to throw light on various problems: On the functional dyspepsias associated with constipation through secondary small intestinal relative stasis and hypertension, especially in the spastic constipations with their more marked pressure symptoms and indicate why there is such variability in symptoms in different types of constipation. On appendicitis and the curiously beneficial results of surgery in certain cases of chronic appendicitis which cause small intestinal recoil through resistance offered and the lack of improvement in others in which the small intestinal stasis is due to permanent pericecal changes. It may help to explain the close relationship between constipation and appendicitis through the irritating effects of stasis in the appendix, just as diverticulitis results from stasis and irritation by retained fecal matter in colonic diverticula. We all know what a proportion of persons suffering from spastic constipation are adorned with appendectomy scars. In this connection it is interesting that according to W. J. Mayo approximately one third of the cases of colonic diverticulitis have had appendectomies, suggesting appendicular irritation as the result of the same colonic hypertension that gave rise to the diverticulosis. The form of the appendix usually suggests the presence of increased intracolonic tension through its outline and direction indicating over-distension and dilatation spectacularly in organic colonic obstruction. In periods of constipation the appendix through its form gives these indications of tension and irritation through increased tenderness which are absent after a thorough defecation.[3] Through its form the appendix is thus a sort of barometer of intracolonic tension.

[3] As an aside it may be noted that the appendix is more tender to pressure when intracolonic tension is increased as in periods of constipation suggesting irritation as a result of such tension. An appendix that is suggestively tender at such a time will generally be much less so after a laxative. The same holds true in the case of a spastic ileac or pelvic colon and in other conditions.

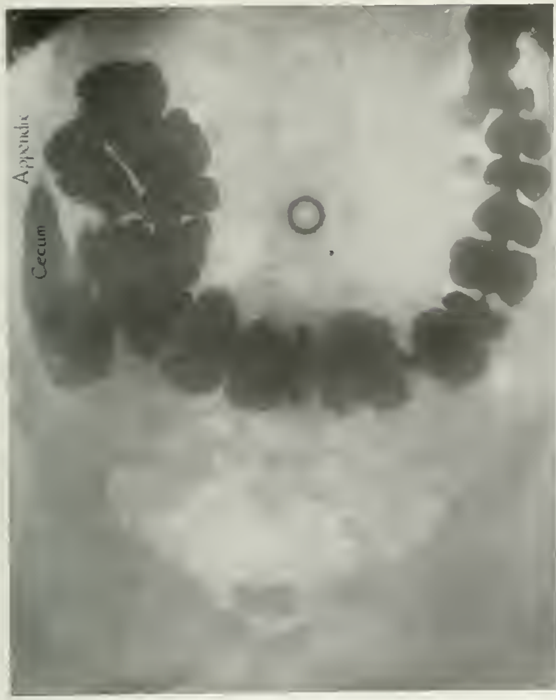

Fig. 33. Dislocation of cecum as a factor offering resistance and resulting in small intestinal recoil (compare with following figure). Condition here the result of exudate secondary to appendicitis. Operative confirmation.

Fig. 34. Atypical small intestinal loops indicating small intestinal recoil from distal resistance resulting from a dislocated cecum secondary to appendicitis. Compare with preceding figure. Same case. Operative confirmation.

Fig. 35. Illustrating immediately distal alimentary dilatation and hypermotility the result of a proximal organic lesion preventing absorption of peristaltic shock. Lesion of unknown etiology. Operative confirmation. Carcinoma (?)—microscopical, negative. Young woman. Illness of five years. Death nine months after present plate taken.

Fig. 36. Showing the characteristic lax pylorus of gastric ulcer possibly the result of impairment of the peristaltic shock-absorbing power of the stomach as the result of the resistance offered through locally lessened elasticity of the ulcer area. A large series of cases show that the pylorus is practically always lax in gastric ulcer and not spastic as heretofore taught.

Fig. 37. Illustrating peripheral colonic motility. The peripheral current surrounding unbariumized fecal contents distal to definite "head of column." No other explanation possible. The barium must be progressing by passing between the colonic wall and the contents of the colon.

Fig. 38. Illustrating peripheral colonic motility. Showing peripheral colonic current locally about central retained unbariumized fecal matter. Pressure of spine probably the factor here making apparent but does not vitiate—rather emphasizes that peripheral current present.

Fig. 39. Illustrating peripheral colonic motility and stratification of haustral contents. At point indicated by arrow it will be noted that there are multiple strata varying in proportion to their barium content.

Fig. 40. Illustrating peripheral colonic motility. Sketchy outline of median transverse colon, of necessity the result of migratory peripheral current, and of interest because colon proximal free of barium.

Fig. 41. Another case showing actual patulence of the motility retarding sphincteric apparatus of the terminal ileum as the result of distal colon resistance beyond due to marked exudative colitis. The terminal ileum is *not* involved. Operative confirmation.

Fig. 42. Showing dilatation of the appendix as the result of increased colonic tension here the result of involvement of cecum and ascending colon in carcinoma of the ascending colon. Foregoing conditions establish factor of resistance to small intestinal motility. See following figure. Operative confirmation.

Fig. 43. Small intestinal recoil as the result of resistance factor in proximal colon, i.e., carcinoma of ascending colon. See preceding figure, same case. Large amount of small intestinal gas suggestive of pathological condition; probably an expression of acquired atony of the small intestine. Operative confirmation.

Fig. 44. Slight dilatation of appendix the result of marked colonic hypertension here a concomitant of spastic constipation. The appendix of spastic constipation is as a rule large—probably slightly dilated—except in cases where such result is inhibited by a degree of appendicular sclerosis. The appendix is thus a barometer of intracolonic tension.

It sounds fantastical but the appendix may possibly have a tension equalizing function similar to that of the gall-bladder. The well-founded surgical rule against the use of purgatives in cases of acute appendicitis illustrates the practical value of an appreciation of the transmission of colonic tension to the appendix. Those of us who have seen castor oil floating in fecal matter among the intestines at an emergency operation have no doubt of the desirability of any new light on the question. It is generally taught that the rupture of the acutely inflamed appendix after a purgative is the result of excited colonic peristalsis. It is primarily so but the actual force that results in the appendicular blow-out is probably applied through the increase in the common intracolonic and appendicular tension (Figs. 42, 43, 19, 44, 45, and 46).

If true the idea of visceral hypertension, its transmission and results, may resolve certain great problems in gastro-enterology to something of a common relationship. Many cases of constipation, many cases of appendicitis, the formation and points of occurrence of multiple colonic diverticula at points of maximum tension as in the abrupt curves of the pelvic and ileac colons and just proximal to points where the colon is compressed as by uterine fibroid or other obstruction of gradual causation (Figs. 29 and 47). The fact that colonic diverticulosis practically only occurs in sthenic and hypersthenic types, except where an obstruction has developed, in whom visceral tonus is inherently great and alimentary motility more rapid, suggests that intracolonic hypertension is the essential cause of diverticulosis. Purgative abuse is probably a chief immediate contributory causative factor. Colonic redundancy which seems to me for certain reasons to be chiefly acquired and not congenital may be an expression of somewhat similar conditions of increased intracolonic tension resulting from fecal retention reacting in a colon of different type and of an essentially lower degree of tonus. Constipation and purgative abuse seem here also the primary causative factors. If all this be true or only in part true it points to the tremendous importance of the correction of constipation and especially its prophylaxis in children through better home, school and industrial hygiene, popular education and so on.

Visceral hypertension and recoil may help to explain auto-intoxication through small intestinal stasis, recalling our not entirely satisfactory efforts to adequately account for it on the basis of a pathological absorption from the colon. It may help to explain the contention of the functionally dyspeptic patient that he is full—as he interprets it—of gas, which the *x*-ray shows is not gas, his coated tongue, his relief on belching or passing flatus through temporary relief of his intra-alimentary hypertension, his distress after inadequate defecation, his improvement on the improvement of his constipation and his insistence on calomel instead of a diet—the guiding principle—the physic of the ages. It may be that in the future we shall attach as much importance to studies of intra-alimentary tension as we now do to blood-pressure observations Certainly its actual determination if possible, perhaps by a modified intestinal tube, would be most interesting. It is probable that intra-alimentary tension would be found to be actually very slight could it be determined and expressed by manometry as suggested by the very moderate degree of pressure necessary to cause a barium enema to retrogress. It is disturbance in relative tensions in different locations that is abnormal and disorganizing.

7. Whenever there is over-rapid small intestinal motility from any source, the small intestinal forms will reflect this indicating over-distension and increased fluidity of the intestinal contents more noticeable in the jejunum. The simplest illustration is that of conditions after a gastrojejunostomy in which the small intestine chiefly the jejunum is often obviously over-distended and at operation can be demonstrated to be dilated. The same thing occurs in achylia gastrica in spite of *x*-ray suggestions of a normal gastric motility and normal pyloric sphincteric action. Frequently the same type of distended loops of small intestine are associated with diarrhea suggesting that this is not altogether colonic as has been supposed (Figs. 48 and 49).

Fig. 45. Appendix showing a degree of hypertension through its form and direction. Case of moderately obstructive carcinoma of pelvic colon. Compare with following figure, same case, after thorough defecation and administration of barium enema. Operative confirmation.

Fig. 46. Form and direction of appendix suggest lack of intracolonic hypertension. Same case shown in preceding figure (obstructive carcinoma of distal colon), but after a thorough laxative and on the administration of a barium enema. Operative confirmation.

Fig. 47. Diverticulosis proximal to extra-alimentary obstruction by great sarcoma originating in bladder and not involving intestines. Patient woman of 79 weighing less than 100 lbs., of hyposthenic habitus. Illustrates probability that diverticula acquired as result of increased intracolonic tension here by extracolonic pressure. Note diverticula just proximal to area of obstruction. Operative confirmation.

Fig. 48. Atypical small intestinal loops characteristic of achylia gastrica and probably an expression of intestinal hypermotility, implying that the diarrhea of achylia gastrica is not entirely colonic and hardly due to gastric hypermotility considered characteristic of achylia but not the case after a barium meal. The form of the loops suggests unusual fluidity of their contents.

Fig. 49. Atypical small intestinal loops the result of simple diarrhea which is suggested by the puddle-like arrangement of small intestinal forms, suggesting that the hypermotility is not limited to the colon.

Fig. 50. Atypical small intestinal loops secondary to distal colonic resistance factor (possibly also general carcinosis) here carcinoma involving descending colon. See following figure. Lesion overlooked three years previous but recently recognized through atypical small intestinal loops in reviewing for this article. No operative confirmation. Patient died shortly afterwards, palpable mass, etc.

Fig. 51. Lesion in descending colon overlooked three years previous and recently discovered through atypical small intestinal loops. See preceding figure.

Fig. 52. Atypical small intestinal loops result of resistance offered by inguinal hernia.

Fig. 53. Pseudo small intestinal recoil such as occurs after the use of laxatives, in conditions of slight diarrhea and the like. Not to be distinguished from forms due to organic conditions except as interpreted through clinical history.

Fig. 54. Plate taken 24 hours after ordinary barium meal showing barium filling distal colon without defecation having occurred. Also indicates peripheral colonic motility by which only it is assumed that such a condition is possible.

Fig. 55. Consider with following figure. Case of beginning scirrhus carcinoma without at this stage incompetence of cardia or evidence of dilatation of duodenum as the result of incompetent pylorus.

Fig. 56. Compare with preceding figure. Same case but two years later as terminal picture of gradually contracting carcinoma of stomach with acquired permanent incompetence of cardia and pylorus to constant esophageal content, resulting dilatation of duodenum and initial gastric hypermotility.

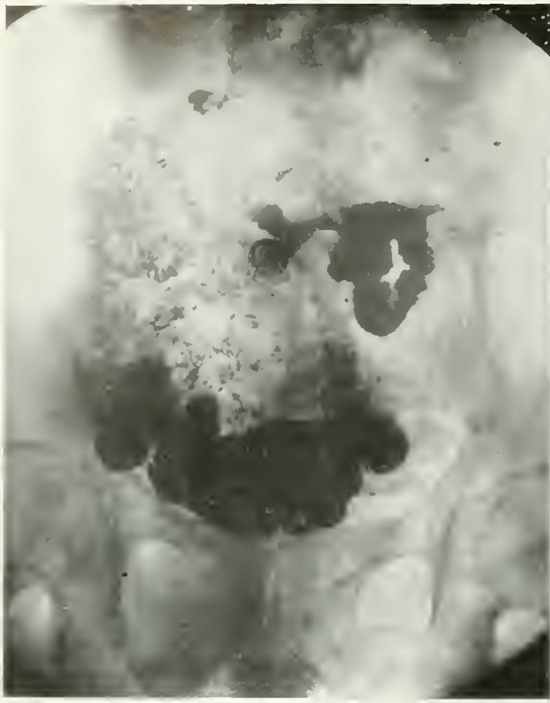

Fig. 57. Atypical small intestinal loops suggesting recoil from distal colonic resistance; factor in this instance colonic diverticulosis.

Fig. 58. Atypical small intestinal loops expressive of slight degree of recoil secondary to colonic resistance; factor in this instance profound colonic stasis due to inhibition from rectal ulcers.

Fig. 59. Atypical small intestinal loops suggestive of recoil due to colonic resistance; factor in this instance constipation and marked spasticity of colon. Small intestinal gas suggestive of degree of acquired small intestinal hypotonicity.

Fig. 60. Atypical small intestinal loops indicating recoil possibly best stasis secondary to highly obstructive carcinoma distal transverse colon. Operative confirmation.

There are arguments against the idea of a relative small intestinal stasis. It may perhaps be justly assumed that the presence of atypical small intestinal forms lacks the conclusiveness of a time motility pressure determining experiment. It is admitted; yet I must urge the overwhelming and suggestive constancy of such findings as have been mentioned in association with certain conditions. It must answer for the present; there are no observations as to the exact rate of small intestinal motility even under normal dietary conditions, a tremendously difficult problem considering physical type and individual variation as to the rate of alimentary motility in response to the same test in different persons. A most refreshing experience has been that in two instances I have been able to predict obstructive organic lesions of the colon overlooked at the time of examination several years previous from the form of the small intestine in reviewing plates for this article (Figs. 50 and 51).

The fact that atypical small intestinal forms are seen after appendectomy without persistence of symptoms is interrogating. Yet the impression is that they are less marked; the reaction may be lesser in degree, or there may be a persistence of acquired hypotonicity without hypertension sufficient to cause symptoms.

The most effective argument against the whole idea is that lesser grades of organic small intestinal obstruction are not associated with exactly the same clinical picture as in functional dyspepsia. However it would be easier to account for this dissimilarity of symptoms as between these conditions on the ground of dissimilar conditions and the probability of a different protective response and individual nervous sensitization than to discount entirely evidence in favor of the conception. There are frequent cases of functional dyspepsia in which the pressure symptoms attributed by the patient to 'gas' are marked yet no commensurate atypical small intestinal forms are apparent on the plate; yet there may be an intra-intestinal hypertension without dilatation through

FIG. 61. Markedly atypical small intestinal loops indicative of recoil if not of stasis, here secondary to carcinoma, involving cecum and probably there primary. Operative confirmation.

FIG. 62. Highly atypical small intestinal loops result of old peritoneal exudate secondary to appendicitis. X-ray evidence of highest practical diagnostic value.

the response of increased tonus on the part of the intestinal wall or other protective reactions. Occasionally the same type of small intestinal loops is to be seen in asthenics and debilitated persons, in cases of hernia (though in this latter instance there may be suggestive resulting symptoms) and after laxatives. Still many sorts of valuable information must be judged in the light of their exceptions. The foregoing emphasizes that the interpretation of atypical small intestinal forms is decidedly a matter of judgment after the consideration of various influencing factors (Figs. 10, 52 and 53).

It may be objected that in this day of complicated physiological studies of alimentary secretions, endocrine disturbances, neuromuscular reactions, and so on, that so simple a mechanical theory is inadequate and improbable. It may be so, yet our most effective knowledge of alimentary disturbances has been gained through an understanding of motility and its abnormalities. Often the directly active forces in the causation of disease are comparatively simple.

I can think of no argument that would discredit the idea of a peripheral colonic motility. I can demonstrate it in a thousand plates—any colon plate taken at a suitable time after a fed test. How is it that the head of the barium column seems to slowly and faintly progress across the transverse colon without dislocating the contents ahead. Instead, barium first appears distally as a thin film outlining the already filled colon—not mixing with its contents but surrounding them. Not very infrequently barium will be seen to have reached the rectum by the time the stomach is empty without a defecation having occurred. It must have passed peripherally. The haustra do not give evidence of having considerably changed. A barium enema given with the colon filled with feces retrogresses peripherally. Often constipated persons taking mineral oil complain of passing it alone without a bowel movement having occurred (Fig. 54). There is reason to think that this peripheral migration at times at least occurs intermittently possibly as a result of periodic expulsive activity of cecum or ascending colon. There is too evidence to suggest that it may progress without proximal propulsion; the median transverse colon alone being sometimes first faintly outlined with the cecum the only other portion of the colon filled. The great colonic movement is but a general collection, clearing the stage for a new setting of the same act (Fig. 37).[4]

TABLE I

INCIDENCE OF ATYPICAL SMALL INTESTINAL FORMS IN SERIES OF 5,735 SUBJECTS DUE TO ORGANIC CONDITIONS

A

[In Organic Conditions Primarily Involving Small Intestine]

General abdominal carcinomatosis and metastatic carcinoma	18
Tuberculous peritonitis	5
Peritonitis and adhesions of other than appendix origin	44
Meckel's diverticulum	1
Peritoneal irritation (peritonitis ?)	2
	70

B

[Where a Secondary Result of Organic Conditions]

Of cecal-appendix origin	142
Post-operative conditons after appendectomy	73
Carcinoma of colon	14
Colitis	8
Diverticulosis and diverticulitis	11
Colonic inhibition stasis, post operative	1
Hirschsprung's disease	1
Extra-alimentary tumor pressure	43
Hernia	16
Redundant small intestine	1
	310

TABLE II

INCIDENCE OF ATYPICAL SMALL INTESTINAL FORMS IN SERIES OF 5,735 SUBJECTS DUE TO FUNCTIONAL CONDITIONS

Constipation	43
Achylia	8
Over-fluidity	14
Over-prompt gastro-enterostomy stoma	1
Debility (asthenia)	4
Ascites	9
Indeterminable	77
	156

TABLE III

INCIDENCE OF ATYPICAL SMALL INTESTINAL FORMS

A

As Recorded in Series of Consecutively Examined Subjects During Past Five Years

Number of subjects	5,735
Number of atypical small intestinal forms	536
Percentage of atypical small intestinal forms	9.3%

[4] Figs. 55 to 62 are not referred to in the text, but further illustrate points mentioned.

B

As Recorded in Series of Consecutively Examined Subjects During Past Six Months

Number of subjects	752
Number of atypical small intestinal forms	205
Percentage of atypical small intestinal forms	27.2%

DISCUSSION

Dr. Skinner. I would like to hear a discussion on this because Dr. Mills' work has fascinated me. I think we are all ready to agree upon internal conformation to body habitus. This is not only a matter of body habitus but it may also be a matter of familial continuity. This has been brought to my attention in many cases not only in the gastro-intestinal tract, but also in the osseous system where we have had the opportunity of raying the second generation. I think as some of us grow in roentgenology we shall have this opportunity of raying the second generation and finding out that the familial type is continued in the gastro-intestinal tract and the osseous system as it is in physiognomy.

The second point is that the diseases of the gastro-intestinal tract, with which we are thoroughly familiar—let us say, gastric ulcer, duodenal ulcer, diverticulosis, chronic appendicitis, are all matters of terminal pathology and that it is necessary for us to engage ourselves with studies such as Dr. Mills presents in order to recognize these conditions before they have developed into the terminal stage. We seem to think that if we make a finding of duodenal ulcer or chronic appendicitis or gastric ulcer that we are rendering the patient great service, but we are only rendering them service in recording something that has affected them to such a degree that it is in the terminal stage and not at a time in the career of their disease when they can prevent this desperate pathological sequence.

One other point in regard to redundant sigmoidal loops. Dr. Mills stated that he felt these were acquired conditions, but I wonder if his experience has permitted him to examine a great number of young children. Since we find redundant sigmoids not only in the chronic intestinal stasis of the adult, but also in that of very young children. We have found chronic intestinal stasis in the very early months of life in desperate constipation. We are inclined to look upon it as congenital in origin or that it develops extremely early in life.

Dr. LeWald. Dr. Mills' paper brings up a field that has been sadly neglected. We have observed several cases of tuberculous peritonitis and tuberculous enteritis in which these findings of the fixed loops of small intestine have been so definite that we had no hesitation in making a diagnosis which has been substantiated by operation in each instance.

I would take issue with Dr. Mills in regard to the question of redundancy of the pelvic colon. We have also had the opportunity of examining a large number of newborn and growing children and we would as positively put ourselves on record as Dr. Mills has in his four types of individuals and say that some individuals are born with short pelvic colons, some with medium length, and others with exceedingly long pelvic colons, and that these conditions remain with the individual throughout life. We are convinced of this because we have had the opportunity of watching children over a period of years and upon reexamining them find each one true to his type. There is an old statement that the child is born with a long pelvic colon and that this is gradually overcome. This statement was made by one of the first pediatricians, Dr. A. Jacobi, but does not seem to be borne out by actual study of individual cases.

Dr. Stewart. The reason that we have overlooked so many small intestinal conditions is largely due to the fact that we routinely examine cases, commencing with the esophagus and stomach and making the next observation six hours later. If you want to catch these small intestinal conditions, you must make frequent observations between the meal and the six-hour-period.

Dr. Case. Most of us deal in the larger parts with functional disorders rather than actual organic lesions; hence the very masterly paper of Dr. Mills should prove of very wide interest. I shall preserve it carefully for frequent reference.

I beg to differ with the observations of Dr. Mills in one point only; that is, relative to the regurgitation of ingested material from the cecum into the small intestine. I am perfectly aware of the fact that regurgitation of an enema into the small intestine is a relatively unimportant phenomenon occurring during a very unnatural process; it does not represent what is happening in any physiological process of the body. But I have seen in at least two dozen cases indubitable evidence of regurgitation of ingested opaque food from the colon back into the small intestine after having once completely left the small intestine. Observation was made in this manner: patients given a barium meal at 8 o'clock in the morning; at 5.30 in the afternoon (nine and a half hours after administration) observation was made and recorded, frequently with plates, that the small intestine was empty, all opaque material being in the colon. The following morning, immediately after breakfast, another observation was made in our routine examinations and in at least two dozen cases opaque material was again found in the small intestine filling the ileum for distances varying from 5 to 15 inches. I therefore feel it is true that ingested food may regurgitate from the colon back into the small intestine. In these very cases, study by the barium enema usually shows an astonishing ileocecal insufficiency with very extensive invasion of the small intestine by the enema.

Dr. Holmes. I want to add one practical point to Dr. Mills' paper. Probably he has already observed it. In cases where there is dilatation of the esophagus it sometimes happens that when the patient is put under an anesthetic that the contents of the stomach regurgitate. I recall one instance in which the results were very bad because the contents of the stomach passed down the trachea while the patient was under ether. Those cases would show definite dilation of the esophagus opening into the stomach. Surgeons should be cautioned to have the stomach washed and cleaned before giving an anesthetic.

Dr. Gray. I want to voice my sincere appreciation of Dr. Mills' paper and ask just one question. I was struck with the clearness with which he shows the rectosigmoidal junction, and want to ask him if these cases of which he showed slides were selected with reference to that, or merely accidentally, and whether he has some direction or posture for making these plates. I do not think I have ever seen plates that show the rectosigmoidal region so clearly.

Dr. Crane. I recall that many years ago Dr. Mills had the best exhibit I ever saw at the American Medical Association where he had literally hundreds of cases charted, showing habitus, position, type of intestines and stomach, and an amount of work which was almost overpowering. In view of the careful tabulation of results which Dr. Mills has been carrying out over a long period of years, we should be very careful indeed in taking issue with him. He undoubtedly knows what he is talking about. When it comes to the discussion of small intestines, we are in the unknown land of the roentgenologist. It would seem from a roentgenological standpoint that the small intestine is very seldom diseased. As a matter of fact, the internist will find disturbances of the small intestine very frequently. I can only hope that Dr. Mills will embody his investigations in book form so that they will be accessible to us.

Dr. Van Zwaluwenburg. It requires considerable temerity to discuss a paper of this sort and quality informally, and I should not undertake it unless asked and unless I had been studying in my own way this particular problem for over six years. For the past six years we have been making a careful and systematic note of the motility of the six main divisions of the gastro-intestinal tract, including the two divisions of the small bowel, the upper and the lower. In that study a great many interesting phenomena have been observed.

Unfortunately, the subject is so complicated that we have never been able to formulate our ideas clearly enough to have them published. I feel certain, however, that the internist is right when he says that the small gut is the most important part of the gastro-intestinal tract; that is where we do all of our digestion and absorption, and that is where we have most of our troubles except those which are purely surgical. I believe many of the conditions which we recognize as surgical are purely secondary: complications and sequelae of conditions not primarily surgical at all.

The subject, moreover, cannot be approached from the purely mechanical point of view. It is not merely a matter of obstructions with proximal dilatations and distal hypermotilities. The subject is far more complicated than that. There must be the influences of the other functions of this portion of the bowel, those of absorption, which depends on digestion, which in turn depends on secretion of the digestive juices. Absorption depends on a number of factors. How shall one explain the observation that one regularly finds a delay in the lower small bowel in cases of tabes mesenterica, and in cirrhosis of the liver, except on the theory of an interference in the absorption function of the intestine and of the portal circulation? Certainly there is no intestinal obstruction in these cases. Why the small bowel hypomotility in obstruction of the pancreatic duct?

Let me further mention the fact that the effect of obstruction is not always a proximal delay. There is the other and opposite phase, that of a compensatory hypermotility. One of our most frequent observations in "obstructive adhesions" about the appendix, is one of hypermotility of the proximal small bowel, not a delayed motility, and so long as this hypermotility is maintained the patient has little or no trouble. When he eats too much or unwisely, there is a failure of this acquired and compensatory hyperkinesis, and when the compensation fails the patient has trouble.

I am convinced the symptoms are not always those of obstruction but frequently due to the effort of compensation. Peristalsis may be so vigorous in its successful efforts to compensate as to be painful of themselves. So firmly convinced am I of this sequence that I have as little hesitation in diagnosing a "chronic appendicitis" on the evidence of a local hyperkinesis or hypermotility as on the contrary findings.

I should like to have you remember that in our laboratory we are attempting to work entirely without clinical data in order to make the observations purely objective and not subjective. We therefore get all sorts of conditions and without warning: hysteriacs with painful bellies, uremics, diabetics, tabetics, pregnancies, literally anything that can be associated with gastric symptoms. We get no information beforehand and it is up to us to pick out the surgical cases and those which are not.

I want to point out again that this problem is very intricate and that the solution is very far away. I think roentgenologists are losing a great opportunity in so largely limiting their observations to conditions proximal to the duodenojejunal juncture and distal to the ileocecal valve. The great field in the future is in the small gut.

Dr. Mills (closing discussion). Please let me thank you for your discussions, especially their charitableness. I fully realize that the subject is new and as Dr. Van Zwaluwenburg has just said, enormously complicated. I was moved by his observation that he had worked six years at it and felt only like holding his peace.

It is a great field and demands attention, and the sooner we all pay attention to it and fight over it the sooner the truth will be sifted out. With regard to the question of colonic redundancy, I only hazard it as my personal guess that redundancy is essentially acquired rather than congenital. The proposition is subject to many modifications. For instance, we must judge as to the physical type. The colon of the asthenic would often seem redundant if occurring in one of sthenic habitus.

Certain people may have redundant colons which to a degree are congenital; others perhaps are acquired. When I see a big person having a colon enormously redundant in an unusual place as around the hepatic or splenic flexure, I wonder very much whether it is congenital.

With regard to Dr. Stewart's observation on plating people only at the six hour period. The six-hour plate, as a rule, will show the small intestine especially in persons of somewhat slow motility. Where alimentary motility is more rapid an observation is best made sooner.

I had 3,500 cases in which I determined the exact time of emptying of the stomach on the same test. One thousand of these were approximately normal. Another series of 2,500 embodied pathological conditions. In these cases conditions such as appendicitis and gall-bladder disease showed a constantly slightly slow gastric motility. Why this is I cannot tell but the inference is obvious; that in some way gastric motility is influenced by distal pathological lesions and that what we call reflex symptoms from such conditions are in reality due to delayed motility. The present presentation is the result of an effort to get light on the subject which it does not solve but has led to interesting findings along other lines.

In regard to Dr. Case's contention about ileal regurgitation. I have not followed the matter as carefully as Dr. Case. It may be noted that Dr. Case has but two dozen cases of actually determined ileal regurgitation in his large material. The question comes up as to whether the two dozen cases to which Dr. Case refers, might not be instances of organic involvement of the terminal ileum.[5]

[5] Dr. Case has since informed me that in certain of these cases an operation was done and no structural abnormalities were found about the ileocecal valve.

Dr. Gray's question with regard to the technique in obtaining plates of the rectosigmoid was inadvertently not answered in the discussion. Certain of these plates are the result of good fortune, others were taken on special technique. We have used a method of injecting barium paste by means of a catheter through a sigmoidoscope, later withdrawn over the catheter, without tension distributing it along the lower pelvic colon and rectum. Others were taken by means of heavily coating the interior of the parts with dry bismuth. Certain others were taken after liquifying bariumized fecal contents with mild laxatives. Various poses were attempted but the most satisfactory were the usual prone pose and as for an ordinary bladder plate.

A CONCEPTION OF CHEST X-RAY DENSITIES BASED ON A STUDY OF GRANITE DUST INHALATION

BY D. C. JARVIS, M. D.

BARRE, VERMONT

DURING the prosecution of an investigation of the granite cutting industry the *x*-ray phase of the medical work naturally assumed a position of major importance for one came to rely upon it to a certain extent as indicating just what was taking place in the granite cutter's chest. The one question above all others requiring an answer was represented by the following: Does the roentgenogram show evidence of tuberculosis? In an attempt to answer this question one naturally became very much interested in densities that were thought to give evidence of the existence of tuberculosis. Many text books were consulted and all the available literature scanned so that a reasonable working basis might be established for recognizing densities that were thought to be suggestive of tuberculosis. The statistician connected with the investigation returned the report that an analysis of the death certificates disclosed the fact that 86 per cent of the deaths were due to tuberculosis and from this it was naturally inferred that many cutters actively engaged in the trade were already in the incipient stage. The object of the medical examinations was to disclose if possible the incidence of tuberculosis among cutters at work, and the committee on Mortality from Tuberculosis in the Dusty Trades appointed by the National Tuberculosis Association under whose guidance the work has been carried on, was of the opinion that the roentgenograms would be of valuable assistance in estimating this incidence.

Early in the course of the examinations, films were checked off as showing densities suggestive of tuberculosis, but as the work advanced it became quite evident that if one continued to report films on the basis of the causal factor one would also be obliged to report films as giving evidence of post-influenzal conditions, lobar pneumonia, bronchopneumonia, carcinoma, sarcoma, lung abscess, pleurisy, etc., but as the cutters coming up for examination considered themselves well, were working every day, and appeared to be in excellent health, one became more perplexed as the work progressed. The return of the physical examination blanks was anxiously awaited and a distinct shock was received when no evidence of either constitutional or physical signs existed in the majority of the men, including those who had been designated as showing on their roentgenograms densities suggestive of tuberculosis. It was naturally thought there must be an error, so we worked together; and when it was quite evident that the physical examination blanks were correct it was then realized that the roentgenograms portrayed various types of pathology, and with this knowledge one relinquished the ability to diagnose other conditions simulating it, because, although there was a profusion of densities, there was absence of constitutional symptoms and definite physical signs.

As the work continued one ceased making a diagnosis on the basis of the causal factor and devoted the time in an endeavor to answer the question: Why do the roentgenograms of granite cutters parallel practically every other type of roentgenogram seen? In looking over textbooks and scanning the literature it seemed nearly always possible to reach for a given film which matched the illustration being studied at the time. One wondered why it seemed possible to duplicate almost all the pathological conditions with the chest films of granite cutters who appeared well, said they were so, and proved it by following daily a strenuous occupation. After this observation the only deduction which seemed warranted was that which led to the conclusion that granite dust inhaled charted the highway for all other irritants gaining access to the lungs by aspiration, whether they were mechanical, bacterial or chemical. It was realized that a pathological process was being observed, which was slight in its beginnings, generalized in its distribution and slow in its development. This very slowness of development it was thought would perhaps enable one to observe, by means of serial roentgenograms the progress of the densities and their behavior during continued dust inhalation, during absence from the same and the affects of a resumption of dust inhalation following periods of idleness. While isolation in the country and narrowness of environment discouraged one from attempting a study of this kind, still round about one were some 2,000 granite cutters and one could not help but feel a conviction that the subject of chest diseases approached from this angle might bring to light evidence which would suggest channels of thought to others. With this hope serial roentgenograms have been continued for the past two years and autopsies secured whenever possible.

LITERATURE

Anatomical. Miller has brought out some of the following points. The normal flow of the lymph in both pleura and lung is towards the hilum. Lymphatics form a rich plexus in the walls of the bronchial tree. They possess occasional valves which open towards the hilum. No lymphatics have been seen in the walls of the air spaces beyond the ductuli alveolares. The plexus of lymphatics about the pulmonary artery communicates freely with that in the walls of the bronchial tree. Valves have only been seen near the hilum and they open towards the hilum. The pulmonary veins are surrounded by a plexus of lymphatics. The bronchial plexus of lymphatics and the venous plexus of lymphatics are connected by lymphatics which follow those branches of the pulmonary vein which have their origin from the bronchial tree. No valves have been found in the lymphatics situated within the lobule of the lung. There is a rich plexus of lymphatics in the interlobular septa and about those branches of the pulmonary vein which are situated in these septa. Such valves as have been found in the lymphatics about the pulmonary vein have been found in the neighborhood of the hilum and they open towards the hilum. In the pleura there is a rich plexus of lymphatics which is provided with numerous valves. In the collecting trunks leading from this plexus all the valves open towards the hilum. The deep lymphatics and the superficial lymphatics are connected by a short vessel which follows that branch of the pulmonary vein which takes origin from the pleura and passes along the interlobular septum. Between the pleura and the point where the first branch of the pulmonary vein coming from the bronchial tree joins that branch of the pulmonary vein situated in the interlobular septum, valves are found in the connecting lymphatics which open towards the pleura. These valves also prevent the flow of the lymph from the pleural lymphatics into the deep lymphatics. The short lymphatic which connects the superficial and the deep lymphatics furnishes a bypath for the lymph in case there is obstruction to its free flow towards the hilum near the entrance of the second branch coming from its bronchial tree into that branch of the pulmonary vein situated in an interlobular septum. No lymphatics unconnected with the lymph-nodes have been seen leaving the lung.

Pathological. The South African Report of the Miners Phthisis Prevention Committee states that "it is important to understand the distribution of the lymphatic channels since it is by their means that dust particles which have been conveyed into the lung are distributed through the organ. Intermediate silicosis may be defined as a diffuse fibrosis due to the gradual accumulation of mineral particles in the lymphatic capillaries as a result of chronic obstruction of the lymphatic circulation." Dr. L. U. Gardner of Saranac Laboratory is in charge of the experimental pathology connected with the investigation, and the following abstract is from his paper read before the National Tuberculosis Association at its annual meeting in 1920. "In guinea-pigs after about three weeks' exposure, small amounts of dust may be found enclosed in mononuclear intra-alveolar cells which often show mitotic figures. These cells are scattered everywhere in the alveoli from the pleura to the hilum. At about two months some of these intra-alveolar cells have begun to mobilize and have formed considerable collections of cells often so closely packed as to simulate giant cells. These cell masses lie in the alveoli along the course of the ductuli alveolares and about and within the small lymphoid collections occurring in the periphery of the lungs. As Miller has shown, such collections occur at the distal ends of the ductuli alveolares and at the division points of the vessels. Dust has already passed through the lung and lodged in small amounts in the tracheobronchial lymphatics. From three to seven months the process continues with a steady increase in the amount of the dust deposit. The invasion of the lymphoid tissue of the lung is more extensive and the larger nodules at the bifurcation of the bronchioles and bronchi become involved. All of the lymphoid tissue of the lung becomes very active and mitotic figures are very common even in the normally small peripheral collections. If the animal be set aside after dust exposure, the lung makes rapid and effective effort to rid itself of the irritant. The clearing process has only been observed up to three months in animals dusted for seven months previously, but at that time practically all the dust is collected within large aggregations of round or oval mononuclear cells which lie in the immediate vicinity of much enlarged lymph-nodules. Heavy deposits occur within such nodules and within the tracheobronchical lymph-nodes.

Roentgenological. In reviewing this phase of the literature one finds a variety of terms used in an endeavor to interpret the densities seen. One cannot but be impressed with the fact that many of these terms are culled from one's experience with life and seem to suggest no pathology. The terms beading, stippling dappling, the likening of densities to the golden rod, the dandelion and the sunflower, presuppose on the part of the reader an experience with the material things of this life paralleling the writer's own, with a resulting conception of the term used coinciding with the conception of the writer. One finds the terms parenchymatous infiltration and perivascular and peribronchial appearing frequently in the literature, and, while such pathological changes may exist, one is dissapointed in his search for autopsy reports giving evidence of having checked up the plate reading with autopsied lung and also in his search for reports on serial roentgenograms following peribronchial and perivascular readings over several years' time. Only in the writings of Dunham does one find a major attempt to correlate the densities seen upon the roentgenograms with the autopsy findings. He has called attention to the fact that the tree-like shadows seen upon the normal chest plate were due to blood-vessels, bronchi and connective tissue, each tree-like shadow being a composite of these three factors; but of the three factors two were constant and one was variable. Of these three the connective tissue which represented the variable factor was the most important and upon the amount present depended the density of the shadow. Attention has been called to the fan found on the roentgenogram in adult tuberculosis, its relation to the lymphatic circulation and the chief cause for its formation due to the limitation of exudate and other pathology. Dunham has shown that the tuberculous lesion starts in the lymphoid tissue within the lung and is spread first through the lymphatics. He does not seem to wish to deny that a tuberculous lesion may start in a capillary or another vessel; nor that it may start within some division of the bronchial tree, but he does seem to wish to assert with emphasis that his research has led him to believe that generally the tubercle bacilli primarily do not cause a lesion in the capillaries or in the air passages, although they must enter the lung by one of these avenues, and that the bacillus is generally removed from the ductulus alveolaris, as is carbon, to the lymphoid tissue centers before the germ has caused a pathological lesion in the air passages. He states that obviously a massive or virulent infection within either a vessel or an air tube, so great that the lymphatic system is overpowered, results in a lesion at such a point. Dunham believes that in the vast majority of cases of pulmonary tuberculosis the bacillus enters the air passages with the dust and soot and is carried into the smaller bronchial subdivisions as far as the ductulus alveolaris and the ultimate lobule, and that from there it is taken by the large phagocytes before the bacillus has caused any infection at its point of lodgment and is carried to the lymphoid tissue, which is abundant in this locality. If neither the phagocyte nor the lymphoid tissue is able to destroy the invader, or if the lymphatics cannot sufficiently drain the part, a tuberculous lesion develops in or near the lymphoid center which at first is only an abnormal increase of the lymphoid cells. If the bacilli grow instead of being destroyed it indicates a greater effort on the part of the economy resulting in the appearance of epitheloid and giant cells. Thus the course of the tubercle bacillus from the bronchus to the parenchyma of the lung coincides with that followed by the dust and particles of carbon, but the coal pigment is received without causing grave pathological changes while the tubercle bacillus lives, grows, multiplies and destroys.

SOURCES OF EVIDENCE

As medical advisor to the Granite Cutters International Association of America it becomes incumbent upon one to study the problem from a number of angles, because one is called upon from time to time to render opinions relative to working hours, rest periods, dust removing devices, etc., and a mass of evidence statistical and otherwise is necessary in order that opinions rendered be based upon a study of the evidence at hand. The evidence for this study was gathered from an economic study of the men, serial films of cutters and from a study of autopsied lungs.

Evidence Gained From a Study of the Men Themselves. Knowing that all men were not safe in the industry and that some broke down earlier than others, it became necessary from an economic standpoint to ascertain if possible the type of individual who would not last long in the industry under present working conditions, and suggest that he take up some other trade, because, while the period of apprenticeship is three years, it takes between eight and nine years to bring a cutter to a final degree of excellence. While these men have been studied during the past twelve years, it is only during the past four years that an effort has been made to discover the type of individual who might be accepted as an apprentice, and the type representing a hazard which if accepted would soon break down in the industry and represent an economic loss both to industry and state. It seemed advisable to examine first the survivors to ascertain if possible the individual characteristics they posessed and their mode of life; therefore, cutters who had inhaled granite dust as long as fifty-nine years were examined and detailed data kept of their condition. The economic phase was so important that attention was paid to small details such as the wearing of a moustache, the length of time it had been worn, its growth as to luxuriance, the amount of hair in each nostril, the condition of the nasal septum, the turbinates, lymphoid nodules upon the posterior pharyngeal wall, the size of the the tonsils, the condition of the teeth and the presence externally of enlarged lymph-nodes. Cutters who had broken down were examined and also several hundred cutters who were working all the time in the endeavor to find the type of individual who would last reasonably long in the industry. As a result of all this work one feels able to detect the type of individual representing a hazard and keep him out of the industry and select the individual who would do well. It was found that the upper respiratory tract held the key to the situation and that an individual was a good risk in proportion to the absence of lymphoid tissue in this region. An apprentice with normal turbinates, a smooth pharyngeal wall, tonsils small in size, no evidence externally of enlarged lymph-nodes, represented a desirable type and one who under ordinary conditions would last long in the industry. On the other hand, if a young man twenty years of age should have hypertrophic rhinitis, enlarged tonsils and lymphoid nodules on the posterior pharyngeal wall, he should keep away from the industry, as he would be likely to break down fairly early under present working conditions without dust removing devices. In case a cutter breaks down the prognosis is influenced by the amount of lymphoid tissue in his upper respiratory tract. Having discovered the lymphoid and non-lymphoid types of individuals, the roentgenograms were checked up in order to ascertain whether the films might be likewise classified. A continued study of them disclosed the fact that, given the same number of exposure years to granite dust inhalation, the cutter with the minimum amount of lymphoid tissue in the upper respiratory tract showed a minimum number of densities on the roentgenogram, while the cutter giving evidence of considerable lymphoid tissue in the upper respiratory tract showed in proportion many densities upon the film. This was especially noticeable in the case of Italians as compared with other nationalities. In view of this fact, is one justified in feeling that the densities seen upon the chest roentgenograms have mainly as their basis changes in the lymphatic system? If one feels that this is the case, it would seem advisable to study these densities in the same individual by means of serial roentgenograms extending over a period of years, so that it may be determined whether the progression of the densities was an outlining of the lymphatics. In order that one may feel reasonably sure that one was not observing a lesion of bacterial origin, it became necessary to witness the densities disappear when absence from work occurred and reappear when work was resumed.

Evidence Gained From Serial Roentgenograms. As one is able, from seeing individuals of all ages, to estimate the span of life and divide that span into childhood, youth and old age, so one is able by serial roentgenograms extending over a period of years to divide the densities appearing on the chest roentgenograms of a granite cutter into stages representing the span of chest densities. It seemed almost imperative at first that one should know the sequence of densities and the complete picture they presented from the beginning to the end. If one has not witnessed the total number of acts of a play he would find it difficult to estimate on stepping into a theatre just what phase of the presentation he was viewing; hence, it was felt that until one had witnessed the complete picture develop by means of serial roentgenograms, one would not be in a position to estimate correctly the densities one was viewing at the time. The very slowness of the development of the densities was of material help in this respect.

NUMBER OF STAGES

Serial roentgenograms disclosed the fact that it was possible, in order of their sequence, to divide the development of the densities seen upon the chest roentgenograms into six stages, as follows: The first density to attract attention in the case of young men entering the industry was that of the hilum and with it to a certain extent appeared the linear trunks, although when the hilum seemed to reach a certain extent the second stage, that of the linear markings, caught one's eye and seemed to demand study. The third stage seemed to do with the circular densities appearing upon the linear markings often spoken of as studding, beading, stippling, and in like terms. These circular densities seemed to appear on the linear markings and at the branching of these markings. The fourth stage seemed to do with the development of the fan-shaped areas, while the fifth witnessed an appearance of a cloud in the periphery of the film, and the sixth beheld this cloud spreading over the lung field towards the hilum. All of these were not observed in any such clean cut manner as the above description would indicate, but rather one stage would be starting as the previous stage was completing.

Stage I, That of the Hilum. Attention has been called in a previous report to the difficulty of describing a normal hilum. It is, however, of prime importance when considering lung densities because if one is willing to look upon it as a lung indicator giving evidence of what has taken place, considerable information may be gained before other densities are studied. When serial chest roentgenograms become a routine procedure, the importance of the evidence gained from a study of the hilum will be more appreciated. One first observes whether the hilum is prominent as a density. Does it still retain its crescent shape or has the central enlargement occurred causing the crescent to be lost? If it retains its crescent without central enlargement, the respiratory environment of that individual has been nearer the ideal, the dust content of the air being the minimum or near the minimum, the bacterial or chemical invasion of the lung from without has been of small amount. Should the crescent feature be lost because of a central enlargement, and the shadow be markedly increased in extent and density, one knows that one of the following may be concluded: that the respiratory environment has been far from the ideal, the dust content of the air being the maximum or nearer the maximum, the bacterial or chemical invasion of the lung large in amount, or that lung irritating material in small amounts for a long period of time or a large amount for a short period of time has passed over the lymphatics on its way back to the tracheobronchial lymph-nodes. By studying the periphery of the hilum shadow one is able, by noticing its bulgings, to tell the portion of the lung that has labored most in times past, or at present is working ad maximum. Serial roentgenograms disclose the fact that the hilum density decreases in extent and density when absence from granite dust inhalation takes place and again assumes its pathological shape and size when dust inhalation is resumed. As long as the lung field remains free from any evidence of a "thickened pleura" the hilum density maintains its individuality, but the appearance of a shadow in the lung periphery is a signal for an expected change on the part of the hilum until when the "thickened pleura" involves the peripheral and a portion of the midzones of the lung the hilum density is wiped out altogether. Why is it wiped out altogether when "thickened pleura" appears? There must be some connection between the two. Would it not seem from this phenomenon that drainage not being possible by means of the pleural lymphatics back to the tracheobronchial lymph-nodes, the density called hilum shadow is really a lymph stasis disappearing when the supply of lymph from the periphery is cut off, that it has largely a fluid basis and not an anatomical one.

Glands in the Hilum. With the hilum density one generally notices in this region circular densities just external to the hilum shadow, which one finds in film readings described as calcified glands or tuberculous glands. When the hilum shadow has reached a certain stage in its extent and density these circular densities appear just external to it. They always seem to follow the development of the hilum. By means of serial roentgenograms these circular densities are seen to appear while dust inhalation is being continued, disappear when absence from work occurs and reappear when granite dust again is inhaled. One wonders if it is possible to produce so quickly, remove and reproduce tuberculous glands. If the cutter continues in the industry these circular densities may increase in area up to between 2 and 3 cm. in diameter when they are then unhesitatingly reported as patches of pleurisy. If they are tuberculous glands, why are they wiped out along with the hilum density when the "thickened pleura" appears in the peripheral zone? One knows that glands occur in this region and that on autopsy are found to be tuberculous, but it would not seem as if there is any direct connection between the circular density seen in the hilum zone and the glands seen at autopsy. Evidence gained from this study warrants one in concluding that these circular densities are valves in the pleural lymphatics, acting as semaphores that endeavor to hold up the irritating material coming in from the lung periphery until the accumulation in the hilum can be moved on. From the academic knowledge that glands exist in this region one wonders if we have jumped to the conclusion that these circular densities in the hilum region were shadows of the glands themselves. Densities in the hilum region are like the shifting sand of the sea, and because a density is present today it would not seem that one is warranted in assuming that it will be there at the next examination.

Stage II, That of the Linear Densities. In studying linear densities it seems possible to divide them into three divisions.

The First Division. This consists of the broad densities in the hilum zone most noticeable in what has been called the descending trunks. It is quite possible to demonstrate on roentgenograms the two vessels making up this density; and if one studies the anatomy and carries on serial roentgenograms in dust workers over a period of years, it will be quite evident why the term peribronchial thickening is used. Miller states that lymphatics form a rich plexus in the walls of the bronchial tree, that they possess occasional valves which open towards the hilum. The plexus of lymphatics about the pulmonary artery communicates freely with that in the walls of the bronchial tree. Valves have only been seen near the hilum and they open towards the hilum. The diaphragmatic pleura does not drain back to the hilum but through the ligamentum pulmoni into the preaortic lymph-nodes. Films of granite cutters show that the pleura, covering the lower fourth of the lung, drains through the ligamentum pulmoni; this area does not extend from the periphery to the mediastinum but only for about two-thirds of the diaphragmatic outline, or to where the fissure divides the lung base. This inner portion apparently drains back by means of the lymphatics in the walls of the bronchial tree and those about the pulmonary artery to the hilum, accounting for the broadened shadow in the situation of the descending branches of the bronchial tree. Here again our academic knowledge tells us the descending branches of the bronchial tree and large vessels of the lung are situated, and while tuberculosis may exist in this region one wonders if we are again jumping to conclusions when these widened linear shadows, which come and go in granite cutters, depending on whether granite dust is or is not inhaled, and which seem to be lymph stasis, are supposed to be the direct shadow cast by the lesion found at autopsy.

The Second Division. This consists of linear densities appearing mostly in the midzone of the lung field. It will be noticed that these densities have a geometrical arrangement enclosing triangles from which we see Dunham's fans develop. Autopsied lungs and a study of serial roentgenograms seem to show that these densities are septa existing between lobules of the lung which Miller formerly designated as secondary lobules.

The Third Division. This consists of finer markings seen in the peripheral zone of the lung and a portion of the midzone. They are the last phase of the linear markings to appear and are the forerunner of "thickened pleura." They resemble a network of threads, but when checked up by means of the roentgenogram with the anatomy of the autopsied lung in cutters of ten years' exposure to dust inhalation, they will be found to coincide with the polyhedral pleural rings. They may be traced from the periphery of the lung field in this arrangement back to the hilum zone and will be found, if traced minutely in their course, to overlie the interlobular septa markings.

Stage III, That of the Circular Densities. There seem to be two types of these; one type appearing at the junction of the interlobular septa and on their outlines, while the other appears on the polyhedral rings.

Stage IV, That of Dunham's Fans. In another article Dunham's fans have been taken up, but since then the stages of development of an individual fan have been worked out. As circular densities and the formation of fans are bound up in one another, it seems advisable to consider them together; hence Stages III and IV will be considered at the same time. The first development noticed in the formation of an individual fan is the outlining of the fan-shaped area by the interlobular septa. The second development is the appearance of a circular density at the apex of this fan-shaped area, the size of this density depending upon the behavior of the densities peripheral to it when they occur. The third development is the appearance of fine linear markings within this fan-shaped area. The fourth development is the appearance of circular densities upon the interlobular septa, acting as sides of the fan-shaped area. The fifth is circular densities appearing upon the linear markings within the fan-shaped area. The sixth is a cloudiness appearing over the whole fan-shaped area obscuring its details. An examination of autopsied lungs in a cutter of ten years' exposure and meeting death by accident, shows that on the roentgenogram made at this time these circular areas are on the course of the lymphatics. In the pleura, where the polyhedral rings are injected as if with methylene blue, these circular islands stand out. They appear as would locks in a canal, the dust from behind bulging the valve and filling the canal behind the lock. By reason of the lock ahead being filled with dust, the valve behind it is unable to open. In the development of the fan these circular areas only appeared as the process progressed.

Stage V, That of the Peripheral Haze. When the three divisions of linear densities have developed one finds a haze appearing in the periphery of the lung field extending from the clavicle downward to various rib levels. This haze is a forerunner of the "pleural thickening" to come.

Stage VI, That of the Pleural Lymph Stasis. The appearance of this thick haze in the lung field has been designated as "thickened pleura," but in cutters having physical signs of a thickened pleura it does not seem possible to demonstrate the presence of this shadow, although we know we must have a thickened pleura. The evidence accumulated would warrant the assertion that we have lymph stasis as a basis of the shadow and that the stasis occurs in the pleura. One is able to witness the formation of this lymph stasis in areas of varying size, it occurring in the granite cutters where autopsies have taught us to expect the greatest amount of dust deposit. It seems to extend from the apex to various rib levels and its variations in extent and intensity are frequent observations in serial roentgenograms of these men.

Influence Upon Roentgenogram Reading. In time when other dusty trades are investigated by means of the roentgen ray, these stages will be checked up by other observers. If one comes to the point where he feels he is observing largely manifestations of lymph activity, he then becomes of even greater assistance to the clinician and by relaying to him pathology in its making the clinician is better able to explain his symptoms; at least, that is the way it has worked out in Barre. One wonders if the next step in tuberculosis is not the step which the roentgenologist will take. One who works from the economic side is obliged to admit to himself that an early case from a medical point of view is a far-advanced case from the economic standpoint, for many times it means the end of an industrial life. If one has a feeling that a method is necessary for discovering suitable soil, suitably prepared in the chest of the individual, long before the râle is present as a physical sign, or tuberculous infection has manifested itself, then he will turn to the roentgen ray and a feeling will come, as he works longer in the field of lung densities, that to the roentgenologist must fall the task of searching out the individual whose chest film tells us he is living in a respiratory environment wholly unsuited to him. Twice a year at least a worker in a dusty trade should have a roentgen ray examination of his chest in order that it be determined whether he has reached the suitable soil, suitably prepared stage. With two hundred dusty trades listed in this country one can in a measure realize from an experience with the granite cutting industry the work in store for the roentgenologist. In searching out the individual who represents suitable soil for the development of tuberculosis his services in the future are going to be invaluable, for in no other way, it would seem, are we so well able to portray pathology in its incipient stages. It would seem from this study that we do not have only one infection by the tubercle bacillus and that occurring in childhood, but that we have innumerable infections all through life and that the occurrence of a lesion depends, in part, upon the efficiency of the lymphatics, they acting as the first line of defense in event of an irritant either mechanical, bacterial or chemical, entering the lungs by way of inhalation. The writer does not wish to close this article without an acknowledgment of the debt he owes Dr. Kennon Dunham for having charted the highway of chest densities. Although up in Northern Vermont, situated many miles from him his stero roentgenography dealing with pulmonary tuberculosis plus his writings have been mainly responsible for progress in this work. As Dr. Dunham found Dr. William Snow Miller's work on anatomy of the lung of valuable assistance, likewise the writer has been driven in his helplessness times without number to Dr. Miller's work. To these two men, Dunham and Miller, he owes a debt which he wishes at this time to acknowledge.

SUMMARY

1. Film densities are like the shifting sand of the sea, and because a density is present at the first examination seems to be no reason for expecting it to be present at a subsequent one.

2. The evidence tends to show that film densities bring into prominence the lung and pleural lymphatics.

3. The same densities are brought into view by various causal factors, apparently being no way in which the roentgenologist can determine, without the aid of the clinical history, the exact cause of the densities he is viewing.

4. When other dusty trades are investigated the necessity for serial roentgenograms in studying a chest condition will be more appreciated.

5. There seems to be a definite manner in which densities progress from stage to stage in the development of chest film densities.

6. It is a question whether the roentgenologist should report on the basis of stages with their pathological import rather than on the basis of the causal factor, which latter it would seem is the clinician's province to determine.

7. The usual basis for diagnosing tuberculous activity is seen so many times on films of granite cutters as they leave and reenter the trade, that it hardly seems possible to consider the phenomena more than an indication of a lung working under stress.

8. It would seem that the next step in tuberculosis is the economic one, when by means of wholesale x-ray examinations occupations will be determined which produce a suitable preparation of the soil for the development of a tuberculous process.

ROENTGEN-RAY TECHNIQUE FOR THE DEMONSTRATION OF SMALL PNEUMOTHORAX*

BY JAMES C. THOMPSON, M.D., AND NATHAN BARLOW, M.D.

Surgeons (Reserve) United States Public Health Service

NEW HAVEN, CONNECTICUT

IN plates made by the usual technique for examination of the lungs, the perception of small pneumothorax is occasionally easy, more frequently difficult, and most frequently impossible. Unless a pneumothorax is large enough to extend from the anterior to the posterior surface of the plate, there is no area on the plate which is free from lung markings, and these small pneumothoraces do not usually produce the extensive and extreme contrasts of density by which the larger ones are so readily recognized. The definite diagnosis of pneumothorax must depend upon the perception of actual separation of the pleural surfaces. Unless much thickened or covered with exudate, the pleura is not visible in the plate, and the tracing of the surface must depend upon bronchial and pulmonary markings which extend to the surface. If plates are taken with so slight an exposure as to carry the pulmonary markings to the periphery at all points, the central parts of the plates will be so dense as to be unreadable. We have found that this difficulty can be obviated by making stereoscopic plates with different times of exposure. When fused in the stereoscope, the dark plate predominates in the picture, and gives penetration and contrast. The light plate carries the detail to the pleura in the central part, and nearly to the pleura in the lateral part if the lung is normal.

In studying plates taken by this special technique we found that delicate pathological changes are frequently shown which are not visible by the usual technique, and particularly that the combination of detail and penetration which is obtained will in many cases permit an accurate study of the parenchymatous tissue in the region of the hilum. For routine use and general study the separation should be somewhat less than for the study of pneumothorax only. We accordingly give a modified technique for general chest work including small pneumothorax, as well as the technique adopted for the special study of these structures only.

We have experimented with various modifications of current, target distance, and time, with vertical and transverse shift, with various length of tube shift, and with intensifying screens. We find that the granular defects of intensifying screens obscure the finer markings. Without the use of the screen, the technique as given below permits the making of from four to six pairs of plates of a thick chest in any one month without the slightest danger of dermatitis. Owing to shorter exposure this number may be slightly increased in cases of thin chest.

Any standard apparatus and plate changer may be used. The technique as given is for a 7 inch Coolidge tube of medium focus. For a tube of different size or focus, appropriate changes in current, spark gap, and time of exposure must be made. A vertical tube shift must be used, as the transverse shift does not reveal pleural separation at the mediastinum; current 50 ma., 70 kv., 28 inch target plate distance, spark 5 inches at the tube. (We believe that one of the chief causes of variation in the results obtained from the same technique in different laboratories, is the difference of resistance between the switchboard and the tube, due to such causes as corrosion or dust on the trolley, imperfect contacts, etc. In our own laboratory, a spark of 5½ inches at the switchboard corresponds to one of 5 inches at the tube.) Target shift, vertical, 2½ to 3 inches. A greater shift causes an apparent stretching of the pleura so that it is not so visible. Ray filter 3/16 inch aluminum.

The patient is stripped to the waist and placed in the vertical position, either sitting upon a stool or standing facing the plate

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changer, chin resting upon the top and extended sufficiently to bring the apices well below the upper border of the plate. The head should not be rotated to either side, or the tracheal shadow will be distorted. The chest must be perfectly flat against the plate changer as any rotation either way will distort the mediastinal shadows and make difficult the perception of pneumothoraces in this region. The patient is then instructed to place his hands flat upon the great trochanters as suggested by Bray, thumbs pointing forward, arms rotated forward until the upper arm and elbow are pressing firmly against the frame of the plate changer. The tube is then placed in position behind the patient at 28 inches target distance from the plate, with the central ray directed through the 4th dorsal spine, and with the tube shift attachment set for the upper position. The operator at the machine then says to the patient, "Take a deep breath—let it out—take another—hold it and don't move." As soon as the patient's chest is at rest in full expansion, exposure No. 1 is made, the tube and plates are shifted and exposure No. 2 is made on the same inspiration. The entire time of both exposures should not be over six seconds, because even though the patient does not breathe, there are changes in the position of the diaphragm and the thoracic wall after the first few seconds, and these slight movements are sufficient to obscure the finer markings.

To obtain uniform results the time of the exposure must be varied according to the thickness and structure of the chest. The correct use of the classification which we give is a matter of judgment, experience, and careful appraisal of the subject. We often encounter moderate or even advanced tuberculosis in patients who are fleshy, but with very little muscle, as determined by palpation. In such cases less exposure is necessary than in the well muscled. The broad chest with well-developed muscles and very little adipose tissue requires a slightly longer exposure than an ordinary chest of the same thickness at the sternum. The best that a careful description of x-ray technique can be expected to do is to furnish a good working basis which must be supplemented by the skill and experience of the technician.

SCHEDULE OF EXPOSURES FOR GENERAL WORK IN UNKNOWN CHESTS

	Plate 1, seconds	Plate 2, seconds
Very thin	3/4	1 1/4
Thin chest	1	1 1/2
Medium chest	1 1/2	2
Thick chest	1 3/4	2 1/2
Very thick, up to	2 3/4	3 1/2

In very thick chests the necessary exposure increases more rapidly.

Somewhat to our surprise we have found that it does not require more exposure to produce a good plate from a chest with considerable fibrosis, than it does from a normal chest, while even a slight amount of active infiltration materially increases the opacity to the rays. If the requests for x-ray examination indicate whether the cases are active or inactive, somewhat better plates may be obtained from the following schedule of exposure.

SCHEDULE FOR PLATES MADE AFTER PHYSICAL EXAMINATION

	Exposure in Seconds			
	Inactive		*Active*	
	Plate 1	Plate 2	Plate 1	Plate 2
Very thin	3/4	1 1/4	3/4	1 1/4
Thin chest	1	1 1/2	1 1/4	1 3/4
Medium chest	1 1/4	1 3/4	1 1/2	2
Thick chest	1 1/2	2	1 3/4	2 1/2
Very thick, up to	2 1/2	3 1/4	3	3 3/4

If the difference in the time of exposure be greater than the above, the dark plate is likely to predominate unduly in the fused image, and the general diagnostic value is therefore reduced. If the sole purpose of the plate is to demonstrate localized pneumothorax, this partial loss of detail does not matter, and the following schedule will sometimes demonstrate separation of pleural surfaces when the routine diagnostic plates showed indicating signs only.

SCHEDULE FOR SPECIAL PLATES FOR PNEUMOTHORAX ONLY

	Exposure in Seconds					
	Inactive		*Slightly Active*		*Active*	
	Plate 1	Plate 2	Plate 1	Plate 2	Plate 1	Plate 2
Very thin	$\frac{3}{4}$	$1\frac{1}{4}$	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$1\frac{1}{2}$
Thin chest	1	$1\frac{3}{4}$	$1\frac{1}{4}$	2	$1\frac{1}{2}$	$2\frac{1}{4}$
Medium chest	$1\frac{1}{4}$	2	$1\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{2}$
Thick chest	$1\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{2}$	2	$2\frac{3}{4}$
Very thick, up to	$2\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{3}{4}$	3	4

SPECIAL METHODS OF STUDY

Plates Made at Full Expiration. In certain cases of very slight peribronchial involvement, the pulmonary markings may be so slight that pleural surfaces are not outlined even though considerable separation is present, as the density of the lung tissue is not very different from that of the air pocket. In such cases plates made at full expiration will sometimes show the pleural surfaces distinctly, owing to the greater comparative density of the lung tissue.

Remaking Plates. Often unforseen densities or unexpectedly clear lungs cause the plates made by any routine to be unsatisfactory. In such cases a second pair may be made with longer or shorter exposures as may be indicated by the first pair.

Unilateral Lesions. Of patients with dense involvement on one side and very little on the other, the same pair of plates cannot satisfactorily show both sides of the chest. In such cases the best diagnostic work sometimes requires one pair of plates for each lung with the appropriate exposures.

The interpretation of these plates requires, not necessarily a better knowledge, but a greater familiarity with the normal pulmonary markings than does the interpretation of the plates ordinarily made. Most hospitals and sanatoria deal with cases of tuberculosis which have progressed so far that there are pathological densities which are far deeper than the normal. Such densities are more easily seen in a plate in which the normal markings are completely blotted out. It is easy to read a plate in which any density is abnormal, but a technique which blots out all of the markings of the normal parenchyma must also eliminate the densities which are produced by very early and very slight pathological changes. In our plates normal and pathological densities must be distinguished from each other.

A localized pneumothorax produces certain changes in arrangement, and distortion of the structures in its neighborhood. These produce in the plate certain alterations in position and certain rearrangements of densities which we have called indicating signs. One or more of them are usually present in cases of small pneumothorax, and their presence should lead to a scrutiny of the plates for evidence of separation of pleural surfaces. In the beginning of the study only such small pneumothoraces will be perceived as are clearly outlined throughout their whole extent. In the greater number of these structures the margins are irregular, thin and flat, and the pleural surfaces are too close together for the separation to be perceived throughout its entire extent, therefore when skill is obtained, if definite separation of pleural surface is seen in the central part of the pneumothorax, the outline of the thin boundary is approximately determined from variations of density and from the distortion of the pulmonary markings.

The indicating signs which make us suspect the presence of a localized pneumothorax become permanent if the pneumothorax persists long enough for fibrosis to fix the structures in their new position, but with the disappearance of the pneumothorax they usually become less angular, less clearly outlined, and less conspicuous. Briefly stated, they are as follows:

A. Areas of Collapsed Lung Tissue. If there is even slight infiltration partial collapse produces a band or zone of density which does not conform to the usual course of development of the tuberculous process. A partial collapse of more advanced infiltration produces a zone of deep density which is often mistaken for complete consolidation or even for caseous pneumonia.

B. Areas of Rarefaction. Very frequently in flat plates the region of a small pneumothorax is as dense as the surrounding parts. Displacement of lung tissue either toward or away from the plate does not alter the density. If there is exudate upon the pleural surfaces, the density in the flat plate may even be greater. In the stereoscopic image a pneumothorax usually appears as a region of lessened density, close scrutiny of which reveals separation of pleural surfaces. If there is sufficient lateral displacement of tissue, even the flat plate shows an area of rarefaction, with an adjoining region of increased density.

C. Pleural Cusps. Pointed cusps and tooth-like projections of the pleura are due more frequently to small pneumothoraces than to any other cause.

D. Deviation of Trachea, Mediastinum, Heart or Diaphragm. There is usually a localized deviation of some of the movable structures of the thorax in the direction of a localized pneumothorax. A sharply angular deviation of the trachea is an almost certain sign of a localized pneumothorax on the side toward which the deviation points. Deviations of a portion of the mediastinum from long perpendicular bands of adhesions, which are placed under tension by localized pneumothoraces of the tube-like form so common in this region, sometimes cause an apparent increase in the size of the pericardial shadow.

E. Atypical position or irregular course of normal markings or pathological densities may be due to displacement or distortion by localized pneumothoraces.

F. Annular Shadows. Under certain circumstances small pneumothoraces produce very definite and distinct annular shadows. There are also other pathological conditions which cause them. The majority of small pneumothoraces do not produce well defined annular shadows.

G. Localized fluid levels which evidently are not due to cavities.

The method of the study of plates by this technique can be given most briefly by an actual example. In practice, routine reports of such detail would depend upon an adequate personnel with a limited amount of work.

REPORT OF THE ROENTGENOLOGIST

In Plate 1 the pulmonary markings extend to the pleura, and the vertebral bodies are not visible through the cardiac shadow showing that there is no loss of detail from over-exposure. In Plate 2 the normal pulmonary markings do not quite reach the pleura, the vertebral bodies are faintly visible through the upper part of the mediastinal shadow, and there is sufficient penetration for the separate perception of structures in the region of the hilum. In both plates the outlines of the ribs and diaphragm are clear and distinct. In the stereoscope the image is fused in all parts. Bones symmetrical with no evidence of pathological change. Thorax long and narrow. Ribs slightly depressed and somewhat closer together on the right. Moderate calcification of the upper three costal cartilages on both sides. Diaphragm smooth and regular, angles clear, apparently slightly elevated on right, small pleural cusp near cardiophrenic angle on right. Heart vertical in position, not enlarged. Mediastinal shadow broadened on right and slightly irregular, especially opposite the third dorsal vertebra. Trachea shows angular deviation of right wall at the level of the third dorsal vertebra.

Right Side. All densities increased in the hilum region, where there are numerous rounded densities, some of which are large. A somewhat triangular small hazy parenchymatous density extends from the hilum to the interlobar septum about one inch from the main bronchus. A group of dense markings with hazy outline which suggests a small distorted fan extending from the hilum to the mediastinal surface. The vertebral trunks and its branches expand into a typical but slightly distorted fan at the apex, which appears slightly compressed laterally. The density of the remaining bronchi of the upper lobe is somewhat increased from the hilum about half way to the periphery. The descending bronchi are of somewhat increased, but clearly outlined density.

Both the ascending and descending bronchi which lie nearest the median line seem to be pushed outward, so that there is a curved band, about one-half inch wide, extending from the apex to the diaphragm, in which the bronchi appear to lie more closely together and more parallel than in normal plates. The density of the interbronchial parenchyma is slightly greater in this band than elsewhere. Between this band and the mediastinum is a perpendicular zone of lessened density which contains fewer markings than on the left. This zone broadens out slightly at the diaphragm and its outer angle is formed by the diaphragmatic cusp already mentioned. The pleura is nowhere thickened but shows a sharp pointed projecting cusp opposite the angular deviation of the trachea. The pleura appears pressed against the root of the lung, especially above, so that the root appears partly compressed into a cylindrical form, especially the upper half. Beginning at the upper surface of the root the mediastinal and the visceral pleura are seen to be definitely separated, enclosing an air space which may be traced about half way to the apex, when it merges into an area of rarefaction containing no pulmonary markings. No markings are seen between this space and the observer, but pulmonary markings are plainly made out between this space and the sternum, showing that it does not extend to the anterior wall. The outer boundary of this space is formed by a delicate pleural line which ascends in a somewhat curved direction from the hilum to the apex, and can be traced farther than can the actual separation of pleural surfaces. Below the hilum separation of pleural surfaces may be traced for about 2 inches, enclosing an air pocket like a somewhat flattened tube, which becomes continuous with an area of rarefaction extending to the base. Pulmonary markings may be seen both in front of and behind that part of the air pocket which lies below the hilum. Pleura otherwise normal.

Left Side. Moderately numerous rounded densities in the region of the hilum which are clearly outlined. The vertebral trunk and the bronchial branches which supply the first interspace show increased density and an apparently increased number of branches which are clearly outlined and do not extend to the pleura.

All of the bronchial branches radiating from the hilum show increased but well-defined density throughout about one third of their length, markings otherwise apparently normal, pleura normal.

Interpretation of Roentgen-Ray Findings. Right Side. Enlargement of bronchial lymph-nodes, some of which are apparently caseous. Peribronchial thickening in the central portion extending to base in lower lobe, small areas of parenchymatous infiltration in the hilum region, focus of infiltration in the apex. The shape and distribution of the lesions and the character of the densities indicates tuberculosis as the most probable cause. Posterior central small pneumothorax apex to hilum, becoming mediastinal from hilum to base. This pneumothorax is permitting slight collapse of the apical lesion. Pathological activity is indicated by hazy character of some of the densities, and clinical activity is indicated by the elevation of the diaphragm and the depression and approximation of the ribs on the right side without other apparent cause. If râles are not present, their absence may be due to the pneumothorax.

Left Side. Enlargement of hilum glands, slight peribronchial fibrosis in the region of the hilum and ascending toward the apex. No indication of any active pathological process.

Diagnosis Indicated by Roentgen-Ray Report. Pulmonary tuberculosis, incipient, right apex.

Note. In advanced disease the involvement at the hilum is continuous with the general process. In disease of long standing there is so much fibrosis in the regions of the hilum and mediastinum that demonstration of small parenchymatous lesions in these regions is difficult. In a series of plates of early lesions taken by the first technique described above, we found fans, tubercles, or other miniature parenchymatous lesions in 24 per cent, 5 per cent recognizable at a glance, and 19 per cent distorted or overlain by fibrotic markings. By re-examining with a technique especially adapted to the hilum region of each particular case, it is possible to demonstrate active parenchymatous involvement at some point of the mediastinal surface of practically every case of localized mediastinal pneumothorax, often when there is no apical lesion. We wish to acknowledge the assistance rendered us by Mr. Abel Emard, Assistant Roentgenologist.

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DISCUSSION OF JOHN W. PIERSON'S "DIAGNOSIS OF PULMONARY CONDITIONS IN CHILDREN" *

Dr. Wittington. Coming from a tubercular resort, we naturally see and are interested in this condition more than many of you who do not see so much of tuberculosis.

We know that in order to insure healthy generations and lower the vital statistics in tuberculosis, it is necessary to begin in childhood. We know by actual experience in our work that the chest of the child is very susceptible to the roentgen ray. If we make our diagnosis in conjunction with the physiological examinations, we can in a short time restore affected children by proper hygienic and medical treatment, prolong their lives and produce a more healthy generation.

I think you have not taken as much interest in this paper as you should. Investigate your children; examine physical conditions; take morning temperature and afternoon rises; then examine them with the *x*-ray and see what conditions you have. The age of from three to ten is a very important period in a child's life.

Dr. Pierson (closing discussion). The appearance which we regard as pathognomonic in tuberculosis is gradual expansion and widening of the mediastinal shadow.

As far as enlargement and calcification of the glands which we see along the larger bronchi are concerned, we do not regard those as pathognomonic processes. We find those things in chronic bronchial pneumonia. Large glands extending out from the mediastinum itself are the ones we think are tubercular. We see great dilatation and increased density of the trunks in tuberculosis and also see the same identical condition in chronic bronchial pneumonia. In both conditions the glands extend out along the main trunks. The only difference is that in tuberculosis we get a very great widening of the mediastinal shadow. That is particularly applicable to young children.

Dr. Pariseau. Would you find it easier to have the child rayed on expiration or inspiration?

Dr. Pierson. That depends on the age of the child. Some have to be taken fast. We usually take our cases, if we can control them, on inspiration.

Dr. Parker. Is there any more tendency to calcification in tuberculosis than in other infection?

Dr. Pierson. We have seen as much calcification in so-called chronic bronchial pneumonia as we have in tuberculosis.

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THE VALUE OF ROENTGEN THERAPY IN DERMATOLOGY*

BY GEORGE M. MACKEE, M.D. AND GEORGE C. ANDREWS, M.D.

NEW YORK CITY

The next speaker, Dr. Hazen, will give the specific results, with statistics, obtained by him by roentgen therapy in skin diseases. We will simply attempt to show the value of this therapeutic agent in the treatment of dermatological affections by enumeration of the conditions in which this treatment is of service, classifying the diseases according to results obtained and comparing, roughly, the results of irradiation with the results obtained with other therapeutic remedies. Because of the condensation of this big subject on account of time and space it will be possible to do no more than to generalize.

It is now pretty generally admitted that the roentgen rays constitute the most useful and successful single remedy we possess for the treatment of dermatological diseases. The only competitor for this distinguished position is radium. In a general way, what one agent will accomplish so will the other. However, roentgen rays save time and expense and can be employed for the treatment of diseases that cover extensive surfaces. They are the more flexible, the more versatile of the two remedies, and therefore they are given the preference in dermatological practice. As a matter of fact, in order to be fully efficient, the dermatologist should possess one or several radium applicators in addition to modern roentgenological apparatus.

That the roentgen rays constitute the most valuable remedy in dermatotherapy, or that the roentgen rays and radium constitute the most useful single agents in the armamentarium of pure dermatology, is shown by the following list of diseases and conditions that are amenable to such treatment, over 80 in number.

LIST OF DISEASES TREATED WITH ROENTGEN RAYS OR RADIUM

Acanthosis nigricans
Acne varioliformis
Acne vulgaris
Actinomycosis
Addison's disease
Angioma, cavernous
Angioma, senile
Angioma, strawberry mark
Blastomycosis
Bromidrosis
Carbunculus
Cheilitis exfoliativa
Cheilitis glandularis
Callositas
Cornu
Dermatitis, infectious eczematoid
Dermatitis exfoliativa
Dermatitis papillaris capillitii
Dermatitis venenata
Epithelioma, basal cell
Epithelioma, multiple benign
Epithelioma, prickle cell
Erythema induratum
Favus, of the scalp
Folliculitis decalvans
Furunculosis
Granuloma annulare
Granuloma fungoides
Granulosis rubra nasi
Hodgkin's disease
Hyperidrosis
Hypertrichosis
Intertrigo
Keloid
Keratosis
Keratosis follicularis
Kraurosis vulvae
Leukemia cutis
Leucoplakia
Lichenification
Lichen planus
Lichen scrofulosorum
Lupus erythematosus
Lupus miliaris disseminatus
Lupus vulgaris
Lymphangioma circumscriptum
Lymphangitis, chronic streptococcic
Lymphogranulomatosis cutis
Neurodermatitis
Nevus pilosus
Onychomycosis
Paget's disease
Parapsoriasis lichenoides
Paronychia
Pernio
Pityriasis rosea
Pompholyx
Prurigo
Pruritus
Psoriasis
Rhinophyma
Rhinoscleroma
Ringworm, eczematized
Rosacea
Sarcoid
Sarcoma, general types
Sarcoma, giant cell
Sarcoma, Kaposi
Scrofuloderma
Sporotrichosis
Sycosis, lupoid
Sycosis vulgaris
Synovial lesions of the skin
Syringoma
Tinea barbae
Tinea tonsurans
Tuberculide
Tuberculosis orificialis
Tuberculosis verrucosa cutis
Verruca vulgaris
Xeroderma pigmentosum

The value of roentgen rays as a therapeutic agent in dermatological practice can be further envisaged by grouping the diseases in relation to susceptibility to this agent and in relation to results obtained with other methods of treatment.

GROUP I

Bromidrosis, localized
Dermatitis papillaris capillitii
Favus, of the scalp
Hyperidrosis, localized
Keloid
Rhinoscleroma
Tinea Tonsurans

Group I comprises diseases in which irradiation offers the sole means of establishing a permanent cure with a reasonable degree of certainty. The preceding statement is not literally true of every

*From the Department of Dermatology and Syphilology, College of Physicians and Surgeons, Columbia University, New York. Read at the Twenty-Second Annual Meeting of The American Roentgenology Ray Society, Washington, D. C., September 27–30, 1922.

individual example of the entities in this group.

It is possible to cure some cases of tinea tonsurans with other methods, but considering the disease in a broad sense it must be admitted that irradiation provides the only successful opposition. The same is true of favus of the scalp.

Surgery may be successful in early cases of rhinoscleroma, but in every case, early or late, irradiation causes fairly rapid involution, and recurrences subsequent to complete cure have not been recorded.

There has been considerable controversy relative to the comparative value of irradiation for the treatment of keloid. There is little room for argument. Occasionally a lesion will not return after excision, solid carbon-dioxide treatment, etc. The rule is, however, for the lesion to develop worse than ever after removal by any method that is traumatic in nature. Recurrence after irradiation has not been recorded. Irradiation and surgery must be combined in the case of very large keloids.

Localized hyperidrosis and bromidrosis are placed in this group because persistent, idiopathic examples of these affections can be cured in no other way.

It is possible to cure dermatitis papillaris capillitii with the older methods, especially in the early stage of evolution. Such treatment is, however, very uncertain, disagreeable and unsatisfactory. Irradiation cures the affection promptly and permanently in the early stages. The late keloidal stage may require considerable treatment.

GROUP II

Granuloma fungoides (mycosis fungoides)	Sarcoma, Kaposi type
Hodgkin's disease of the skin	Sarcoma, giant cell
Lymphogranulomatosis cutis	Leukemia cutis
	Pruritus

Group II consists of diseases in which irradiation is the most useful if not the only useful treatment. With the exception of pruritus these diseases are fatal and they all cause suffering. The immediate effect of irradiation may be highly gratifying, even spectacular, but the result is seldom permanent.

Some cases of granuloma fungoides can be controlled for only a year or two, but it is frequently possible to keep the patient free of symptoms for several years, even indefinitely. No other remedy or combination of remedies will accomplish as much. About the same may be said for Hodgkin's disease. The result of irradiation on leukemia cutis and lymphogranulomatosis cutis is not so well known, but results so far observed seem to warrant the inclusion of these affections in this group.

The roentgen rays and radium provide a specific for giant-cell sarcoma. While it is true that the lesions can be excised, they are likely to be too numerous to be handled by surgical methods. The Kaposi type of sarcoma also yields readily to irradiation. There is no other successful method of treatment for this affection unless the lesions happen to be small, not numerous and favorably situated, when they may be destroyed in various ways. It is possible to obtain permanent cures in both types of sarcoma, but before one hazards an opinion it will be preferable to wait until a large number of cases have been observed for at least five or ten years.

That the roentgen rays and radium are excellent antipruritics has long been known. In cases of persistent, localized, essential pruritus of undiscoverable etiology, they are the only remedies that will with a reasonable degree of certainty effect complete relief. The relief may endure for a month, for several months, or for longer periods. Permanent results are uncommon. Occasional failures are noted.

GROUP III

Acanthosis nigricans	Kraurosis vulvae
Addison's disease	Parapsoriasis, lichenoid type
Granulosis rubra nasi	
Keratosis follicularis	

This group represents diseases in which irradiation is reported to have given excellent results, but too few cases have been treated to permit free generalization. There is no known remedy for any of these affections. If further observation supports the results so far recorded, irradiation will be credited with another list of diseases that can not be controlled by any other means.

GROUP IV

Actinomycosis	Granuloma annulare
Angioma, cavernous	Lupoid sycosis
Angioma, senile	Lupus miliaris disseminatus
Angioma, strawberry mark	Scrofuloderma
Blastomycosis	Sycosis vulgaris
Carbunculus	Synovial lesions of the skin
Callositas	
Tinea barbae	

Irradiation is almost a specific for the diseases of this group and as a rule the result of such treatment is a permanent cure. All of these diseases can be more or less successfully treated with other methods but with less certainty of prompt relief, less certainty of a cure and with less freedom from pain and annoyance. Irradiation can be said to be, as a rule, the method of election for the treatment of these diseases. There must be some selection.

Small angiomata, synovial lesions of the skin and lesions of granuloma annulare can be excised. One treatment with the roentgen rays or radium will permanently cure a synovial lesion of the skin. The same statement is true of the lesions of granuloma annulare, but new lesions are likely to appear from time to time. Surely a treatment that will cause a lesion to disappear as a result of a single exposure of a few minutes to the roentgen rays, is preferable to any surgical method such as excision, desiccation, cauterization, etc.

Strawberry marks disappear very quickly under beta ray applications. A permanent cure can be obtained in one treatment, but in order to avoid sequelae it is preferable to give from two to four treatments, depending upon the size and thickness of the lesions. The result of such treatment is distinctly superior to surgery, solid carbon dioxide or any other method. Surgeons usually hesitate to excise cavernous nevi because of the danger of hemorrhage, infection and deformity or disfigurement. The lesions are often located in regions where it is difficult if not impossible to employ any surgical method. The injection method has not given satisfaction. Solid carbon dioxide has given good results in small, suitably located lesions. Irradiation, however, has given better results than all other methods combined. With care and patience it is possible, without injury to the skin, to completely efface an extensive cavernous angioma which involves most of the face and mouth, which is so extensive and disfiguring as to constitute a monstrosity, and which could not be as successfully treated with any other method or combination of methods.

The annoying callositas on the plantar surface of the feet can be, with difficulty, eradicated by excision, by curettage and vigorous cauterization, by desiccation, the actual cautery, etc. The majority of these lesions can be permanently cured with from one to four applications of the roentgen rays or radium, without pain or inconvenience. Therefore irradiation is the method of election.

A carbuncle may be aborted if treated sufficiently early with an intensive dose of filtered radiation. If well developed, the lesion must be incised. Basing an opinion upon what has been reported in the literature it can be said that the roentgen rays or radium should be used if possible in every case of carbuncle.

The results of irradiation in unselected cases of cutaneous blastomycosis and actinomycosis have been superior to those obtained by any other treatment so far used. Iodide of potassium and other internal remedies are very uncertain in these affections. Small lesions can be destroyed with the curette and cautery. It is difficult and often impossible to cure extensive and deep seated lesions without the aid of the roentgen rays or radium. Unfortunately irradiation is not always successful.

Lupoid sycosis can be cured quickly and permanently with the roentgen rays or radium. Other methods are uncertain, painful and disfiguring.

The lesions of lupus miliaris disseminatus have been found very susceptible to irradiation. They can, of course, be removed with the cautery. The fact that they are often numerous and that they can be removed promptly without pain or disfigurement with the roentgen rays or radium, makes such treatment the method of election. Hygiene, fresh air, sunlight, liberal diet, etc., and tuberculin will not infrequently have to be combined with irradiation in order to obtain a permanent result.

Scrofuloderma, because of the excellent and reasonably certain results obtained with the roentgen rays and radium, should always be irradiated if possible. In this disease, however, irradiation alone should not suffice. These little patients must receive, if possible, the benefit to be derived from fresh air, good food, sunshine, etc. The literature contains good reports of heliotherapy, actinotherapy and ultraviolet therapy in this disease, but the consensus of opinion favors irradiation.

Dermatologists agree that irradiation is the best and very often the only successful treatment for widespread, persistent sycosis vulgaris. Often the result is spectacular but occasional cases are recalcitrant. Not infrequently good results are obtained with autogenous and stock vaccines, by pulling out the infected hairs, together with the local use of antiparasitic remedies. While irradiation is the method of choice it should be combined with vaccine treatment, sanitation and non-irritating topical remedies.

The lesions of tinea barbae can be cured with one application of the roentgen rays or radium. No other treatment is as efficacious or as painless. Nevertheless, the affection can be cured by other means.

GROUP V

Epithelioma, basal cell	Paget's disease
Erythema induratum	Sarcoid
Keratosis	Tuberculosis orificialis
Leukoplakia	Tuberculosis verrucosa cutis
Lupus vulgaris	Xeroderma pigmentosum

Excellent results can be obtained with irradiation alone in the diseases of this group. For the best results the cases must be selected and very often it is necessary to combine irradiation with surgery or other methods of treatment. These diseases can be cured with treatment other than the roentgen rays or radium.

Irradiation gives as high a percentage of permanent cures in unselected basal-cell epithelioma as does surgery. Because of the freedom from pain, non-interference with vocation, good cosmetic results and ability to reach inaccessible locations, it would seem that irradiation might be considered the method of election.

Irradiation and surgical methods share about equal honors in the treatment of keratosis. Beta radiation appears to be the choice for arsenical and roentgen-ray keratoses. The nevoid keratoses should be curetted and the horny layer removed from senile and seborrheic keratoses before irradiation. About the same results may be obtained with curettage and caustics, excision, desiccation, etc., but scarring is likely to be more pronounced.

Beta radiation is often efficacious in small patches of leukoplakia, seldom in large patches. It is possible that the actual cautery combined with oral hygiene is preferable in most cases of leukoplakia.

In lupus vulgaris the result of irradiation depends upon the clinical type. Irradiation alone is to be preferred in most cases of hypertrophic and ulcerative lupus. The roentgen rays and radium are not as efficacious as is a combination of irradiation, surgical methods and tuberculin in atrophic lupus. In general, the roentgen rays and radium are more successful in lupus vulgaris than is ultraviolet ray therapy as employed in this country. The statistics reported from European Finsen institutes are superior to those obtained with the roentgen rays or radium.

As a rule, the lesions of erythema induratum involute subsequent to from one to three applications of filtered radiation without any other treatment. Quicker results are obtained with irradiation combined with rest and hygiene. While no other remedy will effect such prompt cure of individual lesions irradiation alone will not prevent the development of new lesions.

There is some difference of opinion about the efficacy of irradiation in the Boeck type of sarcoid. Our results indicate that it is the method of choice. Others have not obtained good results. In a few years this question will be decided. Evidence at hand in the case of sarcoid of the Darier-Roussy type warrants the belief that irradiation is an extremely valuable and successful treatment. As in erythema induratum these patients should also receive the benefit of hygiene, fresh air, tuberculin, etc.

Caution must be exercised in selecting treatment for Paget's disease. If the mammary gland is involved surgery is indicated. The results of irradiation are splendid if there is no involvement of the deep tissues.

Excellent results have been obtained with irradiation in tuberculosis orificialis, but the method has not replaced surgery, excision, surgical diathermy, actual cautery, etc.

Small lesions of tuberculosis verrucosa cutis will disappear as a result of a single exposure to the roentgen rays or radium. Large lesions are often very stubborn. In some cases surgical methods are preferable while in other cases irradiation is indicated.

Xeroderma pigmentosum as a disease is incurable, but the keratoses and epitheliomata can be cured with the roentgen rays, radium, or surgically.

GROUP VI

Acne varioliformis	Cornu
Acne vulgaris	Lymphangioma circumscriptum
Cheilitis exfoliativa	
Cheilitis glandularis	Verruca vulgaris

In this group the diseases can be cured with regular dermatological treatment or with irradiation. The latter, however, gives the best comparative results.

One should hesitate before venturing a dogmatic opinion regarding the comparative value of irradiation and topical remedies in the treatment of acne varioliformis. More evidence is needed. It would seem, however, from the evidence at hand, that the eruption involutes more rapidly and that recurrences are less frequent subsequent to irradiation than after any other treatment.

There is no question but that acne vulgaris can be cured more quickly and with greater certainty with irradiation than with any other treatment. However, there are clinical types of this disease in which irradiation is not indicated; and not infrequently cases, in which such treatment is apparently indicated, will not get well without attention to the gastro-intestinal tract, the genito-urinary tract, the general health, etc.

Cheilitis exfoliativa and cheilitis glandularis are not common diseases and the evidence so far collected will not permit of dogmatic opinion. They are stubborn affections. The most that can be said at present is that irradiation appears to be superior to any other treatment.

Soft corns can be permanently cured with one application of the roentgen rays or radium, especially with beta rays. Hard corns are more stubborn. It is doubtful if any other treatment is as efficacious in stubborn cases.

Lymphangioma circumscriptum as a rule yields readily to beta radiation. Such treatment is preferable to solid carbon dioxide, caustics, etc.

It is our experience that about 75 per cent of common warts will permanently disappear as a result of from one to three applications of the roentgen rays. We prefer such treatment to desiccation, application of acids, etc., in most cases.

GROUP VII

Onychomycosis	Paronychia, chronic

In these two conditions irradiation is uncertain in its action, but prompt and permanent cures are obtained in some cases. All methods of treatment are uncertain in these diseases.

GROUP VIII

Furunculosis	Rosacea
Pityriasis rosea	Sporotrichosis

Irradiation is useful, even curative, in the affections in this group, but equal and even superior results can be obtained by other forms of treatment.

Irradiation is very valuable in chronic furunculosis when the boils keep developing in localized areas. All cases should, however, receive general medical attention.

Pityriasis rosea is a self-limited affection, the eruption is usually not annoying and involution occurs in a few weeks. Occasionally, however, the eruption is very severe and the disease may endure for several months. Those who have had experience with the roentgen-ray treatment of pityriasis rosea aver that the eruption disappears very quickly when irradiated.

Rosacea, when associated with acneiform lesions and seborrhea, improves markedly when irradiated. It is not scientific, however, to depend upon irradiation in this affection, as it is usually caused by faulty diet and visceral disturbances.

Sporotrichosis can be cured by the ingestion of potassium iodide. Irradiation hastens involution and is of value in obstinate cases.

GROUP IX

Epithelioma, prickle cell	Rhinophyma
Hypertrichosis	Sarcoma, general types
Nevus pilosus	

The diseases in this group may be cured with the roentgen rays or radium, but as a rule better results can be obtained with other methods of treatment.

Prickle-cell epithelioma should be regarded as a surgical disease. Irradiation, however, has its place. Very early lesions may be cured and occasionally brilliant results are obtained in inoperable cases.

Electrolysis is preferred by the majority of experts in hypertrichosis and nevus pilosus. Irradiation is indicated in selected cases.

While irradiation is of some value in hypertrophic rosacea and rhinophyma, the majority of dermatologists depend on topical remedies, multiple scarification, etc.

Brilliant results have been obtained with the roentgen rays and radium in cases of lymphosarcoma and even in melanoma and disseminated sarcomatosis cutis. Sarcoma is considered a surgical disease, but irradiation is of service in selected cases and in inoperable cases.

GROUP X

Dermatitis exfoliativa	Lichenification
Dermatitis venenata	Lichen planus
Eczematized ringworm	Neurodermatitis
Infectious eczematoid dermatitis	Pompholyx
Intertrigo	Psoriasis

In this group of diseases irradiation is often of great service, especially in obstinate cases. It is doubtful if any other treatment will effect such prompt relief from itching and such rapid involution of generalized lichen planus. A similar statement can be made for many members of the eczema group. While irradiation will apparently produce a permanent cure in individual examples of the diseases in this group, such treatment, in order to obtain good average results, should be subordinate to intelligent dermatological management, and employed only when indicated.

GROUP XI

Lupus erythematosus	Tuberculide
Prurigo	

For the diseases of this group irradiation is of service in some instances. Occasionally beta radiation will effect a brilliant temporary result in lupus erythematosus. Roentgen radiation may be employed to relieve the intense itching of prurigo temporarily and to hasten involution of the eruptions known as tuberculide.

GROUP XII

Folliculitis decalvans	Pernio
Lichen scrofulosorum	Streptococcic lymphangitis, chronic
Epithelioma, multiple benign	Syringoma

The roentgen rays and radium have been used with success in the treatment of these affections, but there has not been enough experience to estimate the true value of irradiation.

GROUP XIII

Angioma	Kraurosis vulvae
Cornu, soft	Leukoplakia
Keratosis	Lupus erythematosus
Lymphangioma	

This group consists of diseases in which beta rays appear to be more efficacious than gamma rays or the roentgen rays.

THE ROENTGEN-RAY TREATMENT OF DISEASES OF THE SKIN*

BY H. H. HAZEN, M.D.

Professor of Dermatology, Georgetown Uinversity and Howard University
WASHINGTON, D. C.

THE honor of the invitation to read a paper upon the treatment of cutaneous diseases by means of the roentgen ray is much appreciated by me. The paper will deal exclusively with the results obtained upon private patients, and no attempt will be made to cover the very extensive literature of the subject, this being covered in MacKee's book.[1]

The technique employed has been that advocated by MacKee, namely the use of modern apparatus and the invariable measuring of doses, at first by means of pastilles and later by MacKee's arithmetical formula.

SUPERFICIAL MALIGNANCY[2]

One case of rapidly growing sarcoma was apparently stimulated rather than benefited.

But one case of malignant mole was treated and while the original condition was cured general metastases developed within a year.

One interesting case of xeroderma pigmentosum was followed from the time the child was three months old until death at four years of age. At the early age of two years malignant tumors began to appear on the face and neck. More than twenty of these were entirely dissipated by the roentgen ray, but eventually two rapidly growing lesions developed which were absolutely not influenced by the ray and death resulted from these.

As regards basal-celled cancer 104 persons affected with a total of 147 basal-celled cancers were treated. The results of these have been as follows:

Well over three years	16
Well over two years	17
Well one year	81
Relapses cured	4
Relapses healed	2
Not cured	15

Of the 15 cases which were not cured, 6 were hopeless from the start because of their large surface and deep involvement. Three patients received insufficient treatment because of the failure to attend regularly. One case had had large amounts of fractional treatment. In three instances the cartilage of the ear was deeply invaded and none of these patients responded to radiation although all were cured by the cautery. My experience has been that where the cartilage is invaded the patient does not respond nearly so well to radiation as might be expected. The results obtained in this series of cases are practically indentical with those from good surgery.[3]

Fifteen patients with prickle-celled cancer were treated. Four cases were permanently cured. Three healed under treatment, although it is still too early to say that the patients are well, and eight were not in the slightest degree influenced. The diagnosis in each of these cases was confirmed by pathological examination and it might be added that in one-half of the basal-celled cancers a similar examination was made.

It is unfortunate that we have no extensive statistics showing the comparison between cases treated with and without filtration, or showing the difference between the efficacy of hard and soft rays. However, in three instances no effect had been obtained by excellent roentgenologists who had employed from 1 to 3 mm. of aluminum for filtration and yet all of these cases responded to the unfiltered ray. At the present time I should be much inclined to feel that superficial cancers will yield much more rapidly to unfiltered than to filtered doses and that the very powerful types of apparatus that are now being developed will have no effect upon the prognosis of skin cancer. The technique in all cases of superficial

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cancers was as follows: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, two minutes and fifteen seconds to two minutes and thirty seconds, no filter, intervals about three weeks. However, where there was marked induration various degrees of filtration were employed.

The cosmetic results of treatment were excellent. In about 15 of my cases a slight amount of telangiectasis resulted. This sequela is much less likely to result from three or four very intensive doses over a small area than from the same number of considerably smaller doses over a larger area.

KERATOSES

A large number of keratoses have been treated. There has not been time to review all of the case histories, but we have looked over 48 of them, comprising a total of 101 lesions, and have found only one instance where a cure did not result.

Inasmuch as the majority of these lesions occurred upon dry skin and upon those persons who have been much exposed to the actinic rays of the sun, there has been some hesitancy in the use of the roentgen ray in this disease. However, this list comprises a considerable number of patients who have been well from four to ten years, and even now the skin is absolutely soft and pliable. It has taken from one to three treatments to effect a cure. The technique employed was as follows: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, one miuute and thirty seconds to one minute and forty-five seconds, no filter. In no instance have there been unfavorable complications.

BENIGN TUMORS

Ten cases of keloid were treated. In all instances a complete flattening was secured. One keloid 3 by 4 inches in surface measurement and at least $\frac{3}{4}$ of an inch in thickness was completely dissipated. In three instances some slight telangiectasis resulted. The technique was as follows: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, one minute and thirty seconds to one minute and thirty-five seconds, no filter, intervals of three weeks. From three to ten treatments were necessary to effect a cure, the number of treatments depending upon the size of growth.

It is interesting to note that in our experience at Freedman's Hospital we had the greatest difficulty in influencing keloids in the negro race unless a second degree dermatitis was produced. One of the 10 cases was a Filipino with comparatively dark skin, and her keloid, more than 1 inch in diameter and certainly more than $\frac{1}{4}$ inch in elevation, required eight treatments before it disappeared. This is considerably more than similar growths in lighter patients require.

One case of von Recklinghausen's disease was observed over a sufficient space of time to warrant any conclusions. In this case no attempt was made to treat all the lesions, but simply to establish a suitable working basis for the use of the roentgen ray. Both filtered and unfiltered treatments were given to similar individual lesions and it was found that the unfiltered ray produced much the better results. In order to flatten out the tumor which was about $\frac{1}{2}$ inch in diameter, three treatments with the following technique were given: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, one minute and thirty seconds, no filter, intervals of three weeks.

One case of adenoma of the sweat glands, about $\frac{3}{4}$ of an inch in diameter and proven by histological examination, was cured by two exposures of $1\frac{1}{2}$ H units each.

WARTS

From the standpoint of the roentgenologist warts may be divided into four groups. First, the ordinary verrucæ vulgares of glabrous skin; second, plantar warts; third, warts of the lips; and lastly, flat warts. Unfortunately, there has not been time to review the case histories of the first group, but the results have been somewhat discordant. In about 90 per cent of the cases the lesions have been made to disappear after from one to three treatments with the following technique: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, one minute and thirty seconds to one minute and fifty seconds, no filter, intervals of two to three weeks. But in exceptional instances four to six treatments were required, and in at least 6 cases we have been absolutely unable to effect a cure. In all cases only the wart and not the normal skin is exposed to the ray. Speaking purely from memory, it can safely be said that at least 150 cases of these warts have been handled by means of the roentgen ray.

Twenty-four cases of plantar warts have been treated.[4] All these were cured with the exception of one, and this we were absolutely unable to influence despite very heavy treatments. The technique was as follows: Focal skin distance, 8 inches, 7½ inch spark gap, 4½ ma., time, one minute and thirty seconds to one minute and fifty seconds, no filter, intervals of two to three weeks.

Six cases of warts of the lips were treated, all successful. From two to three treatments were given. The same technique was employed as in ordinary warts of the skin.

The majority of observers believe that flat warts cannot be cured by means of the roentgen ray, and our experience has been that only in exceptional instances do they respond well. We have handled 9 cases with three cures. The technique is the same as that for other warts.

It is probable that an unfiltered ray should invariably be used for verrucæ inasmuch as a pathological study of these little growths shows them to be extremely superficial. One very interesting fact is that four times I have considered a lesion to be an ordinary wart, and later, to my intense chagrin, found that in reality it was cancerous in nature, and that the small amount of treatment had acted as a stimulant. None of the textbooks mentions an ordinary wart as an antecedent of cancer, but it seems worth while to warn the profession that an apparently perfectly harmless wart may in reality prove to be a malignant tumor.

ECZEMA

Eczema is an expression used for a large number of skin diseases.[5] A number of these entities can clearly be separated. The most important of these are as follows: Neurodermatitis, infantile eczema, irritant dermatitis, urticarial eczema, infectious eczematoid dermatitis, and last and by no means least, eczema of the hands and of the feet, which is now known to be a ringworm infection in many instances. It is possible that in a few years the expression "eczema" will be as obsolete as the term "rheumatism" should be at the present day. At times, practically all of these conditions can be benefited by means of the roentgen ray, although the ringworm cases are much more readily cured by proper local medication. The same may be said of infectious eczematoid dermatitis. The conditions, however, can usually be handled with much success.

My associate, Dr. Eichenlaub, in his paper, "The Roentgen-Ray Treatment of the Eczema Group,"[6] reviews 100 unselected cases and finds that an average of 2.9 treatments were required to effect a cure, that the average duration of the disease was 135.50 weeks, and that the average time required to cure was 7.6 weeks. In this series of cases there were four failures. In many instances the rapidity of the recovery has been most startling to the patient. The technique was as follows: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, thirty-five seconds, no filter, intervals of ten days. As an accessory we have frequently employed the well-known calamine lotion.

We have treated one case of infantile eczema in which all medicinal treatment failed, and there was a marked benefit by using the roentgen ray, but the case was not entirely cured. Practically the same technique was employed as for other cases of eczema.

Fifteen cases of seborrheic dermatitis of the glabrous skin improved promptly under the roentgen ray. The technique is the same as for the eczema group, just mentioned.

Three cases of vegetating dermatitis were cured in from three to five treatments. The technique was as follows: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, one minute and fifteen seconds to one minute and forty seconds, no filter, intervals of two weeks. There were no failures in this series.

ACNE VULGARIS[7]

One hundred and seventy cases of acne vulgaris have been carefully followed.

In addition to the roentgen ray treatments the majority of the acne patients have cut down their carbohydrate intake, chocolate has been eliminated, and at times a mild astringent lotion has been employed. It has been the custom to start the majority of these patients upon the usual medicinal treatment: arsenic internally, dietary measures, the use of astringents, and the removal of black heads, but it has been found that this treatment is effective in not over one-third of the cases. The results of roentgen therapy are as follows.

TABLE I

Results	Juvenile	Papulo-pustular	Indurata	Back	Total
Improved	..	17	3	..	20
Cured	2	41	20	4	67
Cured bad relapses	..	3	..	..	3
Cured mild relapse	3	28	5	..	36
Cured question as to relapse	2	26	6	3	37
Failure	..	6	1	..	7
	7	121	35	7	170

Table II will show how promptly they improved.

TABLE II

No. Doses	Juvenile	Papulo-pustular	Indurata	Back	Total
1	..	13	6	2	21
2	2	32	10	3	47
3	4	39	11	5	59
4	1	22	4	..	27
5	..	5	3	..	8
6	1	2	..	..	3
7	..	2	..	..	2
	8	115	34	10	167

As regards the duration of treatment, there are two different ways in which the cases may be handled. They may be kept under observation for at least one year, giving the patients treatment with the following technique, biweekly: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, thirty-five seconds, no filter. After five to eight treatments are given, the time between treatment is gradually increased until bimonthly treatments are given. The second method is to clear up the attack and then each recurrence as it may appear. It should be especially mentioned that the recurrences are usually very much milder than the original attack.

In four instances patients had telangiectases. One of these was due to a deliberate overdose given in a successful attempt to stop a very severe acne indurata, one to the slipping of lead foil, and in a third instance the patient had had previous roentgen-ray treatment. In one case there has been an unpleasant amount of dryness. It has been suggested that cases of acne treated with roentgen rays will sometimes show deeper pits than untreated. However, the general consensus of opinion among competent dermatologists is that such is not the case; and our own experience bears this out. It is not infrequent to find that, owing to the skin becoming dryer than normal, an irritant dermatitis from the use of furs, cosmetics, and soap and water may be rather easily set up. Many brunettes show a marked tendency toward pigmentation, but we have never seen a permanent example of this. Freckling is very common. A number of patients have felt that the growth of superfluous hair is stimulated by roentgen therapy, but I do not believe this is possible. Superfluous hair and acne are very prone to travel hand in hand, both being due to over activity of the pilosebaceous gland apparatus. In addition, the growth of superfluous hair is usually directly under the chin where practically no treatment is received.

In conclusion, it might seem that the roentgen-ray treatment of acne affords much the quickest and surest method of controlling this disease.

ROSACEA

The roentgen-ray treatment of rosacea has not proven nearly so satisfactory as that of acne. Nineteen cases of this condition have been treated. Of these, 4 were cured and 7 were improved; out of the remaining cases a few of them improved somewhat only to relapse severely again. It has been found necessary to employ an entirely different technique from that used for acne. The technique which we have found most beneficial is as follows: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, from ten to twenty seconds, no filter, intervals of seven to ten days.

It is worth while mentioning that some of the best dermatologists feel that the roentgen ray will do much for rosacea; but this has not been the experience in my office despite the use of many different techniques.

PSORIASIS

Twenty-six cases of psoriasis have had their histories carefully reviewed. Of these, 22 were very much improved. One showed little improvement, and 3 cases were made very much worse. In two of these instances there was a considerable temporary improvement at first, but later a more or less complete generalization of the disease developed, and a third case was made worse by the first treatment. Practically all the cases showed relapses, the longest interval of freedom observed being one year. The average time of relapse was about two months. As a general rule the relapses were just as severe as the original condition. In addition, I am rather inclined to believe that sunlight does not have as much beneficial effect upon those patients who have had roentgen-ray treatment as it has upon those who have not been so treated.

Owing to the fact that psoriasis is pathologically an extremely superficial condition, it has been my practice to use rather soft rays, and I am fairly well convinced that soft rays are much more beneficial than are hard rays. The technique was as follows: Focal skin distance, 9 inches, 6 inch spark gap, 7 ma., time, from forty-five to sixty seconds, no filter, intervals of two to three weeks.

In conclusion it might be said that while the roentgen ray will usually clear up a case of psoriasis in an easy and cleanly fashion, it should not be employed as a routine, for relapses are practically sure to follow, and the continued use of the roentgen ray over a period of years is hardly to be advised in the present state of our knowledge, particularly if it is more or less generalized. Exposure to sunlight is unquestionably safer and usually just as efficacious, and the proper rubbing in of chrysarobin ointment is not to be despised. The later work of using stimulating doses to the thymus gland sounds rather promising, but as yet must be regarded as merely on trial.

LICHEN PLANUS

Nine cases of lichen planus have been treated with marked benefit in 8 cases. The ninth case was an old hypertrophic affair which at the present time is responding slowly, but definitely, to treatment. The relief from itching in all cases is markedly improved. While mercury has been used in conjunction with all cases, still the rayed areas have responded very promptly. The technique is the same as for eczema, although it is probable that the hypertrophic cases should receive more than others.

LUPUS ERYTHEMATOSUS

There are many dermatologists who feel that the use of the roentgen rays are inadvisable in lupus erythematosus. I have seen a number of cases where the condition was unquestionably aggravated by comparatively light doses, and it is not unusual to find other cases in which no benefit resulted. However, I have had one case in which the whole face was involved, which resisted all other types of treatment and yet was cured by the roentgen rays. The technique was the same as that employed in the treatment of acne. Of course a stimulating dose should never be employed except in a chronic or subacute type of this condition, the acute type almost invariably being made worse. The use of carbon-dioxide snow or the ultraviolet rays is preferable.

DISEASES SUPPOSEDLY DUE TO THE TUBERCLE BACILLUS

Two cases of tuberculides have been handled with very gratifying results, using one treatment with the following technique: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, one minute and thirty seconds, no filter, which sufficed to resolve the lesion in from one to three weeks.

Scrofuloderma usually does very well. Two cases recovered under three treatments. Owing to the fact that scrofuloderma is usually associated with tuberculous glands very heavy filtered treatments were given.

One case of tuberculosis verrucosa cutis, of many years, duration was cured. The technique was as follows: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, one minute twenty-five seconds, no filter, intervals of three weeks. Four treatments were necessary.

My results in the treatment of lupus vulgaris with the roentgen rays have not been satisfactory. This is in marked contrast to the claims of many authors. However, if one talks with dermatologists, one will find that they are not particularly enthusiastic as regards treating many cases of lupus with the roentgen rays. As a matter of fact, the pathology of a long-standing case of lupus vulgaris is very similar to that of a healed roentgen-ray dermatitis, and one would hesitate for a considerable space of time in treating the last mentioned condition with the roentgen rays. In 2 cases under my observation severe third degree dermatitis resulted from comparatively light treatment. The technique employed was: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, one minute and fifteen seconds, no filter, intervals of three weeks. However, in the early cases, before much scarring takes place, the results may be excellent. Out of 7 cases treated there have been three cures and 4 were improved. The 3 cured cases were all very early ones. In addition to the 7 cases, one case of hypertrophic lupus is still under observation and is being benefited by the roentgen rays.

One case of Boeck's sarcoid was cured by 2 treatments, although the disease had existed for years.

DISEASES DUE TO STAPHYLOCOCCI

Two cases of sycosis non-parasitica were treated with epilating doses. Unfortunately in both cases the fields of exposure were not entirely correct and a few hairs remained which speedily became involved, necessitating further treatment. There can be no question, however, but that the roentgen ray should be used in such cases.

Six cases of folliculitis of the back of the neck have been handled with epilating doses, in every instance with admirable results, although in 2 of the cases a sufficient number of exposures had to be given to produce a permanent alopecia.

Two cases of paronychia were treated with absolutely no results.

DISEASES DUE TO FUNGI

Tinea tonsurans is a most unsatisfactory condition to treat by any method except by the roentgen rays. Some eight years ago I published a series of 225 cases of this disease so treated and to date probably about 350 have been handled. The technique was as follows: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, one minute and twenty-five seconds, no filter. One treatment only is required. The hair is cut short and a line drawn down the center of the scalp from the forehead hair line to the occipital hair line. The middle of this line is determined by the eye and marked either with a skin pencil or by putting a small piece of adhesive on it. This is Point B. Just 5 inches anterior to this point another mark is made—Point A—and just 5 inches posterior to point B is another mark—Point C. On the sides of the scalp and 5 inches equidistant from points A, B, and C we have D and E on the right and left sides of the head, respectively. The tube is centered over each of these points, care being taken that each exposure is given at right angles to the others, and that the required dose is given. The reason for this technique is given very fully in MacKee and Remer's article.[9] Of course, the eyes, ears and shoulders must be carefully protected with lead foil when any of these parts are subjected to the rays.

It is not necessary that every hair in the head be removed: the falling of the diseased hairs and the majority of the others is sufficient to effect a cure provided that the scalp be kept covered with an antiparasitic preparation. Where there are but one or two small spots, it is not necessary to treat the entire scalp if the child is subject to careful and intelligent supervision, but in the majority of instances it is better to remove all the hair at one sitting, for the falling hairs are almost certain to infect other portions of the scalp. If it be decided to treat but one spot, it is best to cut a piece of adhesive plaster that will fit this spot and keep it adhering to the hair or else replace it as soon as it comes off. The hair will come off with the adhesive and not be scattered. Ordinarily, the defluvium is complete in about three weeks and the new hair returns in from six to twelve weeks after falling. In only one case was there a recurrence, although in the various homes there were many instances of reinfection on the same patients.

As regards untoward results we have had 2 cases of permanent alopecia. One of these was due to the stopping of the clock during treatment and the second was due to the child moving so that there was some overlapping of the field of exposure. In the children from one home, too strong an ammoniated mercury ointment was used after radiation and the result was a wonderful crop of boils. The hair does not always return the same color; in one young child with beautiful red hair the new hair was brown. Unfortunately, this was a case in which a partial epilation was done. At times the texture of the new hair is not the same as that of the old. For instance, we have seen a kinky-headed negro secure some beautiful straight hair, for the time being at least, as the result of the roentgen-ray epilation. These facts are additional arguments against partial epilation. In 5 cases there has been a considerable quantity of white hair as the result of this treatment. Analysis of these cases has shown that in each instance the child received at least three different treatments at varying intervals, made necessary because of reinfection. So far as I know this observation has not previously been made.

In conclusion it may be said that the use of the roentgen ray offers much the quickest and surest method of permanent cure in tinea tonsurans, and that with correct technique it is absolutely safe, provided that a case does not have to be epilated frequently as might occur in an institution.

Two cases of ringworm of the beard have been treated with epilating doses of roentgen rays, with immediate permanent cure.

Five cases of ringworm of the nail have been treated, 3 with no results and 2 with cures. In no instance did the nail fall. The technique was as follows: Focal skin distance, 9 inches, 7½ inch spark gap, 4 ma., time, forty-five seconds, no filter, intervals of two to three weeks.

HYPERTRICHOSIS

I flat-footedly do not believe in attempting to remove superfluous hair by the roentgen ray. In the vast majority of instances a sufficient amount of roentgen rays to atrophy the hair follicles permanently, is almost certain to cause an atrophy of the corium, and results in some permanent wrinkling, and even telangiectasis may result. However, this method is possibly permissible beneath a very prominent chin where such wrinkling would not be noticed. In 4 cases the attempt has been made to remove hair from small hairy moles by means of the roentgen ray. However, it was soon learned that this was not easily done. The technique necessary to effect a permanent cure was as follows:

Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, at least two minutes and fifteen seconds, no filter.

HYPERHIDROSIS

Considerable difficulty has been experienced in curing hyperhidrosis by means of the roentgen rays. Apparently a large number of heavy exposures are required, and at the present time I am not prepared to recommend an exact technique, although I am sure results can be obtained.

PRURITUS

Eight cases of pruritus of the genitalia have been treated. Two were complete failures, 2 were temporarily improved and the other 4 were greatly improved. It seems too much to expect the roentgen rays permanently to cure this condition, which in the majority of instances is probably due to a psycho-neurosis. The technique was as follows: Focal skin distance, 9 inches, $7\frac{1}{2}$ inch spark gap, 4 ma., time, forty-five seconds, intervals of two weeks.

UNUSUAL CONDITIONS

One case of granuloma annulare was cured by two exposures. One case of mycosis fungoides has likewise been improved. The tumors resolve very rapidly under comparatively light treatments. However, so far as I can learn, no case of this condition has been permanently cured by means of the roentgen rays.

CONCLUSIONS

Roentgen rays are probably the most useful single therapeutic agent that the dermatologist possesses today. It is of the greatest value in both malignant and benign tumors, keratoses, warts, eczema, acne, lichen planus, some forms of tuberculosis, sycosis and folliculitis of the back of the neck, tinea tonsurans, tinea barbae, some cases of pruritus, granuloma annulare and mycosis fungoides.

At the same time a word of warning must be issued, for since the war scores of physicians with totally inadequate training are rushing into roentgen-ray therapy and it is certain that some disastrous results will follow. In no case should an erythema dose be administered to the skin, except after careful consideration of malignancy. In addition, it should always be remembered that an erythema dose over a large area of skin is much more apt to result in disastrous sequelae, especially telangiectasis than is the same size dose over a small area. Treatments should never be continued for more than six months, except under very special circumstances.

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SUPERFICIAL MALIGNANCIES*

BY CHARLES F. BOWEN, M.D.

COLUMBUS, OHIO

Every case of superficial cancer can be cured if seen while it is still a localized disease. Whether or not all cases are cured is another question. What I want to do in this paper is to give some of the reasons why I have not cured all my cases and to describe the methods used at the present time, which are almost 100 per cent efficient.

Twenty years ago we treated our epitheliomas every day or every other day, with mild roentgen ray without filters. If the cancer did not heal, it was because the patient got tired of coming for the treatments, or else we produced a roentgen ulcer, which, of course, could not heal under continued roentgen-ray treatments.

A little later we began to understand the ill effects of overtreatment and began to use filters. This led to the time when we gave our patients heavier treatments farther apart, say once a week. We soon had a technique which would cure practically all the cases which stayed with us.

About three years ago, while checking my results over a considerable period, I was surprised to find that a considerable number of patients took only one, two or three treatments and then failed to return. This amounted to two or three cases per week. Practically all these cases could have been cured if only they had taken a sufficient number of treatments. Letters were written to a great many of them and to their referring physician, requesting the reasons for discontinuing treatment. We soon discovered that the majority of them stopped treatment because they did not see any improvement. They had heard so much about burning out cancers that they were frankly disappointed when they did not see some decided change after one or two treatments. A number of patients wrote that their cancer gradually got well of its own accord, after stopping treatment, refusing, however, to give the roentgen ray any credit. Others were so disappointed at the apparent failure that they refused to take any kind of treatment and died the usual cancer death.

The cause of failure, then, of the majority of the cases, was the failure of the patient to continue treatment. We are not surprised at this when we consider that the majority of cancer patients are old and sometimes feeble. On the other side of the case, we have the personal equation of the operator. This I can sum up as follows: Failure to realize the extent and seriousness of the case; failure to give sufficiently hard or severe treatments at the beginning of the series; failure to stop treatments after the cancer cells are destroyed, allowing the ulcer to heal.

This led us to devise ways and means of curing our patients with fewer and fewer treatments. We tried massive doses and various modifications of this method, but there were always a certain number of cases which would not respond to treatment and would get away from us.

Radium was used with about the same results as with the roentgen ray, always leaving a certain number of cases which would not respond to treatment. Electric coagulation and fulguration were used with about the same results. This led to the conclusion that no one method would cure all cases. The use of escharotics in the form of paste, liquid or what not, has long since been discarded, as destroying too much healthy tissue, being entirely too painful to the patient, and on the whole, being too unscientific.

The three remedies, or agents, at hand, which offered the most hope, were the roentgen rays, radium and electric coagulation. These three, in proper combination, I believe will kill any cancer within reach.

We proceed somewhat as follows: All the growth projecting above the normal skin is destroyed by electric coagulation, after injecting novocaine with a little adrenalin. The burnt tissue is carefully

*Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1922.

curetted away and the base of the ulcer thoroughly heated with the electric current. The roentgen rays are then used to destroy any cells which were lying deeper in the tissues. At least 50 ma. minutes of unfiltered rays are used over an area a little larger than the ulcer.

Any of the cancerous tissue which is covered by normal epithelium, is exposed by the electric coagulation. The main object is to expose all the cancer tissue and form an open ulcer.

This, in short, has been our method of attacking these cancerous growths involving the skin.

At the June, 1921, meeting of the American Medical Association in Boston, the American Radium Society was the guest

Plate 1. Cancer of the corner of the eye before treatment, after excess tissue was removed by electro-coagulation, and after healing had taken place. One intensive treatment was given immediately following the electro-coagulation.

Plate 2. Epithelial carcinoma on the face before treatment, after electro-coagulation and end result. The excess tissue was burned down to the skin level and the base thoroughly heated; this was followed by a massive roentgen-ray treatment.

of the Harvard Cancer Research Commission at the Huntington Memorial Hospital. Many interesting things were discussed by members of the commission, but one thing stood out as being more practical than all the others.

Plate 3. Cancer of the lip which had undermined the normal skin and mucous membrane. The undermined portion was exposed by electro-coagulation, as shown in the middle picture. One x-ray treatment with the above end result.

Plate 4. Cancer of the tongue before treatment, after electro-coagulation, and showing radium needles in place. The involved area was about one inch in diameter. This was thoroughly burned away and radium needles imbedded through the base of the ulcer and into the root of the tongue. Deep roentgen-ray therapy was used over the glands of the neck. The end result was good.

Dr. Bovie, a biologist, told of the effects of the roentgen rays, radium and heat upon cancer cells. He said that a certain dose of roentgen ray would only sicken the cancer cell and that heat would do the same thing. He then said that if the cancer cells were first treated with the roentgen ray and sickened, as he called it, that they were then much more susceptible to the heat and easily destroyed.

Since learning of this fact from Dr. Bovie, I have reversed the process of treating skin cancer. I now give a massive dose of the roentgen ray to the growth and surrounding tissue, and then destroy the superfluous tissue by heat, using the electric coagulation method. As an added measure we frequently apply radium to the open ulcer, using all three agents or methods at one sitting. This may be called a gun-shot method, but I have found it very efficient. The patients are sent home with instructions about keeping the ulcer clean and are asked to return in one month.

The large majority are healed when they return. Patients frequently fail to return, but upon inquiry, I learn that healing has taken place. A few cases will need an occasional roentgen-ray treatment to complete the healing process.

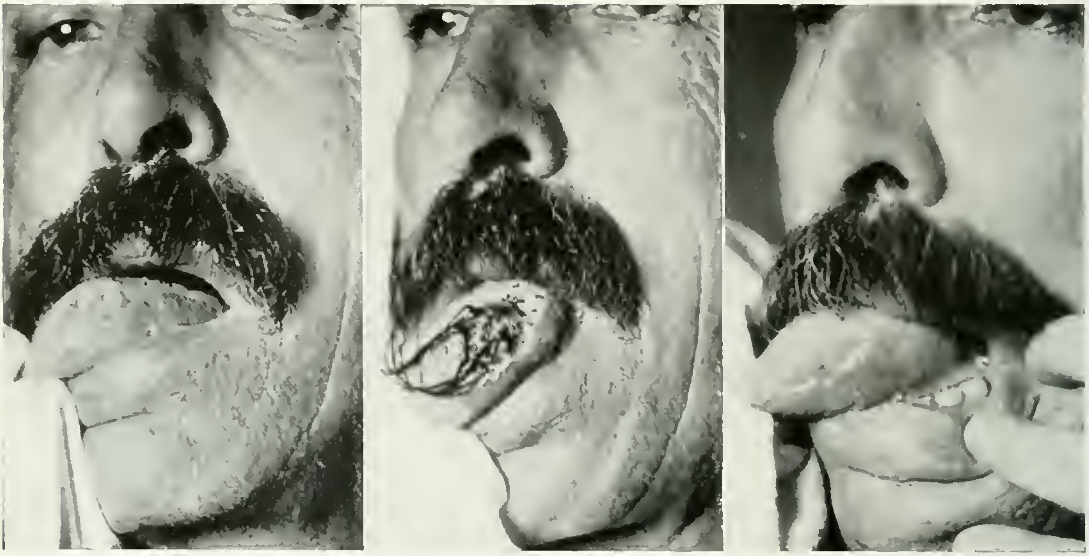

Plate 5. First, cancer of the tongue; second, after electro-coagulation and radium needles inserted; third, end result. Tongue received only one coagulation and radium treatment. Later roentgen-ray treatments were applied to the cervical glands.

DISCUSSION OF PAPERS BY DRS. HAZEN AND BOWEN

Dr. Geo. E. Pfahler. I just want to talk on one or two points. First I want to say that my experience conforms exactly with that of Dr. Bowen, and I carry out the same technique. I believe, however, that there is perhaps greater advantage in destruction preceding radiation, as Dr. Bowen has written and said. Heat also partially devitalizes these cells and therefore the *x*-ray will have a correspondingly greater effect because of that preceding heat. Many of the malignant cells may still be remaining in the tissues at the time of radiation.

The patients that electric coagulation will help and that radiation will not help are those having involvement of cartilage or bone. You who have had much experience, know that if you keep on radiating cartilage that has been involved by epithelioma, you do not cure unless you first destroy the disease by coagulation.

Warts: Warts that grow around the fingers and especially those underneath the nails, I have found it difficult to cure by either radium or *x*-ray. They disappear but do not get well. Those which have given me the best results were treated by the combination of coagulation and radium.

Dr. A. H. Pirie. Dr. Hazen mentioned superfluous hairs after treatment of acne. I have never seen that. Dr. Hazen has had an opportunity to follow up his cases. Did he follow up cases of superfluous hairs following acne? I have seen superfluous hairs following treatment of tuberculous glands. When treating such cases I have found hair to grow long where the edge of the protecting lead covered the neck. The skin is vignetted at the edge of the protecting lead and this vignetted area receives just the right dose to stimulate growth of hair.

These superfluous hairs follow acne as Dr. Hazen said; but are they not temporary and do they not go away afterwards? I have found that hairs following treatment of tuberculous glands do go away.

Dr. Hazen mentioned that the *x*-ray was not good for lupus erythematosus. I have found solid carbon dioxide treatment followed by perfect cure. He also mentions hyperdridosis. I have treated that since 1909 and never had a case that did not respond. The only complaint I have had is that the patient gets too dry and desires to have a little perspiration left.

Dr. C. F. Bowen (closing discussion). In regard to massive dose; I use 7 in. backup, 8 in. distance, 5 ma., for ten minutes;—no filter. If there is any likelihood of the glands being involved, I give the heaviest dose and heaviest backup I can use on all glands of the neck and lymphatic glands involved. In that case I use 10 mm. al. and sole leather, about 9¼ in. backup, for twenty minutes, at an 8 in. distance. I use a single dose in those cases where I think there is no malignancy and no glandular involvement. When finishing, I tell the patient that if he gets a swelling around the neck he must come back. I then treat it as an internal case and not as superficial malignancy.

Dr. H. H. Hazen (closing discussion). Dr. Pfahler said that warts underneath the nails do not respond to *x*-ray. I must have been remarkably lucky because I have had a series of eight cases and all of them are well,—permanently well. I attribute this entirely to luck.

With regard to the treatment of keloids: I think a great deal of the technique depends upon the keloid. If it is one that is very much infiltrated, I use filter of 2 mm. al. The technique for a small keloid, about the size of a quarter and not over 1/16 to 1/8 of an inch thick, is as follows: 1½ skin unit, measured by Mac Kee's formula, 9 in. distance, 1 min. and thirty-five to forty seconds, 7½ in. backup, 4½ ma. three weeks' interval, 4 to 6 treatments. With deeper keloids, of course, we use a certain amount of filtration.

Acute eczema: There are two types of eczema. One is clearly due to external irritants and it is not necessary to use the *x*-ray on these cases. In the vast majority of cases of so-called acute eczema we use *x*-ray right away, and we do not believe that the *x*-ray is contraindicated in the vast majority of acute eczema cases. We use it daily and with good results. We use the same dose as for acne, ½ skin unit, thirty-five seconds, 9 in. distance, 7½ in. backup, 4 ma. over about ten days to two weeks.

Superfluous hairs: We have seen a number of cases of superfluous hair following acne, which have been permanent over four or five years; and I am inclined to think they are going to continue. In addition, the vast majority of superfluous hair are those who have had acne when hair developed. They come in for needling work.

With reference to the use of carbon dioxide snow in treatment of lupus erythematosus. There are two types of this disease—acute and chronic. Carbon dioxide snow in the acute cases does not work well. I am partial to carbon dioxide snow in chronic cases. I have found it better than the ultra violet light. I have had better success with its use.

Acne and tonsils: We have had a theory for awhile that acne might be made worse because of bad tonsils. We have had 3 cases in one week where acne developed after bad tonsils were taken out. We have had six or eight acne patients whose tonsils have been removed without influencing the acne at all.

PERISTALSIS OF THE COLON

BY PRESTON M. HICKEY, M.D.

DETROIT, MICHIGAN

WHEN a patient is given an opaque meal, the peristalsis of the stomach and small intestine can be easily studied from the fact that the peristaltic waves affecting the stomach move along with a rapidity which is favorable usually for their observation, but the rate of travel may be either so rapid that the movements are difficult to follow, or so slow that the observer's patience becomes exhausted. The peristalsis in the small intestine is usually easy to be studied. The rate of travel, while often very rapid, easily permits of accurate observation.

When the patient is given a barium meal by mouth, the peristalsis in the colon is so slow and so infrequent that opportunities are rarely found when the movements may be observed. In consequence of this infrequency of colonic peristalsis, comparatively little is known about its method of appearance, and the observer has no chance of witnessing the rate of travel of the colonic peristaltic waves, the frequency of their occurrence and the vigor of their action. In the great majority of observations upon the colon, whether it is filled by a barium meal or filled from a barium enema, the examiner can report only the size, shape and relation of the component parts of the large gut.

If one is desirous of observing colonic peristalsis, the following procedure is recommended: After a cleansing of the large gut, either by enemata or by laxatives, the colon is filled by injecting through a soft rectal tube the usual barium enema. After the colon is completely filled, preferably slightly distended, the examiner disconnects the rubber tube from the enema reservoir and lowers it into a covered pail for the reception of the return flow. The colon, being stimulated to activity by the presence of this large amount of fluid which naturally is mildly irritating, becomes the seat of peristaltic contractions which may then be conveniently studied. If the ampulla of the rectum has been over-distended, there is a rapid emptying of it which is later succeeded by emptying of the sigmoid. After the emptying of the sigmoid which does not usually reveal active peristalsis but rather the exit of the fluid by a process of tightening, we find that peristalsis begins to be observed in the transverse colon. The point of the starting of the peristaltic wave being usually found to occur about the junction of the middle and right third of the transverse colon. The peristaltic waves having their origin at this point pass along the transverse colon, partly emptying the same, and force the content of the gut along through the splenic flexure, distending the upper portion of the descending colon. Here usually the peristaltic waves become interrupted for a time and then pass on emptying the lower portion of the descending and starting up two peristaltic waves in the sigmoid. After the transverse and descending colons are partly emptied, the peristalsis, in a normal gut, is seen to start in the lower portion of the cecum and empty the same very rapidly. Such is the usual phenomena observed when the colon filled by a barium enema is watched during the process of evacuation.

One of the advantages of this procedure is the ability to differentiate between the spastic constrictions of the transverse colon, for example, and organic strictures. One of the first cases examined by this method gave very instructive results. The clinical history was that a woman of sixty years of age who had been examined and a tentative diagnosis of annular carcinoma of the first portion of the transverse colon had been made. A narrowing of the gut at this point was observed, both by observation of the colon after the barium meal, and also after the barium enema. Manipulation of the transverse colon failed to satisfactorily fill this apparent defect. The patient's general appearance seemed to substantiate the tentative diagnosis of carcinoma at this point. However, there seemed to be a very reasonable doubt as to the correctness of a diagnosis of malignancy. However, the patient after being given a barium enema on a subsequent examination, the process of the emptying of the colon was watched and it was noted that the peristaltic waves as they passed along the transverse colon produced a relaxation of the spasm and the spastic constriction disappeared with a full relaxation of the muscular fibers as the waves passed along. In this case, the possible diagnosis of malignancy which was under debate for some time was disproved in a very graphic fashion and in a way which admitted of no further argument.

When one recalls the number of cases which have been operated upon for supposed malignancy in the transverse colon and where the findings at operation were those of an apparently normal colon, it is realized that this procedure of watching the colonic peristalsis is a valuable aid in diagnosis.

In watching the behavior of the peristaltic waves about the cecum in cases of right lower quadrant symptoms persisting after the patient has had the appendix removed, it was found that the peristaltic waves in the region of the cecum do not start at the tip as in an apparently normal cecum but start at the junction of the middle and upper third of the cecum. In some of these cases, the point of beginning of the peristaltic wave was very marked, giving the observer the impression of a band tied around the upper portion of the cecum. This appearance was found in few cases where the examination was made for the purpose of determining whether the patient presented the roentgen-ray findings of a so-called chronic appendix before the appendix was removed. In those cases where it was found by the barium meal that there was cecal retention, as well as retention in the appendix, the barium enema when observed with a returned flow catheter showed the sharp constriction at the junction of the middle and upper thirds. These findings substantiate the observation that in the upper portion of the cecum is often found a valve-like action of the constrictor muscular fibers.

In cases of constipation due to atony of the colon, we find the peristalsis very slow in starting, often requiring mechanical massage of the abdomen over varying areas of the colon to start the peristaltic waves. It is possible also by this method to study the comparative response of different sections of the colon to abdominal massage. Observations are being made at present to determine the value of this method in the investigation of tuberculosis of the cecum.

In conclusion, we believe that the use of the return flow rectal catheter after the introduction of a barium enema affords an easy method of studying normal colonic peristalsis, and also the variations produced by intracolonic pathology.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor: H. M. Imboden, M.D.

Associate Editors: James T. Case, M.D. H. K. Pancoast, M.D. J. S. Shearer, Ph.D.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922

Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page vii of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to Roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

LOS ANGELES MEETING

One afternoon of the Los Angeles session will be devoted to "sealed verdict" cases.

Any member having an interesting or unusual case, the roentgen diagnosis of which has been verified by surgery, pathological section or post-mortem examinations, is requested to send in lantern slides of the roentgenograms and a full clinical history. The verified diagnosis should also be forwarded in a sealed envelope. After the clinical history has been read and the lantern slides shown, an opportunity for all to express an opinion will be given. When everyone has made a "snap diagnosis" the seal will be broken and the verdict read.

All members of the Society, especially those not presenting communications at the annual meeting, are requested to take part in this portion of the program.

Send all communications regarding the above to:

Dr. W. H. Stewart,
222 West 79th Street,
New York City.

ANNOUNCEMENT

The Fourth Italian Congress of Radiology will take place at Bologna on May 9th, 10th and 11th at the Rizzoli Orthopedic Institute, under the presidency of Prof. Aristide Busi.

Annexed to the Congress an Exhibition of radiological apparatus will be held in which Italian, as well as foreign firms, may participate.

For further information apply to Dr. Alberto Possati, Secretary of the Congress, Villa Verde, Bologna.

CORRESPONDENCE

To the Editor:

There seems to be a considerable misunderstanding regarding the use of certain terms relating to the measurement of kilo-voltage of an *x*-ray tube. It occurred to me that it might be advisable to have this explained in the columns of the American Journal of Roentgenology, so that roentgenologists would have, at close hand, a place of reference in the future.

The misunderstanding seems to have arisen after a paper that I read in Chicago, in which I used the term "crest value."

We sometimes hear the term "peak value." After I had read this paper, using the term "crest value," there seemed to arise an opinion that I was introducing a new term. This is not the case, however. The terms "crest value" and "peak value" are used to mean the same thing, the difference being that the term "crest value" is standardized as the proper term by the American Institute of Electrical Engineers. This body of professional men publish a book called "Standards of the A. I. E. E.," and if one refers to the index of this book (1921), one will find that the term "peak value" does not appear. But, if the definition for crest factor or peak factor be consulted, the term "crest value" will be found defined. Section 3266 reads as follows: "*Crest factor* or *peak factor* of a wave is the ratio of the crest, or maximum, value to the r.m.s. value." Therefore, the term "crest value" is the proper term and "peak value" is not.

Section 8004 defines *Crest Voltmeter:* "A crest voltmeter is a voltmeter depending for its indications upon the crest, of maximum value of the voltage of the system to which it is connected. Crest voltmeters shall be marked in true crest volts and also in the r.m.s. value of the sinusoidal wave having the same crest value."

Section 2362 relating to *Measurements with Voltmeters*, states, relating to testing kilo-voltage: " . . . testing voltage must be checked by a spark gap as set forth in 2364 and 2366 or by a crest-voltage meter." Dr. H. M. Imboden:

Thus we have as crest voltmeters any kind of a device which depends upon the crest or maximum value of the wave for its reading.

Needle point gaps are acceptable within their ranges of voltages and certain size sphere gaps are usable within their ranges of voltages. There are also other devices which give continuous crest value reading which come within the specifications of the A. I. M. E., among which might be mentioned those of Farnsworth & Fortescue, Sharp & Doyle, Simplex Instrument, that of Ryan, and others.

Particular attention is directed to the fact that the A. I. E. E. *Standardization Rules* does not say that the crest value must be measured with a sphere gap nor does it say that only sphere gap measurements will be considered as standard, but only that the readings of the metering device must depend upon the *crest* or maximum value, only.

Montford Morrison

Consulting Engineer Research Laboratory
International X-Ray Corporation
326 Broadway, New York, N. Y.

TRANSLATIONS & ABSTRACTS

Stone. William S, The Present Position of Radium in the Study and Treatment of Uterine Cancer. (*Surg., Gynec. and Obst.*, June 1921.)

This entire article deserves careful reading by both the surgeon and the radiologist. It is possible here to give only the author's conclusions.

The histological changes produced in malignant tumors by the action of radium are described and the author states that clinical reparation follows such histological changes in tumors of the uterine cervix with such regularity that radium seems to have an almost specific effect.

From the study of 400 cases of uterine cancer the writer offers the following as the present therapeutic position of radium. In all recurrences it produces immeasurably better results than operation, provided they are not too far advanced and are not so closely associated with bladder or rectum that fistulae or severe functional disorders will result. Treatment of recurrences must be within narrower limits than in primary cases but in numerous instances it is possible to relieve pain, stop hemorrhage, and hinder the progress of the growth by one carefully adjusted dose, even when the advanced stage of the disease precludes the idea of any considerable regression.

Radium should be considered the method of choice for treatment of all cases of primary uterine cancer, with very few exceptions. Statistics of cases treated at the Memorial Hospital are given in support of this view.

Radium has particularly demonstrated its value in the so-called borderland cases. "With a properly adjusted dose and form of application, radium may be expected regularly to destroy all intra-uterine tumor tissue, and it is capable of destroying extra-uterine tumor tissue to a depth fully within the limits of what is generally regarded as operable with more certainty than operation." Operation after radium has produced an apparent regression of the tumor is probably a mistake. If radium treatment has produced an entire cure, operation is unnecessary, and if it has simply caused degeneration of the tumor cells and their encasement in fibrous tissue, operation can only serve to destroy the framework of fibrous tissue and free the cells for further activity.

When radium is used in conjunction with operation it is best used prior to it, but is also valuable as a prophylactic measure following operation.

Numerous cases of cauliflower growth are best treated by removal of the mass by the actual cautery and application of radium to the base, but care must be taken in these cases not to produce too far-reaching an effect.

In cancer limited to the body of the uterus the writer believes that operation is the only safe method of treatment. Radium, however, does not stimulate nor unfavorably influence such lesions and should be used one or two weeks prior to operation. He believes that such use will materially improve the results that have hitherto been obtained by operation alone.

Cancer limited to the cervix, especially if lymph nodes are involved should be operated upon but there should also be a previous application of radium.

The writer discusses the relative value of large amounts of radium used for a short time and small amounts used for a long time. Attention of those using a small amount of radium is directed to the necessity of adequate filtration and avoidance of the use of the soft beta radiation either by filtration or by obtaining distance by means of vaginal gauze packing. There should be a better appreciation of the undesirable effects of radium upon necrotic and infected tumor tissue. "In general, the chief error in the use of radium is overdosage."

A final plea is made to avoid treatment of primary cases that are too far advanced. Such treatment serves only to produce unnecessary suffering and will soon discredit the use of radium.

A. C. Christie.

William P. Graves, Present Status of the Treatment of Operable Cancer of the Cervix. (*Surg., Gynec. and Obst.*, June, 1921).

"The immense value of radium as a palliative agent in relief of inoperable cancer of the cervix was immediately established when it was first employed. The problem that confronts us at the present moment is not with regard to general value of radium in relieving symptoms and prolonging life; the specific question is whether we are justified in resorting to the simple application of radium in cases that are frankly operable, and in which an ultimate cure by surgical means is reasonably possible." The writer's personal experience answers this question somewhat as follows. There have been numerous surprising temporary cures from the use of radium which always eventuate in recurrence. The preoperative treatment of border-line cases has been disappointing. Postoperative use of radium has resulted in prolonging life in comparative comfort, but without cure. So far as known he has not cured any case of inoperable cervical cancer. The logical outcome of his own experience in the use of radium in inoperable cancer is the conclusion that he is not justified in substituting it for radical surgery in cases favorable for operation.

The writer discusses his results in 119 cases of radical operation for cervical cancer, with 6 deaths due to the operation and a five year curability percentage of 27.6 to 34.2, according to the method of computation.

Conservatism in the surgical treatment of cervical cancer has been made more rational by the advent of radium, for there is no longer the necessity for attacking the far advanced cases.

"Whether the ultimate treatment of curable cases shall continue to be surgical or whether surgery shall yield to radiation, the general outlook is encouraging. It depends in great measure upon the success that attends our efforts to educate the laity and profession to an earlier detection of the disease."

A. C. C.

Fowler, W. Frank. Benign Gastric Ulcer in a Known Syphilitic: A Résumé of the Literature Concerning the Diagnosis of Organic Gastric Syphilis. (*Surg., Gynec. and Obst.*, May, 1921.)

The writer summarizes his communication as follows:

Organic gastric syphilis is more frequent than formerly supposed. The gross lesions of gastric syphilis are (1) gummata in various forms, and (2) diffuse infiltration. Specific ulcers result from the degeneration of gummata. Symptomatically such lesions differ from benign ulcers chiefly in the absence of pain, ease from food and alkalies, less periodicity, anacidity, vomiting with good appetite, excessive weight loss and improvement in gastric function with specific treatment. Without operation the diagnosis usually rests upon a past history of early syphilis, present late syphilitic signs, Wassermann reactions and the therapeutic test. However, a negative Wassermann reaction does not exclude the possibility of gastric syphilis, and benign lesions of the stomach may occur in a known syphilitic. At operation specific ulcers are always multiple, ragged lesions occurring usually at the cardia, the lesser curvature, or the pyloric region accompanied often by perigastric adhesions, thickened gastric walls, and gastric deformity. Large gummatous tumor masses or cicatricial contractions subsequent to extensive ulceration simulate carcinoma, particularly as regards the type of dyspepsia, the vomiting, the rapid weight loss, and the anacidity, although the cachexia and loss of strength are less than that encountered in malignancy, and the course may have been longer. The operative findings consist, usually, of an irremovable gastric tumor mass indistinguishable from carcinoma. The *x*-ray evidence also simulates carcinoma. The roentgenographic signs of organic gastric syphilis in general consist of encroachments upon the lumen, distortions, and deformities. The microscopical evidence consists of the characteristic syphilitic obliterative endarteritis and perithelial lymphocytic infiltration with atrophy of the mucous membrane and hypertrophy of the submucosa and the muscularis. Post-mortem confirmation of the diagnosis is infrequent.

Conclusions:

1. Organic gastric syphilis may simulate (a) benign gastric ulcer, (b) gastric carcinoma, or (c) present an atypical gastric picture.
2. The diagnosis of organic gastric syphilis is often difficult and sometimes impossible.
3. A negative Wassermann reaction does not disprove the existence of syphilis and a positive reaction does not prove that a gastric lesion is specific.
4. The "therapeutic test" is usually reliable but not infallible.
5. The roentgenographic evidence is not conclusive.
6. Exploration may not be determinative, particularly as regards differentiation from carcinoma.
7. Atypical, chronic gastric disorders which are unresponsive to the usual treatment should arouse suspicions of syphilis.

A. C. C.

Pirazzoli. The Oculo-Esophageal Reflex as Seen on the Screen. (*Radiol. med.*, September 10, 1921.)

In the course of his routine work in the radioscopy of gastrointestinal diseases the author has been able to study an oculo-esophageal reflex, a phenomenon which does not seem to have received attention before. It seems to be accompanied by the oculocardiac reflex almost constantly, being elicited by the same pressure on the globe of the eye. At the instant of compression the subject is asked to swallow a large gulp of fluid. The pulse is tested at the same time in order to note the presence or absence of the oculocardiac reflex. The examination of the screen in the right anterior oblique position shows that at the moment of compression of the eyes the esophagus dilates and then rapidly evacuates itself. The pneumogastric nerve distribution makes possible this reflex. Water is held in the mouth at the time of the test.

The other or sensory portion of the reflex arc is the trigeminus nerve. The reflex proper is the sudden dilatation of the esophagus, the subsequent contraction being the sequel.

This phenomenon may have some diagnostic value in doubtful cases of stenosis, in spastic conditions, etc., by showing that the esophagus is intact.

Hoffmann. Radiotherapy of Mammary Carcinoma. (*Beitr. z. klin. Chir.*, 1921, cxxi, Heft 2.)

This author has collected material from the surgical clinics of Tubingen, Marburg, Rostock, Heidelberg, etc. and finds that radiotherapy for breast cancer is in the tentative stage. The absorption of the rays may be reckoned as 100–110 per cent of the erythema dose of the skin. But the intensity diminishes rapidly as the rays penetrate and at a depth of 2 cm. possesses only 70 per cent of that of the surface. This necessitates compensatory raying. The postoperative effect is the more commendable as the indications to prevent the recurrence are coherent. If the nodules of recurrence can be reached, they will disappear. Attempts should be made to reach cancer cells which the operation may have left behind, and which will provide the nodules of recurrence. The author does not favor the promiscuous and excessive radiation of the thorax.

In the present state of our knowledge we are not justified in radiation before operation. The ratio of success for scirrhus is one benefited or cured for the time out of 2 treated: while in the case of medullary cancer this ratio is one to 3.6. These ratios seem to refer to surgical results and show what radiation must accomplish to equal surgery.

Bancroft, Frederick W. Acute Haematogenous Osteomyelitis. (*Ann. Surg.*, June, 1921, lxxii, 6.)

A study of acute haematogenous osteomyelitis in children with drainage and postoperative Dakinization leads to the assumption that it might be possible to sterilize dead particles of bone, obviously sequestra from the roentgenogram, and permit them to be assimilated into the reparative process in the same manner as sterile bone grafts.

In an effort to determine the practical possibilities of such a method, a sterile osteomyelitis was produced in animals by inserting through a small opening in the bone, a capsule containing croton oil and plugged with agar-agar. The croton oil was confined in its container for a sufficient length of time to permit primary healing of the cortex before any evidence of the destruction caused by the liberated croton oil could be seen.

The sterile osteomyelitis which resulted caused extensive bone destruction and in several cases pronounced sequestration. This sequestration process was examined, not only from a roentgenographic standpoint, but also in gross and microscopic sections. True sequestration had occurred which in time was incorporated in the new bone formation. This would tend to show that sterile sequestra might be expected to act as bone grafts when present in the path of new forming bone.

Two cases in human beings were sighted and well illustrated, which suggest that a definite sequestrum, even in pyogenic osteomyelitis, may by Dakinization be rendered sterile, so that it may be incorporated in the new bone.

L. R. Sante.

Gähwyler, M. Nontuberculous Adenopathy of the Bronchial Glands and Calcification of the Same. (*Schweiz. med. Wchnschr.*, April 7, 1921, li, 14.)

According to the author, the presence of a deepened hilus shadow and the appearance of calcification must not be assumed as tuberculous. The profession have gone too far in this interpretation of *x*-ray plates. In some cases an ordinary hilus shadow has been so interpreted. The *x*-rays register these appearances, but the diagnostician must use other methods to make the differential diagnosis. The author now gives in detail case histories, of which we may repeat one. The patient was a boy, fifteen years of age who gave a history of much throat trouble from the age of six. After extirpation of the tonsils he had had numerous attacks of angina with fever. He kept well for a year, but had a return of the anginal attacks with dyspepsia and palpitation. He was a rugged boy, weighing 121 pounds, with enlarged, hard cervical lymph-nodes, sensitive to pressure, isolated. The physical signs suggested tuberculosis, but numerous repeated von Pirquet's and general tuberculin tests were negative. In the author's sanitarium at Arosa he soon lost his fever, but went through an attack of influenza which left him with a spasmodic tracheal cough difficult to control until a false membrane detached itself. At the same time a temperature of 104° subsided to normal. The *x*-ray findings at this juncture were cloudiness in the right apex; enlarged hilus shadow, diffuse with dim contours; while beneath the middle of the clavicle were two pea-sized bodies. The appearances in the left hilus were somewhat similar. The right lung was dull on percussion to the midscapular region; there were roughened breathing and reinforced whispering voice. Despite the suspicious evidences, the diagnosis was nontuberculous infection of the cervico-bronchial lymph-nodes.

The *x*-ray signs of bronchial tuberculosis, as described by at least four authoritative works on the subject, were found in 5 of these 7 cases, while two other writers demand something more than a mere increase of the normal hilus shadows. Conversely we know that rarely in bronchial tuberculosis are the usual *x*-ray appearances in evidence. Some of the most recent contributions to the subject contain opinions much less confident than those expressed by earlier workers. Thus Bandelier and Röpke state that the difficulties of recognition are underestimated. Much states that differentiation between tuberculous and other conditions may be almost impossible. Gottschalk has seen presumptive tuberculous shadows in asthma, and Güterbock mentions non-tuberculous bronchites with adenopathy of the hilus glands. After quoting other dissenting opinions the author sums up by stating that non-tuberculous affections of the bronchial glands may give all the evidence of tuberculosis, including the roentgen-ray plate and d'Espine's sign; that there is no typical *x*-ray plate of bronchial gland tuberculosis; that in the most varied conditions there may be enlarged and even calcified bronchial glands; that Nägeli's old autopsy findings should be revised up to date, as indicative of latent tuberculosis, and that no diagnosis of bronchial gland tuberculosis should be made without a tuberculin subcutaneous reaction test.

Pochon, G. (Paris). Tuberculosis and Decalcification. (*J. de méd. de Par.*, 1921, March 10, xi, 7.)

This subject is of great importance, but seems to have attracted but little attention from roentgenologists. If, as is claimed, the tuberculous subject has lost lime, either as a result of or contributory factor to his disease, and if, as is alleged, this decalcification should be sufficient to show at times in the shadow of the skeleton, the numerous plates of consumptive thoraces and long bones—in the case of surgical tuberculosis—do not seem to show any such state of affairs, nor is there any comment of any sort in the average *x*-ray report on the state of the skeleton. About 1900 Paul Ferrier wrote a classical paper on the relation between caries and tuberculosis. This and subsequent reports appear to show that the consumptive has somewhat more caries than the average dispensary patient and perhaps twice as much as the sound subject. In the absence of the literature we are ignorant as to the period at which decalcification appears, but find the statement that caries is seen in the pretuberculous period, and hence is rather a cause than an effect. A similar theory, not mentioned by Pochon, was set up years ago as the basis of the treatment of tuberculosis by hypophosphite of lime. Pochon relates the case of a highly tuberculous family in which the contagion must have been propagated from person to person. One of the children, tuberculous at the age of eleven (tracheobronchial glands), subsequently outgrew his condition and at nineteen was playing football. In this game he sustained a fracture of the leg in which the roentgen-ray examination showed total failure of callus formation and general decalcification of the skeleton. The patient had to wear a brace by reason of the incomplete union, although there was no pseudarthrosis. After the accident there was a sudden development of pulmonary tuberculosis. Both happenings are attributed to decalcification.

Palugyay, J. (Vienna). Traction-Diverticulum of the Esophagus Shown by Radioscopy. (*Wien. klin. Wchnschr.*, April 7, 1921, xxxiv, 14.)

As a rule this affection is silent during life and is discovered by chance at autopsy. In contradistinction from pulsating diverticula there is no interference with swallowing, nor does the cavity become stuffed with food, because its opening is wide and the volume small. Symptoms tend to appear only in infection, with ulceration or necrosis at the apex. But one case is on record of satisfactory demonstration by *x*-rays of a traction diverticulum reported by Helm in 1918, and the author is able to add another. Patient was a man of fifty-nine years with cancer of the fundus of the stomach extending to the cardia. Repeated roentgen-ray plates and ordinary inspection of the esophagus failed to bring this malformation to light. In one plate a concentration appeared in the mediastinal area which suggested a possible induration. Finally, however, the screen was used in the Trendelenburg position to bring out the function of the cardia. When contrast-pulp was introduced into the esophagus, peristalsis was seen to extend to the cardia, the contrast-mass being carried to this point, and as it passed the level of the tracheal bifurcation the shadow of the diverticulum appeared—of funnel shape with rounded apex, directed obliquely cranialwards. This was about the size of a small plum, the opening being about 1.5 cm. broad. After the contrast-mass had been carried along, some of it still remained in the diverticulum, which was on the right side of the esophagus at the level of the bifurcation.

Upon the death of the subject from cancer, autopsy confirmed the diagnosis. On the screen it would hardly have been possible to exclude pulsating diverticulum. Perforating cancer of the esophagus would not have been compatible with the smooth walls of the diverticulum and of the near-by esophagus. The character of the peristalsis should have excluded the likelihood of spasm of the esophagus.

Edling, Lars (Lund). On Plastic and Elastic Means of Application in Radium Therapy. (*Acta Radiologica*, Sept. 20, 1921, Vol. 1 No. 2.)

This work gives a report on a method of application in radium therapy originally discovered by the author in 1915 and developed by him in the following years by the use of plastic dental compounds.

The first part of the work describes the origin and development of the author's method. His technique may be thus summed up: *An impression of the tumor and its immediate neighborhood is prepared out of the plastic compound. On the outside of this cast the radium tubes and filters are attached according to the indications furnished by the impression, the plastic compound itself serving partly as a secondary filter and partly as a means of regulating the distance of irradiation. Finally, both the protective arrangements for the healthy tissues and the actual fixing of the apparatus are secured by the aid of the plastic compound.*

This method may be used not only in skin diseases, but also on the tumors of a great many mucous membranes.

Further on, the author dwells in considerable detail on the results of the chemical and physical researches brought about by him in order to investigate the filtering properties of the dental compounds. Among the compositions thus analyzed the "Kerr Perfection Impression Compound" proved by far the most suitable. All the compounds seem to have a percentage of inorganic substance, varying between 50 and 57 per cent and virtually consisting of aluminum-magnesium oxide, probably a modification of the mineral *Spinel* (Mg_0, $Al_2\ O_3$). This is to be regarded as an advantage, since aluminum and probably also magnesium are distinguished by giving a relatively inconsiderable secondary radiation.

The filtering measurements of the plastic mass have been carried out by comparison with the secondary filter mediums heretofore generally used, viz: india rubber, paper and surgical gauze, and have given the following results, illustrated by curves:

(*a*) The impression compounds as well as the secondary filters just named absorb the primary radiation of radium in a very slight degree (12–20 per cent of the total radiation).

(*b*) As to the emergence radiation of the secondary filtering mediums as such, it will rapidly increase with a very thin layer of material (about 1 mm.) but then again rapidly diminish; with "Kerr," it is considerably less than with the other secondary filters (at least in thicknesses of 2–10 mm).

(*c*) The measurements of combinations of lead filters with various secondary filter mediums have shown that these will cause a considerable decrease of the emergence radiation with thin layers of the material (as to "Kerr" by a percentage of about 80 per cent with a layer 1 mm. thick, an absorption that will remain nearly constant with an increase of thickness up to 10–11 mm., which proves the advantage of that substance in radium therapy).

In the following parts of the work the author gives an account of the general principles of the use of the plastic substance in therapeutics, and further, in special chapters, detailed descriptions of the different appliances and modifications afforded by the plastic method in the treatment of tumors of various skin regions, of the lips, of the mucous membranes of the mouth, jaws, palate and tongue. Next he discusses the application of radium in the upper air-passages, including the palatine arches, and finally in the female genital organs. As to these different details, however, we must refer to the work itself.

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ROENTGEN RAYS AND RADIUM IN THE DIAGNOSIS AND TREATMENT OF CARCINOMA OF THE PROSTATE*

BY H. C. BUMPUS, M.D.

Mayo Clinic

Rochester, Minnesota

THE favorable results reported by Pasteau and Degrais (1910) in the treatment of cancer of the prostate by radium inspired the hope that a satisfactory treatment for this condition had been discovered. Since then many others have reported similar results, but such reports have been made too soon after treatment, or the series of cases reported has been too small on which to base judgment. Neither have there been series of cases reported of what might be termed normal or untreated cases with which to compare results. Thus it has been difficult to judge accurately the results obtained with the use of radium.

The series of 646 cases of carcinoma of the prostate which I shall report is sufficiently large to afford statistical data of value with regard to the various forms of treatment employed, especially radium. Until within recent years correct diagnoses in cases of cancer of the prostate were often not made unless the patients were operated on. Thus many cases were classified as benign hypertrophy which were undoubtedly malignant.

During the past three years 1,641 patients with prostatic enlargement were examined. In 260 of these (15.84 per cent) the prostates were malignant, a percentage which I believe is accurate and indicative of the prevalence of the disease. In the series of 646 patients the prostate was removed in 146, no form of treatment was employed in 325; the remaining 197 patients were treated by radium. The statistics in the first two groups afford a basis on which the results of radium treatment in the 197 patients may be compared.

The results of surgical treatment are tabulated in Table 1.

DISCUSSION OF TABLE 1

The fact that 80 per cent of the patients died within two years after operation and that of the sixteen patients who lived more than three years only seven are alive, explains the readiness with which surgeons relinquished this group of cases to radium treatment.

Just as in the past, reports of the results of surgical treatment were made too soon after operation to be accurate, so in the present the reports of the results of radium treatment are made too soon to afford accurate data. It is evident that in order to judge accurately the various forms of radium treatment it is fairer to compare data from a series of patients who have not been treated than from a series of patients treated surgically, who were in good physical condition and in whom the disease was not far advanced.

The group of 325 untreated patients includes patients in all stages of the disease and represents the type that have

* Due to the great length of the paper awarded the Leonard Prize, the Committee decided not to publish it in the JOURNAL. Certain of the other papers which were awarded Honorable Mention, of which this is one, will be published.

Table I

ONE HUNDRED FORTY-SIX PATIENTS OPERATED ON

Operative Mortality 5.5 Per Cent

	Patients	Per Cent	Average Duration of Disease, Months	Prostatectomy* Perineal	Prostatectomy* Suprapubic	Average Length of Life After Operation, Months	Average Age, Years
Heard from......	120	.....	62.36	42	75	24.86	64.27
Dead..............	96	80.0	51.3	41	52	21.72	64.95
Living..............	24	20.0	80.2	1	23	35.2	63.58
Patients who lived							
1– 12 months............	41	34.16	40.4	19	22	6.18	65.8
13– 24 months............	23	19.16	45.95	8	15	18.86	63.13
25– 36 months............	14	11.66	56.64	8	6	38.14	65.07
37– 48 months............	1	0.83	168.0	1	0	41.0	62.0
49– 60 months............	3	2.5	77.33	1	2	53.3	65.0
61– 72 months............	2	1.66	95.5	1	1	70.0	60.5
85– 96 months............	1	0.83	168.0	1	0	96.0	64.0
97–108 months............	2	1.66	156.0	0	2	103.5	72.0
Not stated	9	7.5	......	2	4		
Patients living							
1– 12 months............	4	3.33	66.75	0	4	10.2	64.75
13– 24 months............	8	6.66	67.85	0	8	19.87	66.25
25– 36 months............	5	4.16	71.0	0	5	31.8	61.4
37– 48 months............	1	0.83	87.0	0	1	48.0	69.0
49– 60 months............	2	1.66	83.0	0	2	52.5	53.5
61– 72 months............	2	1.66	83.0	0	2	67.5	59.0
73– 84 months............	1	0.83	139.0	0	1	78.0	75.0
109–120 months............	1	0.83	174.0	1	0	120.0	61.0

* Operation not stated in three cases.

Table II

THREE HUNDRED TWENTY-FIVE PATIENTS NOT TREATED

	Patients	Per Cent	Average Duration of Disease, Months	With Metastasis	Without Metastasis	Average Length of Life After Examination, Months	Average Age, Years
Heard from................	231	.....	34.59	55	176	11.8	64.84
Dead....................	215	93.0	32.82	52	163	9.58	64.71
Living....................	16	6.9	59.15	3	13	39.06	66.6
Patients who lived							
1– 12 months............	149	64.5	29.1	42	107	4.97	64.34
13– 24 months............	32	13.85	41.66	9	23	17.53	65.18
25– 36 months............	8	3.46	46.28	0	8	28.37	67.5
37– 48 months............	3	1.29	75.0	0	3	44.3	67.0
49– 60 months............	2	0.86	68.0	0	2	52.0	68.5
73– 84 months............	1	0.43	.....	0	1	78.0	69.0
Not stated................	20	8.65	.....	1	19	.....	.....
Patients living							
1– 12 months............	4	1.73	10.0	1	3	19.3	66.5
13– 24 months............	4	1.73	32.7	2	2	19.75	68.7
25– 36 months............	1	0.43	149.0	0	1	29.0	70.0
37– 48 months............	2	0.86	120.0	0	2	47.0	68.5
49– 60 months............	1	0.43	49.0	0	1	49.0	66.0
61– 72 months............	2	0.86	73.0	0	2	70.0	63.5
73– 84 months............	1	0.43	.....	0	1	79.0	63.0
108–120 months............	1	0.43	144.0	0	1	118.0	62.0

been treated with radium. Information has been received concerning 231 of these (71 per cent), thus affording an opportunity to study the disease when its course was not altered by treatment and to compile accurate statistics as a basis of comparison with the results of several methods of radium treatment.

DISCUSSION OF TABLE II

The noteworthy fact in this series is that the patients who died, and in whom, therefore, the disease had run its course, lived an average of 9.58 months after they were examined and an average of 32.82 months from the time of their first symptoms; this may be considered representative of the average duration of the disease. The sixteen patients (6.9 per cent) who are still alive constitute two types, those who have recently refused treatment and who have not lived out their allotted 32.82 months, and those whose cases were wrongly diagnosed. This percentage seems remarkably low when it is considered that the diagnoses were all made by palpation alone and were not checked up by pathological findings as were the diagnoses in the surgical group. The low percentage is undoubtedly due to the fact that when the diagnosis was in doubt the patient was given the benefit and operation was performed. It does not seem legitimate, however, to use these percentages as a basis of comparison in ascertaining the results of radium treatment, since fifty-five of the patients had metastasis at the time of their examination.

While opinions differ concerning whether or not radium and the roentgen ray treatments are beneficial in cases in which metastasis has occurred, I believe that all observers are agreed with regard to the influence of metastasis on prognosis.

DISCUSSION OF TABLE III

The influence of metastasis on prognosis is illustrated in the group of fifty-five patients, 94.54 per cent of whom died on an average of 7.72 months after their examinations, two months earlier than the average. It is probable that the majority of patients with carcinoma of the prostate develop metastasis some time before death, but in some this occurs early and the presence of many such patients in this group explains the shortening of the average duration of the disease, which was 29.25 months, four months less than the average.

It may also be noted that the average age of these patients, 63.5 years, is below the general average of the patients with the disease.

The fact that 76.36 per cent of these patients died during the ensuing years is sufficient evidence of the hopelessness of the condition. Palliative treatment, such as the roentgen ray or radium, was not attempted in these cases. The smallness of this group, consisting of 27.6 per cent of the patients examined, is evidence that

Table III

NINETY PATIENTS WITH METASTASIS

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Length of Life After Examination, Months*	*Average Age, Years*
Heard from...	55	.....	28.78	8.15	63.4
Dead.........	52	94.54	29.25	7.72	63.5
Living.........	3	5.45	21.3	15.0	64.0
Patients who lived					
1–12 months.......	42	76.36	27.51	5.56	62.42
13–24 months.........	9	16.36	37.75	17.1	67.6
Not stated............	1	1.81	....	....	....
Patients living					
1–12 months...........	1	1.81	10.0	8.0	65.0
13–24 months..........	2	3.63	27.0	18.5	63.5

until recent years it has not been appreciated how frequently metastasis occurs, especially in the bones.

TABLE IV

METASTASIS REVEALED BY ROENTGENOGRAMS: 228 PATIENTS

	Examined	*Metastasis*	*Per Cent*	*Age*
Total	228	69	30.26	63.3
Pelvis	153	46	30.7	62.76
Spine	154	40	25.97	62.5
Lungs	140	8	6.4	65.5
Ribs	141	8	5.0	66.0
Femurs	122	7	5.7	63.4

DISCUSSION OF TABLE IV

Of the 646 patients only 228 (35.29 per cent) were examined roentgenographically for metastasis, and of this number 163 (71 per cent) were examined during the past three years. In the early cases, the roentgen ray was not as easily available as it is now, and the impression seemed to prevail that it was sufficient if the chest was examined for metastasis. This accounts for the fact that until within the last year more roentgenograms were made of the chest than of the spine and pelvis. Data compiled previous to the last year showed that the pelvis was involved in 37.5 per cent of cases, the lumbar spine in 35.8 per cent, and the lungs in 3 per cent; the latter were never involved unless metastasis was demonstrable elsewhere. It is significant that these percentages which were compiled from a series of only 135 cases, still hold true in this larger series of 228 cases in which the pelvic bones were involved in 30 per cent, the spine in 25.97 per cent, and the lungs in but 6 per cent.

The data in Table IV shows that if the spine, the pelvis, and the femurs are examined by the roentgen ray routinely in all cases of diseased prostates suspected of being malignant, a negligible number of cases of metastasis will remain undiscovered. It does not seem necessary to examine the chest as a routine procedure since metastasis to the lungs alone probably never occurs in these cases. It would seem conservative to state that 30.26 per cent, or practically one-third of all patients with carcinoma of the prostate, will be found to have metastasis to the bones, and the overwhelming percentages will be found in the pelvis, the spine, and the femurs. The average ages of the patients also bear evidence of the lateness of metastasis to the lungs. The average age in the entire series of 646 patients is 64.6 years; the average age of patients with metastasis to the pelvis and spine is from one to two years less; and of patients with metastasis to the lungs and ribs from one to two years more, demonstrating still further that metastasis does not occur in the chest until after it occurs in the spine and pelvis.

Stewart believes that in the majority of cases of metastasis to the bones the primary growth can be diagnosed by the roentgenographic appearance of the metastasis. He

FIG. 1 (345,243). Metastasis to the pelvis, sacrum and lumbar spine.

quotes from Phemister as follows: "Metastasis in bony structure following a primary carcinoma assumes the characteristics of the original growth; if the stroma predominates in the primary lesion, we are sure to have a condensing or osteoplastic form of metastasis; if the primary cancer were of a medullary form, we would have a secondary rarifying or osteoclastic process."

Stewart calls attention to the fact that in carcinoma of the prostate the stroma predominates, and a condensing form of secondary lesion should occur (Figs. 1, 2, 3, 4, 5 and 6). This is in keeping with von Recklinghausen's findings and applies to the majority of cases, but as may be seen in Figures 7, 8 and 9 osteoclastic metastasis also occurs and although it occurs infrequently there is little chance of error in the diagnosis. The osteoclastic type of metastasis is found in the majority of cases. The close similarity of this type to Paget's disease has recently been emphasized by Carman and Carrick; this may be readily appreciated by an examination of Figures 10, 11, 12, 13, 14, 15, 16 and 17, in which the two conditions in similar locations are illustrated for comparison.

Fig. 2 (181,438). A condensing form of secondary lesion with extensive osteoclastic metastasis in the femur and pelvis.

Fig. 4 (201,980). Metastasis to the lumbar spine, pelvis and sacrum.

Fig. 3 (181,438). Extensive metastasis to the sacrum, lumbar spine and ilia.

Fig. 5 (194,448). Area of metastasis to the right lung.

In cases in which the prostatic enlargement is unquestionably malignant, the possibility of error in diagnosis is negligible. However, there is a less frequent form of prostatic malignancy in which the uniform enlargement was without any of the irregularities of contour presented by the common type of carcinomatous gland and without the characteristic stony hard areas. This type of malignant gland resembles true inflammatory hypertrophy and often is confused with it, but it differs in that the resilience is lost, while in inflammatory disease it always remains. Such glands never reach a size that cannot be

Fig. 6 (288,379). Metastasis to the ribs.

Fig. 8 (125,337). Osteoclastic metastasis; the right pelvic bone and ischium destroyed.

Fig. 7 (289,964). Destruction of right ischium, as the result of a metastatic growth in which the osteoclastic tendency predominates.

Fig. 9 (311,469). Destruction of the right ischium, the result of a metastatic growth in which the osteoclastic tendency predominates.

outlined by the examining finger, because they are composed of cells which exhibit no tendency to acinus formation but are scattered throughout a somewhat increased fibrous stroma and metastasize so early that death results before the gland becomes greatly enlarged. A section from this type of gland (Fig. 18), illustrates its close resemblance to scirrhous carcinoma of the breast. The reason for early metastasis is shown by the cells infiltrating a somewhat increased fibrous stroma and exhibiting no tendency to acinus formation. In such cases the rheumatic pains of metastasis, or the paraplegia of spinal involvement, are frequently the first symptoms, and the patients often die before any urinary symptoms occur to call attention to the prostate as the primary focus of extensive metastasis to the bones. Or, if the prostate is examined its slight enlargement and its atypical feel of carcinoma make a diagnosis of malignancy doubtful. If it cannot be determined that the prostate is malignant, and there are no urinary symptoms, the condition may be Paget's disease. The mistake has been made of diagnosing as malignant an old firm inflammatory prostate because the roentgenograms revealed what was supposed to be metastasis to the bones. In Paget's disease the bodies of the lumbar vertebrae are flattened and widened, while

Fig. 10 (345,243). Metastasis to the spine from carcinoma of the prostate.

Fig. 11 (343,042). The spine in a case of Paget's disease. Pronounced flattening and deformity of the vertebræ (Fig. 10).

FIG. 12 (324,762). Lumbosacral region in a case of carcinoma of the prostate with metastasis. Note similarity of condition with that shown in Figure 13.

FIG. 13 (318,460). Lumbosacral region in a case of Paget's disease. Note similarity of condition with that in Figure 12.

in malignant conditions there is little if any change in the shape of the vertebrae. However, as Carman and Carrick point out, there is one means of making the diagnosis certain: "If the skull shows the pathognomonic changes of Paget's disease, that is,

FIG. 14 (334,035). Metastasis to the pelvis from carcinoma of the prostate.

thickening and density of the inner table and the finely porous outer table with scattered nodules of bone over the vault, the diagnosis of Paget's disease is certain." Therefore, in all cases of apparent metastasis to the bones in which the prostate is suspected of being malignant, roentgenograms should be made of the head before a

FIG. 15 (302,252). The pelvis in a case of Paget's disease.

positive diagnosis is made. From the foregoing, it is evident that if the untreated cases are used as a basis of comparison of results obtained from radium therapy, the cases in which metastasis was found must be excluded (Table v).

DISCUSSION OF TABLE V

Since the patients who received radium treatment were treated immediately following the diagnosis, it seems logical to consider the length of life of the untreated

Fig. 16 (212,968). Metastasis to the femur from a case of carcinoma of the prostate.

Fig. 17 (289,230). The femur in a case of Paget's disease, showing similarity to Figure 16.

patients following the diagnosis, to be comparable with the length of life of those who received treatment. This period in the untreated patients is 12.98 months, or thirteen months.

In order not to base such an extensive statistical study on one period of time the duration of the disease in each case from the first symptom to the time of death has been obtained. These data are subject to a certain degree of error, since carcinoma may develop on benign hypertrophy and

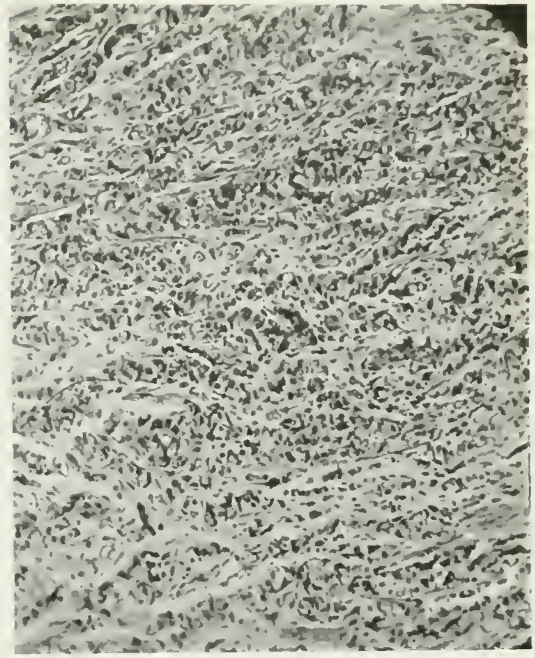


Fig. 18 (20,348). Highly malignant adenocarcinoma. This type causes only slight local enlargement but metastasis early, often resulting in the metastasis being confused with Paget's disease, because of slight prostatic enlargement.

the first symptoms may be due to the benign hypertrophy rather than to the malignancy. However the group of patients with atypical carcinoma of the prostate who do not have symptoms until the disease is well advanced, offsets this error and it seems accurate to consider the average length of the disease to be 36.61 months or three years, and the average duration of life after diagnosis, thirteen months. These periods are used as the basis for judging the results of the various methods of radium application. Besides these averages there is recorded for comparison in each group the number of patients that died in each year after treatment, for it is evident that if averages alone are used as the basis of comparison, the few successfully treated patients become merged in the general average and their importance as a basis of comparison is lost. Also, in considering the length of the disease, it must be kept in mind that the patient is never considered cured, and if the length of the disease has been extended by any method of treatment beyond the three-year-average period for untreated cases, it is considered favorable.

TECHNIQUE OF RADIUM TREATMENT

In the first cases of carcinoma of the prostate treated by radium the radium was introduced through the urethra. In well-advanced cases, however, the necessity of applying large doses resulted in urethral burns. Cross-firing was then attempted by applying half the dose through the rectum. The mucosa of the rectum proved to be even more susceptible to burns than that of the urethra and great care was necessary in screening and in regulating the duration of the exposure. An applicator similar to the one described by Young was used, the rectal mucosa being protected by brass and lead screens except at the point of exposure. The treatments were given every third or fourth day until the desired dosage was obtained. Forty patients, including seven in which

TABLE V

TWO HUNDRED THIRTY-FIVE PATIENTS WITHOUT TREATMENT AND WITHOUT METASTASIS

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Length of Life After Examination, Months*	*Average Age, Years*
Heard from	176	.....	36.61	12.98	65.25
Dead	163	92.6	34.08	10.13	65.09
Living	13	7.3	70.5	44.61	67.23
Patients who lived					
1– 12 months	107	60.79	29.72	4.76	65.1
13– 24 months	23	13.1	43.09	17.69	64.21
25– 36 months	8	4.5	46.28	26.37	67.5
37– 48 months	3	1.7	75.0	44.3	67.0
49– 60 months	2	1.13	68.0	52.0	68.5
73– 84 months	1	0.56	..	78.0	69.0
Not stated	19	10.79	.	......	.....
Patients living					
1– 12 months	3	1.7	10.0	9.66	67.0
13– 24 months	2	1.13	38.5	21.0	74.0
25– 36 months	1	0.56	149.0	29.0	70.0
37– 48 months	2	1.13	120.0	47.0	68.5
49– 60 months	1	0.56	49.0	49.0	66.0
61– 72 months	2	1.13	73.0	70.0	63.5
73– 84 months	1	0.56	....	79.0	63.0
108–120 months	1	0.56	144.0	118.0	62.0

TABLE VI

FORTY PATIENTS TREATED BY RADIUM THROUGH THE RECTUM AND THE URETHRA

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Urethra*	*Rectum*	*Milligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from	37		44.09	2.36	250.0	1537.91	1585.2	18.27	66.2
Dead	33	89.18	42.2	2.5	225.0	1581.9	1622.8	15.31	62.6
Living	4	10.81	62.3	1.2	400.0	1175.0	1275.25	42.0	70.75
Patients who lived									
1–12 months	17	45.94	33.4	1.23	220.0	1162.6	1286.1	6.64	63.58
13–24 months	7	18.91	39.0	2.68	.	1503.4	1503.4	17.0	66.0
25–36 months	6	16.21	57.5	5.55	250.0	2269.0	2310.6	28	69.00
37–48 months	2	5.4	93.0	4.7	.....	3250.0	3250.0	43.0	67.5
Not stated	1	2.7	.....		...	.....	.	.....	....
Patients living									
37–48 months	4	10.81	62.3	1.2	400.0	1175.0	1275.25	42.0	70.75

both urethral and rectal applications were given were treated in this manner. Information has been obtained concerning thirty-seven (92.5 per cent) of these (Table VI).

DISCUSSION OF TABLE VI

The technique employed in the treatment of these forty patients had several distinct advantages, the most important of which is the great amount of radiation reaching the periphery of the growth in which location the greatest cell activity occurs. The application is easily accomplished and a comparatively small amount of radium is required, a standard of 50 mg. or 100 mg. tube being sufficient. The applicator is of simple design and adapted to general use. The chief drawbacks were the irritability of the rectal mucosa which frequently did not permit the amount of radiation indicated even with the greatest care in screening. Although the area of greatest cell activity receives the greatest amount of radiation, yet even in moderately enlarged glands, comparatively small amounts of radiation reach the center of the growth where cell activity, although not so active, nevertheless takes place. Therefore, unless all portions of the growth receive sufficient dosage to impair this activity, satisfactory results cannot be expected.

With these disadvantages in mind, it is interesting to observe the clinical results recorded in Table VI. In these the average length of disease was forty-four months, eight months longer than the average of untreated patients. The average length of life after treatment is eighteen months, five months longer than could be expected if no treatment had been given. While these data are evidence of the inhibitory influence of radium on the disease, this inhibitory influence is not sufficient to commend the treatment. For merely to delay the inevitable for a short period, rather than appreciably to arrest the disease process, is a result which is not to be sought when death is often more longed for than dreaded.

Statistics of the average length of life are valuable, but they must not be taken as final since they may obscure several cases in which the results indicate marked advantages to such treatment. For example, six patients (16.21 per cent) lived more than three years; four are still alive, while only seven (3 per cent) of those not treated are alive three years after examination. This is encouraging when the hopelessness of the condition is considered, but not encouraging enough to warrant urging the patient to take the treatment with considerable expense and inconvenience. Marion, realizing the difficulty of properly radiating all parts of the gland by this method, and probably being cognizant of the clinical results, inserted a trochar directly into the substance of the gland, and by means of the obturator placed the radium tube directly into the tissue. The tube was withdrawn by means of an attached string after the required application.

Barringer described a similar but far superior method. He placed the radium in a hollow needle, and guided by a finger in the rectum, inserted it directly into the gland through the perineum. This method seemed so superior to all others that the earlier procedures were for the time abandoned. The cases so treated are reported in Table VII.

DISCUSSION OF TABLE VII

The thirty-five patients whose cases are reported in Table VII were treated by means of needles alone. The average length of the disease in the twenty patients heard from in this group is prolonged approximately four months beyond the normal three years. The average length of life, however, after such treatment, is two months less than that of those not treated. The dosage in this series averaged 1,200 mg. hours, approximately 455 mg. hours less than in the group in Table VI. The decreased dosage is not a sufficient reason to explain the poorer results obtained, results which are still more strikingly brought out when the individual cases are examined. Ten (50 per cent) of the patients died the first year after treatment, seven of the remaining ten died the second year. The date of one patient's death is not given, and the two living patients have not yet lived two years after treatment. Regrettable as

Table VII

THIRTY-FIVE PATIENTS TREATED BY NEEDLES

	Patients	Per Cent	Average Duration of Disease, Months	Average Duration of Treatment, Months	Needles	Milligram Hours	Average Length of Life After Radium Treatment, Months	Average Age, Years
Heard from.	20		39.68	1.5	1201.9	1201.9	11.0	63.95
Dead.........	18	90.0	41.05	1.75	1250.94	1250.94	10.47	63.5
Living.........	2	10.0	28.0	1.0	760.0	760.0	15.0	68.0
Patients who lived								
1–12 months.......	10	50.0	37.6	1.17	1246.1	1246.1	5.4	61.3
13–24 months....	7	35.0	29.6	2.76	1657.6	1657.6	17.0	65.4
Not stated.......	1	5.0	...	....	....	......		.
Patients living								
1–12 months....	1	5.0	29.0	1 da.	850.0	850.0	7.0	68.0
13–24 months....	1	5.0	27.0	1 da.	671.0	671.0	24.0	68.0

these results may appear they are nevertheless valuable, for they demonstrate clearly that neglect to radiate the periphery of the growth, where the greatest cell activity occurs, will result in failure. They also show that if radium is placed within the gland tissue, the gamma rays do not penetrate sufficiently to reach the peripheral cells, or, if they do, are too greatly diffused to be effective. It was evident, therefore, that the amount of radium should be increased, and an attempt was made to give, if possible, between 3,000 and 4,000 mg. hours, 2,000 by needles, the remaining 1,000 by rectum and urethra.

In giving this larger dosage a modification of the old applicators was found useful. The great majority of such apparatus consists of an arm attached to the examining table which holds in place a metal tube containing the radium. It was found, however, that a piece of sheet lead cut in the shape of a spoon (Fig. 19) is the most satisfactory applicator. The small metal container holding the radium is placed in the bowl and the lead is bent over three sides of it. Over this a hard rubber tube is slipped to filter the beta rays on the exposed side; thus the rectal mucosa is screened by lead except the portion directly over the prostatic area; there the irritating rays are filtered out by the hard rubber tube. When the applicator is inserted and placed in the desired position, the open side of the bowl is placed next to the prostate, the handle is bent at right angles and attached to the thighs or buttocks by surgeons plaster. This method allows the patient to move around freely while recumbent and while the applicator is still in position, instead of subjecting him to the discomfort of remaining in one position on an examining table to which a rigid mechanical arm is attached. In making the urethral applications, screened only by the standard silver container, nothing has proved so

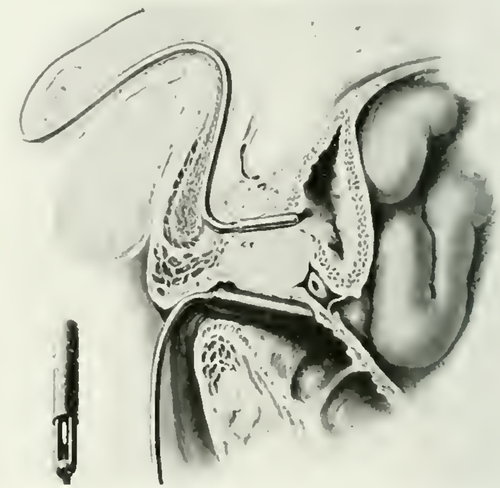


Fig. 19. Cross-section through the pelvis. Rectal and urethral applicators in place. Inset: rectal applicator; (a) hard rubber sheath, (b) lead spoon, and (c) standard radium tube.

useful as a stick of soft solder, the end of which is threaded so that the container may be directly screwed on. The stick of solder can be bent to adapt it to the various prostatic curves, and is easily kept in position (Fig. 19).

The results of the increase in dosage and more thorough radiation of the prostate are difficult to interpret, because this group of patients was treated more recently than the others. A casual examination of Table VIII might lead to the conclusion that the change in treatment had not resulted in improvement.

DISCUSSION OF TABLE VIII

Obviously in dealing with recent cases, the duration of the disease to the time of treatment only 28.78 per cent died the first year. Although sufficient time has not elapsed to give a higher percentage among the living it should be noted that the length of life following treatment already exceeds the average for the patients not treated and that the living represent 54.54 per cent of the patients heard from. The results argue well for the change in treatment.

Table VIII

NINETY-SEVEN PATIENTS TREATED BY NEEDLES AND BY URETHRA AND RECTUM

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Needles*	*Urethra*	*Rectum*	*Milligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from	66	...	34.37	6.9	1655.9	304.95	437.47	2240.72	12.76	64.33
Dead...	30	45.45	26.96	4.32	1144.7	352.88	423.55	1625.46	11.28	64.9
Living.	36	54.54	39.88	7.56	2081.91	291.03	448.69	2753.44	13.91	63.86
Patients who lived										
1–12 months...	19	28.78	26.52	2.37	1242.68	374.33	319.61	1609.15	6.84	65.57
13–24 months.	8	12.12	32.42	6.4	777.5	...	402.5	1180.0	18.5	62.37
37–48 months..	1	1.51	...	3.2	2062.0	550.0	2870.0	5482.0	38.0	55.0
Not stated...	2	3.03	.....	.	......	.....	......	......	.....	.....
Patients living										
1–12 months..	19	28.78	40.94	4.6	1627.0	274.22	471.0	2410.42	8.94	64.21
13–24 months.	15	22.72	38.07	8.49	2593.73	330.5	524.26	3255.73	17.89	63.6
25–36 months..	1	1.51	36.0	1.9	2210.0	120.0	120.0	2450.0	26.0	62.0
37–48 months..	1	1.51	49.0	2.45	1920.0	......	120.0	2040.0	37.0	63.0

Table IX

ONE HUNDRED SEVENTY-FIVE PATIENTS TREATED BY RADIUM ONLY

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Needles*	*Urethra*	*Rectum*	*Millligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from.	126	..	38.58	4.27	1526.65	296.76	836.65	1866.49	14.17	64.88
Dead....	84	66.6	37.3	2.89	1183.79	301.73	1040.09	1541.16	12.83	64.96
Living.	42	33.3	40.97	6.95	1959.73	294.43	521.3	2493.9	16.66	64.71
Patients who lived										
1–12 months....	46	36.5	31.44	1.69	1243.86	159.33	729.94	1410.86	6.45	63.91
13–24 months.	22	17.46	33.9	4.14	1154.71	.....	916.26	1424.28	17.57	64.5
25–36 months..	6	4.76	57.5	5.55	.....	250.00	2269.0	2310.66	28.6	69.66
37–48 months..	3	2.38	93.0	13.8	2062.0	550.0	3123.3	3994.0	41.3	63.3
Not stated.....	7	5.55	....	..	....	....	......	.....	......	....
Patients living										
1–12 months....	20	15.87	38.9	4.6	1588.15	259.78	471.0	2332.4	8.85	64.4
13–24 months....	16	11.76	37.33	7.97	2473.55	330.5	524.26	3094.18	18.25	63.87
25–36 months..	1	0.79	36.0	19.0	2210.0	120.0	120.0	2450.0	26.0	62.0
37–48 months.	5	3.96	59.0	5.9	660.0	......	964.0	1428.0	41.0	69.2

death and the length of life following treatment do not represent completed averages. Judgment must, therefore, be based on other sources. In the group of patients treated by rectum and by urethra, 45.94 per cent died during the first year after treatment; in the group treated by needles alone, 50 per cent; in the untreated group, 60.79 per cent; and yet with the combined

DISCUSSION OF TABLE IX

In Table IX are summarized the results of all forms of radium treatment.

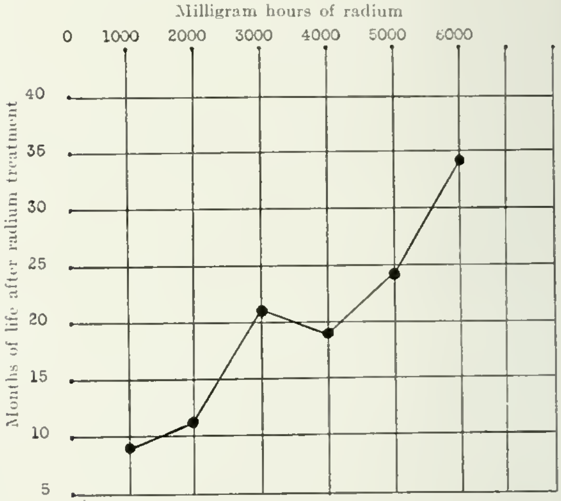
Of the 126 patients heard from, the average duration of the disease from onset to death is 38.58 months, a little longer than may be expected if the malignancy is allowed to take its course. The average dosage was 1866.49 mg. hours and the length of life following treatment, 14.17 months, only slightly longer than the average length of life of patients not treated.

A comparison of the results followng radium treatment with those obtained by surgery demonstrates the superiority of the latter, for in the surgical group the disease extended 50 per cent longer, reaching on the average, 62.36 months, and the length of postoperative life averaged ten months longer. At the end of two years 29.16 per cent of the patients treated surgically are alive and only 11.9 per cent of those treated with radium are alive. These comparisons are not wholly just, for the patients operated on represent a picked group and in 27 per cent of them, the cancer was only discovered at operation, while the patients treated by radium were unselected and the disease was advanced sufficiently to make a diagnosis. However, by examining the results from an entirely different view point, namely, with reference to the size of dosages, the percentages are more encouraging. In the three groups of patients studied, the length of life after radium treatment (completed cases) appears directly proportional to the dosage. That is, the average dosage for patients who lived two years was greater than for patients who lived one year, and less than for those who lived three years. That this was not accidental is borne out by grouping the patients according to the amount of radium they received instead of according to the years they have lived. The data are more accurate when taken from the completed cases, the patients who have died, for the number living includes patients who are alive because of mistaken diagnosis.

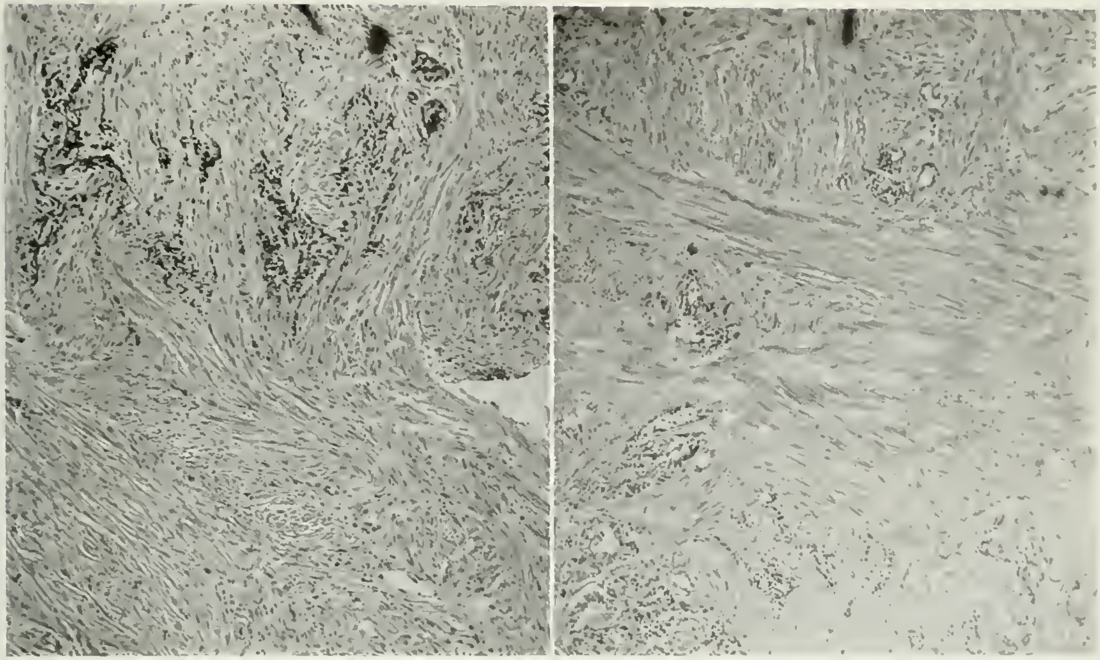
DISCUSSION OF TABLE X

The data in Table x might be interpreted as meaning that because the patient lived longer, he had more opportunity to receive radium, rather than that he lived because he received it. That this is fallacious is apparent from the duration of treatment, which averages between six months and one year. This relationship between dosage and the prolongation of life is undoubtedly due to the fact that a more thorough radiation of the malignant growth had taken place and cell activity had been largely destroyed. In four of the twenty-two patients who received both radium and surgical treatment, the prostatectomy followed a thorough course of radium treatment, and was done to relieve the patients of urinary obstruction, not with the idea of removing the growth. Tissue in these cases yielded sections in which the end-results of radium are clearly manifest, microscopically.

TABLE X. Eighty-four patients



In Case 219,826 (Figs. 20 and 21) 1,742 mg. hours of radium were given, the last treatment three months before the removal of the gland. Moderate hyaline degeneration is shown throughout the section and a marked proliferation of fibrous tissue surrounds and compresses the remaining cancer cells in interlacing fibrous bands. These malignant cells are atypical in appearance, being pressed and squeezed in distorted shapes by an ever-increasing proliferation of connective-tissue cells (Figs. 22 and 23). The reproductive function of the malignant cells is undoubtedly impaired and if all malignant tissue can be thus affected, complete cessation of the process must occur. The immediate results of radium treatment by needles a few days before death are shown in Figure 24. The necrotic and discolored appearance in the center of the photograph gives a clear idea of the limited extent of the radiation. Figure 25 is a photomicrograph of an area beyond the influence of the



Figs. 20 and 21 (219,826). Adenocarcinoma of the prostate after it had been exposed to 1,742 mg. hours of radium. The last treatment had been given three months before.

Figs. 22 and 23 (219,826). Adenocarcinoma of the prostate after it had been exposed to 1,740 mg. hours of radium. The last treatment was given three months before. The distorted and flattened cells indicate the extreme pressure exerted by the proliferation of fibrous tissue cells. In places, this compression is so marked that only the remains of the cancer cells are seen as a few deeply staining nuclei fragments.

radium treatment. Typical cancer cells have replaced the normal glandular tissue. Their clear outline and marked staining qualities, and the occasional mitotic figure show their viability and gives impressive evidence of malignancy. Figures 26 and 27 represent other sections from the same gland but are taken closer to the area affected by the radium. Many of the cells show evidence of rapid degeneration, and there is a loss of the definite cell outlines of the viable cancer cells shown in Figure 25. These cells take the stain poorly and fragments of destroyed cells are seen throughout the section. The entire picture is that of cellular destruction and is in sharp contrast with Figure 25.

The microscopic findings, and the marked softening and shrinking of the gland, often found clinically following radium treatment, are clear evidence that if the entire growth can be reached by the radium rays, satisfactory results will follow. Clinical findings, however, demonstrate that except in occasional cases satisfactory results have not been obtained.

The question arises, should radium treatment in cancer of the prostate be abandoned? Undoubtedly it should be abandoned in a great many instances; after the growth has extended beyond the capsule the lymphatics are probably always involved, and the duration of the patient's life will not be altered, even if the local and original growth is softened by the treatment. Apparently much more good can be accomplished by proper care of the urinary retention by means of suprapubic drainage or daily catheterization than will be accomplished by treating the gland with radium. In a few cases a subsidence of the urinary obstruction and a marked reduction in the amount of residual urine will result but as a rule the amount of residual urine remains unchanged and occasionally the obstruction is made greater. In the early cases, in which the malignancy is still confined within the capsule, radium should be used, but its application must be modified if better results are to be expected even in this limited group of cases.

As is apparent in Figure 24, the changes due to radium, namely, cell destruction and necrosis, are confined to a limited area. Sections of other portions of the

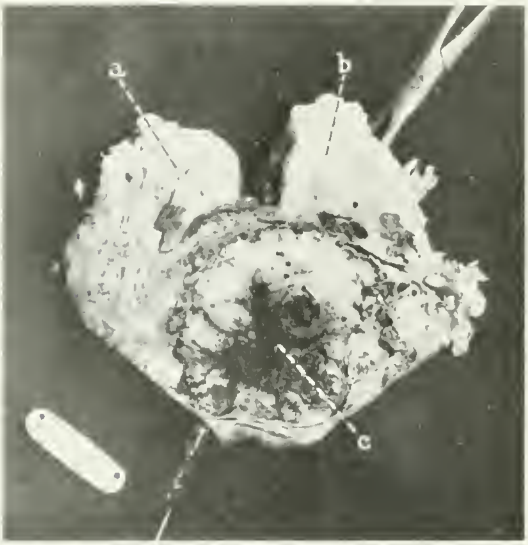


Fig. 24 (332,467). Adenocarcinoma of the prostate treated thirty-two days before death with 700 mg. hours of radium. A limited area of the carcinoma was affected and a localized necrosis resulted. (a) and (b), lateral lobes, and (c) point of radium application. Note limited area affected by large dosage.

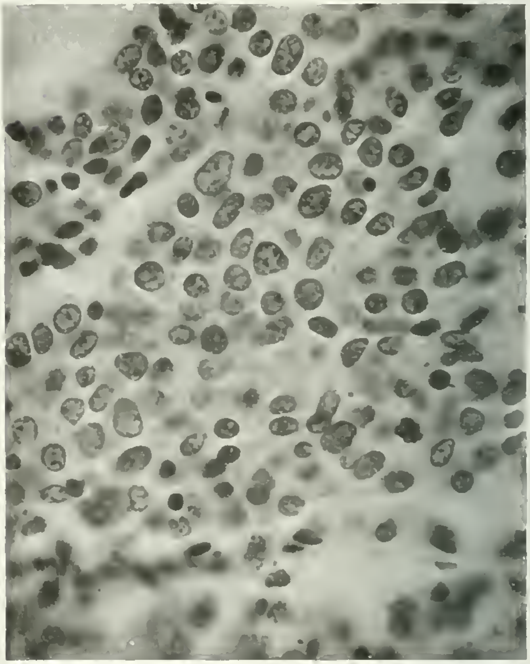
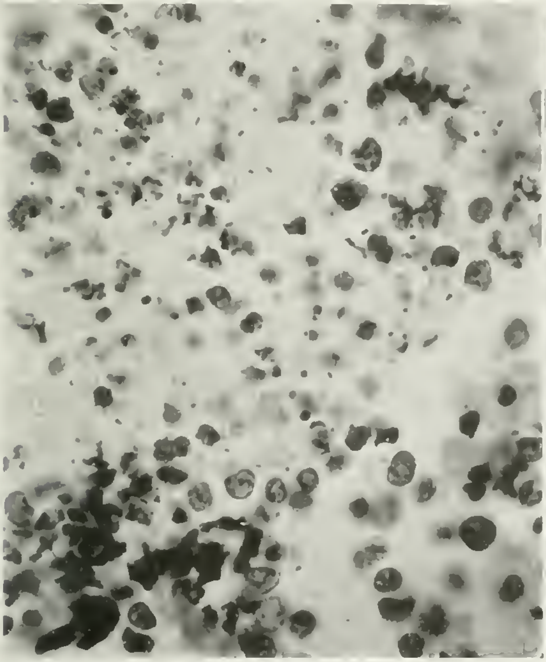


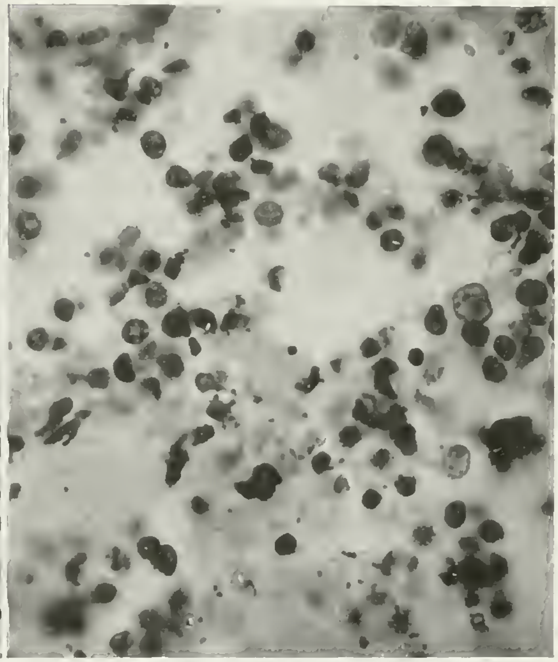
Fig. 25 (332,467). Adenocarcinoma of the prostate showing well formed and highly malignant cells unaffected by radium exposures given in other portions of the gland.

gland (Fig. 25) show no evidence of radiation. That such necrosis occurs where radium is applied directly into the tissues has been clearly demonstrated by Bagg, who shows that the area affected by 1 mc. tube is approximately 1 cm., that necrosis occurs for about 1 or 2 mm. but beyond this point the malignant cells are killed for approximately 0.05 cm. Increasing the dosage from 1 to 5 mc. does not correspondingly increase the area of affected tissue which remains approximately 1 cm. in diameter as before, but it does increase the area of necrosis around the emanation tubes, a result to be avoided since it permits nonseptic toxic absorption and is responsible for the so-termed radium reactions.

The poor results in the past have evidently been due to overradiation of one portion of the gland, while other portions received too little. The poor clinical results are particularly apparent in the cases in which needles alone were used, owing undoubtedly to the lack of radiation to the periphery of the growth, to which the gamma rays did not penetrate, or, if they did, were scattered and had little effect.

It is evident, therefore, that to obtain better results, a greater area of the gland must be radiated with smaller doses. In the past, this has been excessively difficult and nearly impossible, for to insert needles more than once at a single treatment causes too great pain. An attempt was made to obviate this difficulty by inserting multiple tubes, as described by Bagg, but their exact position was uncertain and it was difficult accurately to estimate the position of the first tubes when the next one was applied. It is better not to leave emanation tubes in this deep lying gland, for if complications, such as sloughing, occur, nature may attempt to throw off the foreign bodies rather than to encyst them. For this reason it seems that if radium needles could be used more thoroughly, they would be preferable.





Figs. 26 and 27 (332,467). Recently radiated area of adenocarcinoma of the prostate, showing the effect of radium rays on the individual malignant cells. Marked disintegration has resulted as shown by the loss of cell outline, poor staining qualities, and masses of cell fragments.

The possibility of now using radium needles more satisfactorily has recently been greatly favored by a method of inserting the radium needles under sacral anesthesia, as described by Scholl. He states, "Nerve blocking in no part of the body offers more satisfactory or successful results than sacral anesthesia. It is not new, nor is its application to this use unusual, but its almost complete neglect indicates that its good results are not generally recognized." The absolute anesthesia obtained throughout the perineum and prostate, and the complete relaxation of the rectal sphincter make it ideal for placing needles within the prostate gland (Fig. 28), since the exact location desired can be reached without pain to the patient. The relaxed rectal sphincter makes careful palpation of the growth possible.

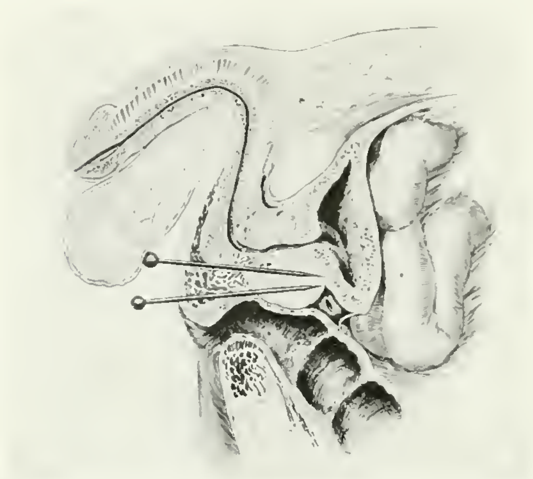


Fig. 28. Cross-section of pelvis. Radium needles inserted into the prostate.

The anesthetic is administered with the patient on his abdomen. After sterilizing the sacral region with iodine, a 6 cm. needle with stylet is introduced through the sacral hiatus at the lower end of the sacrum, into the sacral canal (Fig. 29). About 30 c.c. of a 2 per cent solution of novocaine is injected while the needle is being slowly withdrawn. After this, the patient is kept in the sitting position for from ten to fifteen minutes, while the solution diffuses through the sacral nerve sheaths. This diffusibility is greatly increased if sodium carbonate is added to the novocain. The formula is as follows: Novocain 0.6 gm., sodium carbonate 0.15 gm., sodium chloride 0.1 gm. added to 30 c.c. of freshly boiled distilled water gives a sterile 2 per cent solution of novocain in normal salt solution.

The anesthesia is complete and commences in about four minutes at the anosacral area (Fig. 30), the exact location at which the needles are inserted (Fig. 31). The anesthesia may be repeated at any time and the position of the needles in the gland changed, so that new areas are radiated. After the second injection the anesthesia is much more profound and

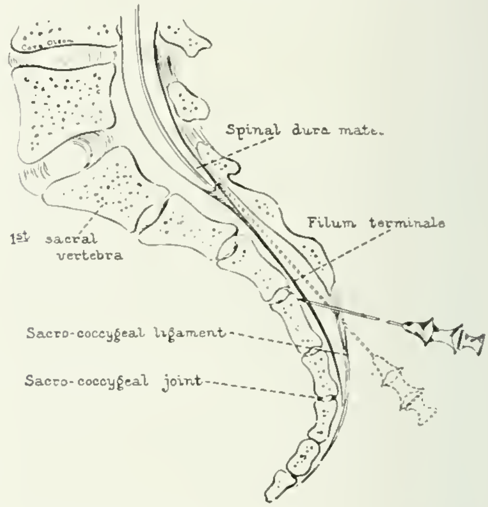


Fig. 29. Cross-section of sacrum. Sacral canal and point of insertion of needle. The novocain is given outside the spinal dura mater.

Fig. 30. Point of initial anesthesia in the perineum, which corresponds with point of needle insertion.

lasts from five to eight hours, permitting a third shifting of the radium-containing needles and giving the patient a period of rest and freedom from pain during the procedure. This anesthetic has been used in more than 100 instances with complete satisfaction. Patients are no longer reluctant to take a second treatment and the increased ease with which the needles are applied, owing to the complete relaxation of the rectal sphincter, adds greatly to the exactitude of the procedure, and before the completion of the treatment all parts of the gland will have been radiated.

The entire treatment is given within a few days and the patient need not return for subsequent treatments. It is scarcely necessary to call attention to the advantages gained by this method. There is no opportunity for growth of the untreated portions of the gland between treatments. Necrosis does not occur, since fibrous tissue, which greatly reduces the blood supply, has not formed as the result of previous radium treatment.

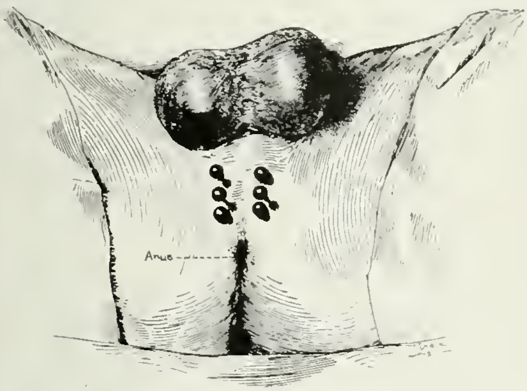


Fig. 31. Six radium needles inserted in the perineum.

Summary

1. The average duration of cancer of the prostate, if untreated, is approximately three years.

2. Roentgenograms show that metastasis to the bone occurs in about one-third of the cases of cancer of the prostate.

3. Metastasis from atypical carcinoma of the prostate, in which the cells, because of their tendency to early metastasis, produce only slight local enlargement, may be frequently mistaken for Paget's disease.

4. The clinical study of these cases demonstrates that in order to treat successfully cancer of the prostate with radium it is necessary to use in the aggregate large doses (3,000 to 4,000 mg. hours), exposing all parts of the gland to comparatively small doses.

5. It is demonstrated that the increased duration of life following radium treatment in cases of cancer of the prostate is in direct proportion to the amount of radium radiation applied.

6. No one method of application radiates all portions of the gland.

7. The malignant gland must be radiated by urethral and rectal exposures, and by needles inserted directly into the neoplasm in order to produce complete radiation of all portions.

8. It is demonstrated microscopically, that large doses of radium placed directly into the gland affect only a limited area; this is substantiated by the clinical findings which prove that the course of the disease after such treatments is but slightly affected.

9. In the parts of the gland affected by the radium, fibrous tissue is produced which enmeshes and compresses the cancer cells, preventing their further proliferation. If this process could be brought about in the entire growth, complete cessation of the disease would result.

10. Sacral anesthesia is a useful adjunct in the application of radium needles, making it possible to place the radium accurately and to change the position of the needles without pain; thus a more thorough radiation of the gland is accomplished.

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THE ROENTGEN-RAY DIAGNOSIS OF NON-OPAQUE FOREIGN BODIES IN THE AIR PASSAGES*

BY WILLIS F. MANGES, M.D.

PHILADELPHIA, PENNSYLVANIA

At the meeting of the Eastern Section of the American Roentgen Ray Society in January, 1920, Dr. Jackson,[1] Dr. Spencer and I presented a paper on this same subject. The object of the paper was to bring to the attention of the roentgenologist this very important group of foreign body cases, to impress upon him the serious nature of the condition, to describe briefly the symptoms and physical signs, to demonstrate the roentgenologic evidence, and to illustrate the value of cooperation between the bronchoscopist and the roentgenologist. The paper from the roentgenologic point of view was based on the study of six cases.

Dr. Samuel Iglauer published two articles,[2] one in 1911 and the other in 1912,[3] in which he described the roentgenographic appearance of overdistention of the lung of the affected side and displacement of the mediastinal structures toward the unaffected side in peanut cases. One of these articles contained the reproduction of a roentgenogram which showed the signs very beautifully. He also described the mechanism by which the emphysema was brought about, his theory being, "The physiologic inspiratory expansion of the bronchus produced a valve-like action, admitting and entrapping the air beyond the foreign body, and this undoubtedly led to an emphysema of the right lung,"—the case being one of peanut in the right bronchus.

It seems appropriate to present our further studies of this class of cases for the reasons that the evidence is of increased value because of the constancy of it, that there are a few important points not mentioned in our former paper, and, further, that there are variations and complications at times which deserve more careful consideration. Then, too, there have been twelve cases in which, because of history, symptoms, or signs, foreign body has been suspected but not actually recovered. A study of this group serves to illustrate some of the problems in differential diagnosis.

It is extremely important that every roentgenologist should be thoroughly familiar with these signs, for he is often called upon to determine whether or not a foreign body is present, and upon his decision rests perhaps the very life of the patient.

The present paper is based on a study of 56 cases in which foreign body was present or suspected, and all of these with two exceptions (pebble, F. B. No. 624 and cockle bur, F. B. No. 723) have come to Dr. Jackson's Clinic at the Jefferson Hospital since January 1920.

The cases studied are listed in Table I.

Table I

	R. B.	L. B.	Trachea	
Peanut kernel	16	4	2	22
Watermelon seed	1	2	5	8
Corn		2	2	4
Almond kernel	2			2
Walnut kernel	1			1
Chestnut kernel		1		1
Coffee bean		1		1
Navy bean		1		1
Peanut shell			1	1
Cockle bur		1		1
Corn stalk		1		1
Pebble	1			1
				44
Suspected cases	12			12
Total				56

A brief analysis of the proven cases serves to show the constancy with which diagnostic roentgen-ray evidence and localizing signs are present. Although the analysis does not show it, compensatory emphysema is always present in the unaffected lung. The cases are listed in the sequence of their appearance and the "F. B. No." is that given by Dr. Jackson.

* Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27-30, 1921.

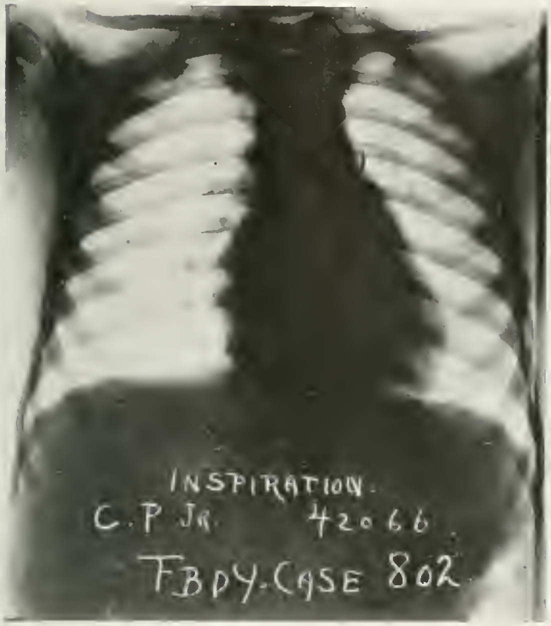

Fig. 1*a*.

Fig. 1*b*.

Fig. 1. F. B. No. 802. Signs are not marked, but positive. Exposures were made during quiet breathing: (*a*) Inspiration; (*b*) Expiration; (*c*) After removal.

The roentgen-ray signs of acute obstructive monolateral emphysema are:

1. Increased transparency of the affected lung.
2. Depression and partial fixation of the diaphragm on the affected side.
3. Displacement of the heart and mediastinal structures away from the affected side.
4. Increased excursion of the diaphragm on the unaffected side, due to compensatory emphysema.

The diaphragmatic signs are the most important, for by them alone can one rule out compensatory emphysema.

In our former paper, sign No. 4 was suggested as "Increased density in the lung shadows on the opposite side due to retained secretions." We now feel that this is not sufficiently constant to be classed with those mentioned above. It does occur in a small percentage of cases and is present probably for the reason that the foreign body has shifted from one side to the other and caused an inflammatory reaction, the products of which add to the density of the unobstructed lung, especially at expiration.

Fig. 1*c*.

The above enumerated signs are present in proportion to the degree of expiratory obstruction. They may be so slight that repeated observations and exposures are necessary to establish them beyond doubt, or it may be necessary to make the child cry in order to record the changes that

TABLE II

F. B. No.	F. B.	Location	Sojourn	Age	Roentgenologic Signs: Ob. Emph.	Atelectasis	Retained Secretions	Abscess or Bronchiectasis	Remarks
624	Pebble.	R. Bron.	3 days	4 yrs.	R. lung		.	. . . .	.
723	Cockle bur	R. Bron.	1 yr. 5 mos.	16 yrs.	. . . .			R. lower lobe	.
769	Peanut	Trachea	1 day	6 yrs.	R. and L. lung				
781	Peanut	R. Bron.	7 days	3 yrs.	R. lung		R. upper lobe	. .	. . . . . .
783	Corn.	Trachea	4 days	2½ yrs.	Limited motion both diaph.		L. lung	.	Shifting F. B.
787	Peanut	L. Bron.	17 days	21 mos.	L. lung		R. lung		Shifting F. B.
789	Peanut	R. Bron.	19 days	2 yrs.	R. lung				. . . . . .
790	Corn	Trachea R. Bron.	6 days	5 yrs.	R. lung				Shifting F. B.
799	Peanut	R. Bron.	16 days	3 yrs.	R. lung				
800	Peanut shell	Trachea	2 hrs.	14 mos.	R. and L. lung				
802	Peanut	R. Bron.	9 days	3 yrs.	R. lung				
815	Peanut	L. Bron.	4 days	2½ yrs.	L. lung				
819	Watermelon seed	Trachea	6 days	4 yrs.	No x-ray signs except inflam., thickening at hilus on both sides				. .
824	Watermelon seed	L. Bron.	4 days	5 yrs.	L. lung (no x-ray signs when F. B. was in trachea at first observation)			.	Shifting F. B.
827	Watermelon seed.	Trechea	4 days	2½ yrs.	L. lung		R. lower lobe		Shifting F. B.
828	Peanut	R. Bron.	11 days	3 yrs.	R. lung				. . . . . .
832	Chestnut	L. Bron.	10 days	2½ yrs.	L. lung				Shifting F. B.
833	Coffee.	R. Bron.	14 days	2 yrs.	. . . .		R. lower lobe		
838	Corn	L. Bron.	1 day	1 yr.	L. lung				
839	Watermelon seed	R. Bron.	3 mos.	22 mos.	R. lung slight			. . .	.
846	Peanut	R. Bron.	18 days	23 mos.	R. upper lobe			R. lower lobe	
856	Peanut	R. Bron.	3 mos.	21 mos.	R. lung			. . . .	Unusually mild reaction
871	Peanut	L. Bron.	3 mos.	2 yrs.	L. upper lobe			L. lower lobe	. . .
872	Almond	R. Bron.	3 mos.	2 yrs.	R. lung			.	Physical signs of abscess not confirmed by x-ray

Table II (Continued)

F. B. No.	F. B.	Location	Sojourn	Age	Roentgenologic Signs: Ob. Emph.	Atelectasis	Retained Secretions	Abscess or Bronchi-ectasis	Remarks
875	Peanut	R. Bron.	4 days	2 yrs.	R. lung				
877	Peanut	R. Bron.	5 days	3 yrs.	R. lung				
880	Peanut	R. Bron.	9 days	13 mos.	R. lung				Shifting F. B.
884	Peanut	R. Bron.	2 days	31 mos.	R. lung				Multiple F. Bs.
890	Peanut	R. Bron.	7 days	4 yrs.	R. lung		R. lower lobe		
891	Peanut	Trachea	8 days	27 mos.	Not studied before removal				
892	Peanut	Trachea	2 days	2 yrs.	R. and L. lungs				
898	Corn stalk	R. Bron.	5 wks.	15 yrs.				R. lower lobe	
900	Bean	R. Bron.	1 day	3½ yrs.		Entire R. lung			
904	Peanut	L. Bron.	13 days	5½ yrs.	L. upper lobe	L. lower lobe			
905	Peanut	R Bron.	7 days	3 yrs.	R. lung				
911	Watermelon seed	Trachea	4 days	11 mos.	R. lung (?)				Shifting F. B.
919	Watermelon seed	Trachea	3 days	2 yrs.	No x-ray examination before removal				
918	Watermelon seed	Trachea	3 days	4 yrs.	No x-ray signs				Movable F. B.
920	Peanut	R. Bron.	15 days	3 yrs.	R. lung				
927	Watermelon seed	Trachea	5 days	5 yrs.	No positive signs				
928	Watermelon seed	Trachea	2 mos. 8 days	15 mos.	No positive signs				
931	Corn	Trachea	16 days	3½ yrs.	R. and L. lungs				
932	Peanut	R. lower bron.	45 days	56 yrs.	R. lower lobe				
936	Peanut	R. Bron.	29 days	16 mos.	R. lung				

The following signs may be elicited by the roentgen ray, either alone or in combination, when the foreign body is lodged in a bronchus: 1. Obstructive emphysema, monolateral. 2. Retained secretions, or drowned lung. 3. Abscess formation, or septic pneumonitis. 4. Atelectasis in part of a lobe or perhaps one entire side.

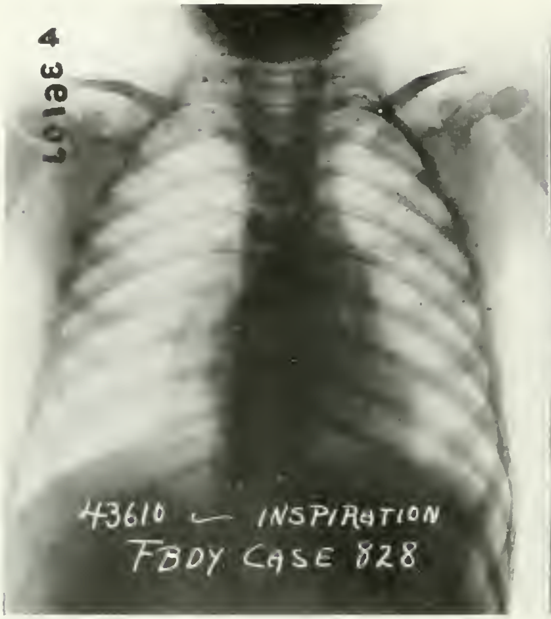

Fig. 2a.

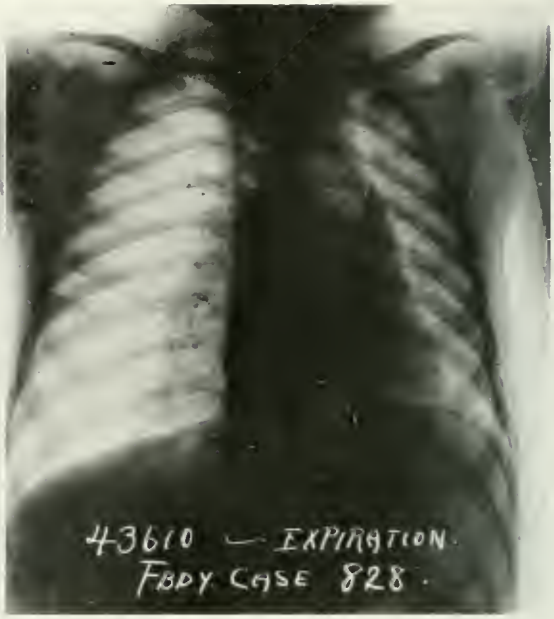

Fig. 2b.

Fig. 2. F. B. No. 828. Signs are quite marked. High degree of expiratory obstruction. (*a*) Inspiration; (*b*) Expiration; (*c*) After removal.

occur between full inspiration and full expiration (Fig. 1, a, b, c). On the other hand, they may be so pronounced that even at full inspiration the displacement of the diaphragm and mediastinal structures plainly indicate obstructive emphysema on the affected side. The most important point to remember is that the signs are accentuated most at the end of expiration—a point which was not made clear in our former report— and no examination is complete without instantaneous roentgenograms at both full inspiration and the end of expiration (Fig. 2, a, b, c).

We have reasons to believe that these signs may be elicited very soon after the foreign body lodges. In F. B., No. 824, at the first examination, no obstructive evidence was obtained,—the foreign body being in the trachea—but on the second examination, within a few hours after the first, there was most positive evidence of obstructive emphysema of the left lung (Fig. 3, a, b, c). The foreign body had in the meantime lodged in the left bronchus. In F. B., No. 838, the signs were present at the first observation, and the foreign body had been present only one day. We believe further that the inflammatory

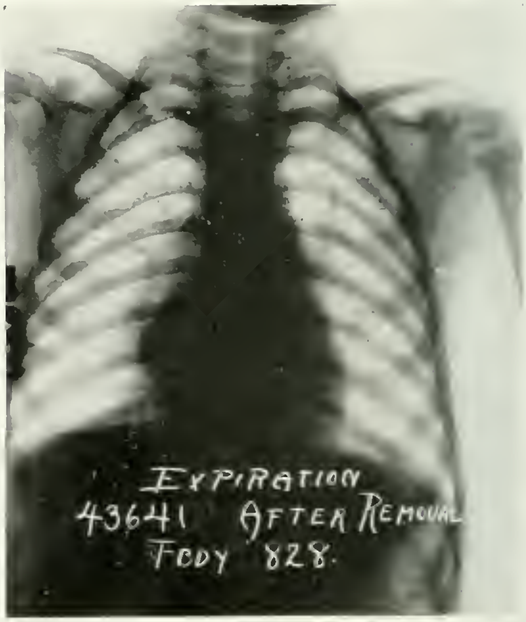

Fig. 2c.

reaction, especially edema, plays an important rôle in the mechanism of obstructive emphysema when the foreign body is of irregular shape, but that the signs may be elicited very promptly if the foreign body is of such shape that it will markedly obstruct

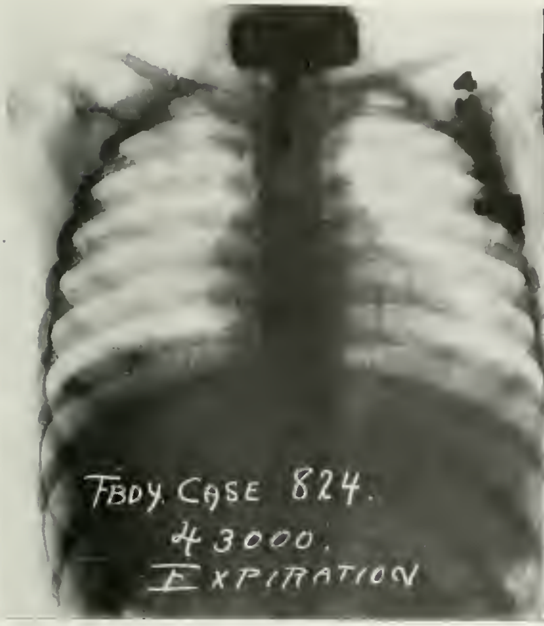

Fig. 3*a*.

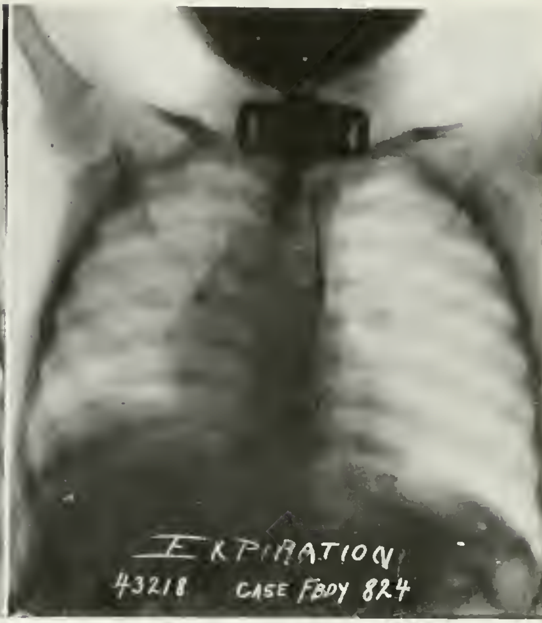

Fig. 3*b*.

Fig. 3. F. B. No. 824. No evidence of foreign body at first examination. Marked expiratory obstruction of left lung at second examination. Foreign body had shifted from trachea into left bronchus. (*a*) Expiration, first examination; (*b*) Expiration, second examination; (*c*) Expiration after removal.

the inspiratory current and almost completely obstruct the expiratory current.

Slight evidence of these signs is occasionally present for a period of hours after removal of the foreign body if the inflammatory reaction has been severe, but if it is at all striking or persists after twenty-four hours another foreign body must be assumed to be present until proven otherwise. In F. B., No. 884, the signs were present after removal of the first foreign body, became still more positive and remained so on subsequent days until a second fragment of peanut was removed. Following removal of this, the child coughed up a third fragment on its way to the ward, after which the signs of obstructive emphysema disappeared entirely and the child promptly recovered (Fig. 4, a, b, c).

We have noticed that the signs vary from day to day to some extent, but we are strongly of the opinion that they will remain positive as long as the foreign body remains in the bronchus, or until some change occurs distal to the foreign body to prevent further ingress of air. In case No. 789, peanut, there was a sojourn of nineteen days in a child two years of age; in No. 839, watermelon seed, the signs were positive after a sojourn of three months; and in No. 932, the signs were positive when the foreign body, a

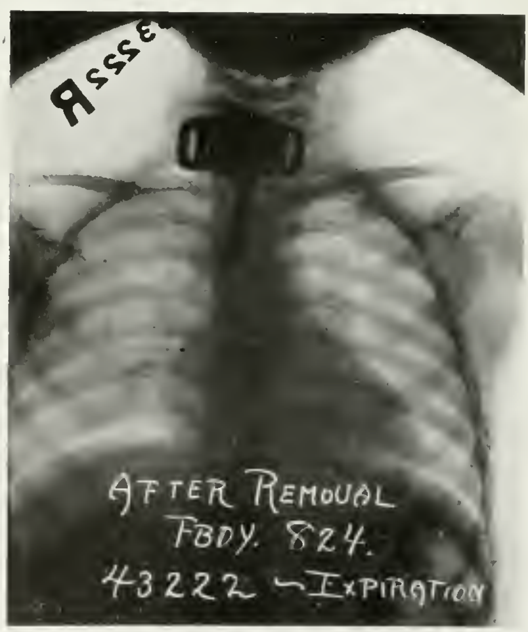

Fig. 3*c*.

Fig. 4a.

Fig. 4b.

Fig. 4. F. B. No. 884. Expiratory obstruction of right bronchus quite positive after removal of first fragment of peanut kernel. Signs are absent after removal of second fragment and expulsion of a third fragment. (*a*) Inspiration, after removal of first fragment; (*b*) Expiration, after removal of first fragment; (*c*) After removal of second fragment and expulsion of third fragment.

Fig. 4c.

portion of peanut kernel, had been lodged in the right lower lobe bronchus forty-five days, but in this case, a man aged fifty-six years, the upper lobe was not involved (Fig. 5, a, b).

Obstructive emphysema may be present in an upper lobe with beginning abscess or increased density due to retained secretions in the lower lobe, or, one portion of a lobe, usually the dependent portion, may contain sufficient secretions to cast quite positive shadow, while the rest of the same lobe shows evidence of air distention. It requires very careful observation to elicit these combinations of signs.

We have never seen evidence of obstructive emphysema in an upper lobe with normal function and normal shadows in the lower lobe, but theoretically it might occur.

Retained secretions beyond the foreign body may collect in sufficient amount to produce a shadow of increased density in the dependent portion of the lung involved. This condition has been described by George C. Johnston as "drowned lung." It is more or less filmy in appearance, the bronchial shadows being visible. It is difficult sometimes to differentiate this from the early stage of actual abscess. In the later stages of abscess, the shadow is much more dense, the bronchial detail is lost, and the edges have a ragged appearance, and more or less round shape. In the one case when the area is drained through the bronchoscope, the products are mostly of a thick mucous character, while in the other, pus is clearly and bountifully obtained. After removal of the foreign body and bronchoscopic drainage of retained secretions, the lung shadows approach the normal. In case of abscess, there is the irregular density of tissues thickened by the infection. One rarely sees a cavity after such drainage, but may later find evidence of bronchiectasis.

We know of no law controlling the collection of retained secretions in amount sufficient to cast a positive shadow, unless it is one based entirely on the mechanics of the situation,—that is, that the thick mucus and products of edema collect beyond the foreign body and by force of gravity together with the relatively strong current of inspired air go to the dependent portion of the lung, where they are not influenced by the relatively weak current of expired air, the coughing effort, or physiologic expulsory functions.

Drowned lung shadows, when definitely recognized, are practically diagnostic of foreign body. This condition is frequently seen in metallic foreign body cases, and has the same appearance as in the organic foreign body cases. On the other hand, the absence of such sign has no negative diagnostic value.

We know that these foreign bodies have a tendency to dislodge from time to time, and it is probable that each time the foreign body moves upward, the secretions below are evacuated to some extent. Then, too, the lymphatics must take care of a considerable quantity. By referring to the analysis, it will be seen that in F. B. No. 787 a quantity was present in a peanut case of seventeen days, whereas in F. B. No. 839, a watermelon seed had been present three months and the lung shadows were clear. In this study, roentgenographic signs of retained secretions were present in six cases; of abscess, in three cases.

Absccess is necessarily the result of infection. It seems remarkable, considering the degree of inflammation and trauma, that infection does not follow more frequently. Of course, such a result will eventually

Fig. 5a. Fig. 5b.

Fig. 5. F. B. No. 932. Expiratory obstruction of right lower lobe in a man 56 years of age. Note that the upper lobe is not involved, and that displacement of the heart is more striking than fixation of the right diaphragm. (*a*) Inspiration; (*b*) Expiration.

occur if the foreign body remains long enough, regardless of the nature of the foreign body.

Atelectasis of the entire right lung was present in F. B. No. 900, a bean lodging in the right bronchus only one day. The extreme displacement of the heart and mediastinal structures as well as the diaphragm could not be explained in any other way. This lung was expanded to almost its normal capacity within a few hours after removal of the bean (Fig. 6, a, b). F. B. No. 904, a portion of peanut kernel produced atelectasis of the left lower lobe and obstructive emphysema of the left upper lobe (Fig. 7, a, b). In this instance the atelectatic lobe contained a considerable quantity of secretions, but the marked displacement of the heart toward the affected side determines clearly the element of atelectasis.

Fig. 6a.

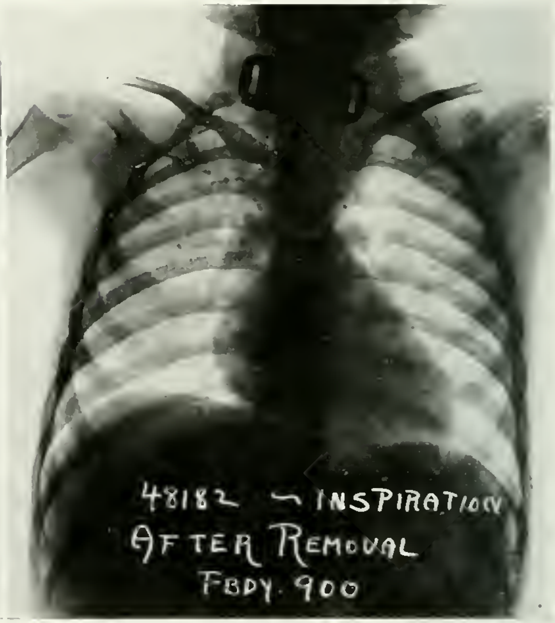

Fig. 6b.

Fig. 6. F. B. No. 900. Complete atelectasis of right lung. Note marked displacement of heart, and remarkable return of function a few hours after removal of bean. Compensatory emphysema of left lung before removal. (*a*) Inspiration before removal; (*b*) Inspiration a few hours after removal.

Childs,[4] in a report of six cases of foreign body in the respiratory tract, cites two instances of navy bean as the intruder. In case No. II of his article, atelectasis was present. In his other bean case, No. III of his report, he interprets the dense shadow of the left chest as being due to "complete consolidation of the left lung." We believe that his excellent roentgenogram shows a definite degree of atelectasis. A completely consolidated lung should not diminish in size and therefore not permit marked displacement of the heart and contraction of the left chest wall, such as is beautifully shown in his roentgenogram.

Fletcher[5] also reports the presence of atelectasis in the case of a navy bean as a bronchial foreign body.

It would seem probable that atelectasis follows only when the foreign body completely obstructs the bronchus both to ingress and egress of air, the residual air being more or less rapidly absorbed.

The signs of atelectasis are:

1. Displacement of the heart to the affected side.
2. Retraction upward of the diaphragm.
3. Marked density of shadows in the area involved.

It is necessary to determine that the patient has not previously had an empyema, since all of these signs may be present in certain of its stages. Atelectasis has been present in a few other of Dr. Jackson's cases, in which the foreign body was also opaque. These are not included in the present analysis. When definitely proven to be present, atelectasis is diagnostic of foreign body, as well as of its location. Compensatory emphysema is present in the other lung.

Tracheal foreign bodies may not give definite roentgen-ray signs, but when they are present are nearly as positive as the signs of bronchial intruders (Fig. 8, a, b). Fortunately, when they do not present the roentgen-ray signs, they usually do present the most striking and positive physical signs.

Dr. Jackson[6] says: "Any object small enough to pass the glottic chink yet too large to enter either main bronchus may be found." In the same treatise, he also discusses the influence of shape and character of surface on the location of the object. Again, the mechanics of the situation determine the presence or absence of roentgen-ray signs. For instance, a watermelon seed, large enough to enter the trachea, may be too large to enter a bronchus, and, because of its flat shape, may allow free passage of air both during inspiration and expiration, so that obstructive emphysema may be entirely absent. In five of the nine cases of watermelon seeds included in this study, roentgen-ray signs were absent. However, in one of the five, at a subsequent observation, there was positive evidence of obstructive emphysema of the left lung (F. B. No. 824). The seed had become at least temporarily impacted in the left bronchus. Of the other four cases of watermelon seed, three showed signs of monolateral obstructive emphysema, and one was not examined before removal.

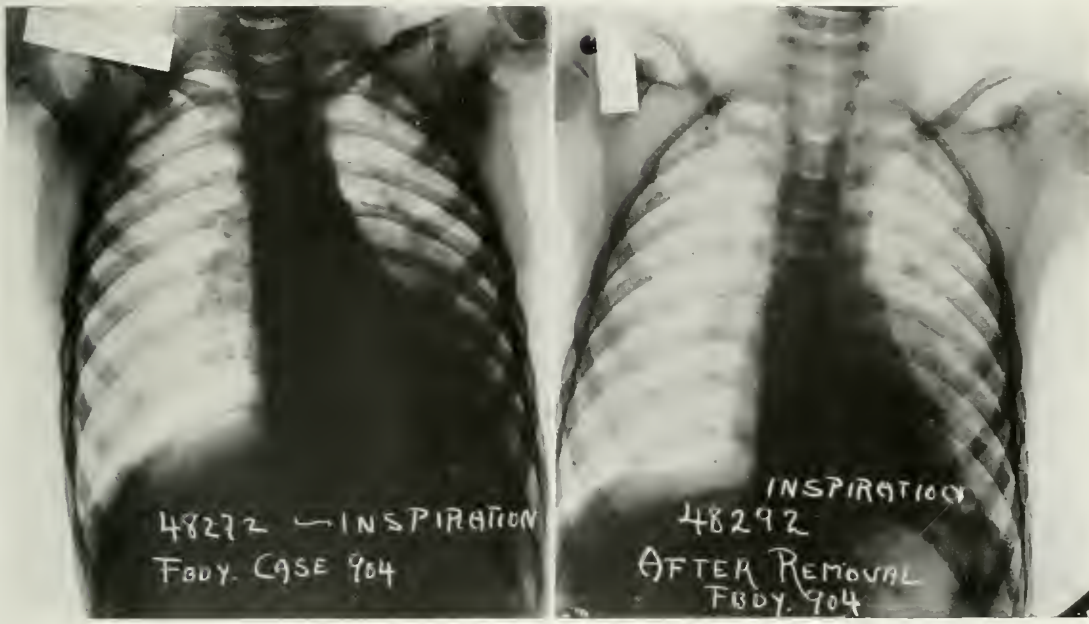

Fig. 7*a*. Fig. 7*b*.

Fig. 7. F. B. No. 904. Partial atelectasis and retained secretions left lower lobe. Slight obstructive emphysema left upper lobe. Compensatory emphysema right lung. (*a*) Inspiration before removal; (*b*) Inspiration after removal.

On the other hand, a tracheal foreign body that does not move freely, and, because of its size and shape, interferes with respiration to a considerable degree, will manifest the signs of obstructive emphysema of both lungs. The diaphragm is depressed on both sides and is lower on expiration than on inspiration, being overcome by the more powerful intercostal muscles of respiration; the heart is more in the median line and more vertical, appear-

TABLE III

Case No.	History	Obstructive Emphysema	Dense Pathology	Bronchoscopic Findings	End Results and Remarks
46,309	No history of aspiration	R. lung	R. upper lobe	Previous bronchoscopy negative; ulcers seen	Tracheotomy; death from severe gastroenteritis
41,741	No history of aspiration	Both lungs (slight)	R. upper lobe; cleared up gradually	No bronchoscopy	Tracheotomy; recovery
45,080	History of peanut aspiration	None	None	None	No development of symptoms of arachidic bronchitis
45,155	History negative	R. lung; due to external pressure	R. upper lobe, probably suppurating peritracheal gland; gradually cleared	Bronchoscopy for diagnosis; obstruction of R. main bronchus; no foreign body found	Tracheotomy; recovery
46,463	Positive peanut	None	R. upper lobe	No foreign body found	Physical signs were positive; F. B. probably expelled before *x*-ray examination; recovery
47,280	Negative	Both lungs; 2d exam. R. lung	Enlarged gland, compressed trachea and obstructed R. bronchus; later broke down and caused rather extensive lesion	No bronchoscopy	*X*-ray treatment; temporary improvement; pneumonic process; recovery
47,552	Suggestive; popcorn	L. lung	None	No foreign body found; diffuse tracheobronchitis; L. bronchus much swollen	Tracheotomy; recovery; F. B. probably expelled; convalescence similar to proven cases
48,103	Positive almond	L. lung	None	Tracheobronchitis, typical of arachidic bronchitis; no F. B. found	F. B. probably expelled; signs disappeared after bronchoscopy; convalescence like proven cases; recovery
47,904	Negative	None	Larynx; seen clearly on film	Papilloma removed from larynx	Recovery
48,241	Suggestive pretzel	None	None	Papilloma removed from larynx	Recovery
48,367	Positive timothy head	None	R. middle lobe; three days later this had cleared and R. lower lobe was consolidated; cleared like lobar pneumonia	No bronchoscopy	Recovery as from lobar pneumonia
49,232	Negative	None	None	Diffuse tracheobronchitis; influenzal type	Recovery

ing in its entirety above the diaphragms. These signs will be very slight or quite positive, according to the degree of obstruction. Occasionally they are distinguishable only by comparing roentgenograms made after removal with those made before removal. They are always more pronounced if the child struggles or cries, but it frequently occurs that the patient will

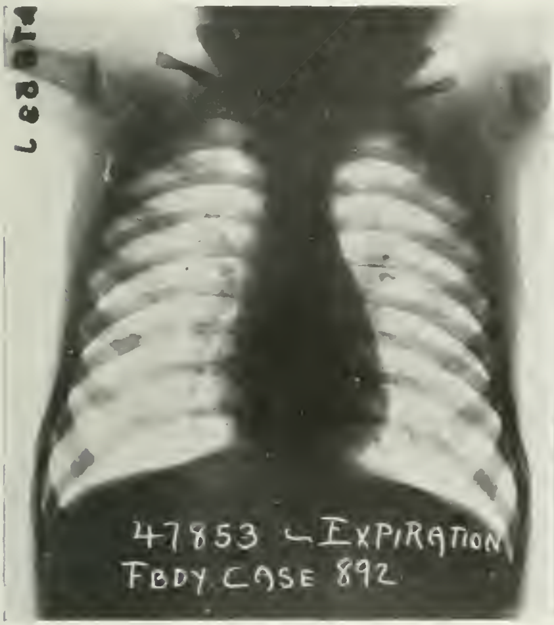

Fig. 8*a*.

Fig. 8*b*.

Fig. 8. F. B. No. 892. Quite marked depression of the diaphragm on both sides, rotation of heart, overdistention of both lungs. Peanut in trachea. (*a*) Expiration before removal; (*b*) Expiration after removal.

breathe quietly with the utmost determination, for the reason that any violent expiratory effort is apt to force the foreign body upward against the glottis and produce an agonizing paroxysm.

A separate brief analysis of the twelve suspected cases is given to avoid confusion with proven cases of foreign body. Case number refers to serial number of *X*-Ray Department records. The number given is for the first examination only. All cases were examined repeatedly; a new serial number, given each time, is not shown here.

Of the twelve cases listed and analyzed as suspected or unproven cases, all had some or all of the symptoms and signs of foreign body, usually severe dyspnea, paroxysmal cough, wheeze, etc., to a sufficient degree to warrant roentgen-ray examination.

It is difficult to estimate the value of the study of these cases because of lack of proof in some of them, especially those with positive or suggestive history of aspiration of foreign bodies, but we feel that our assumptions as to probabilities are fair.

Case 46,309 was particularly puzzling. Signs of obstructive emphysema were quite positive, especially at the second examination. The dyspnea was distinctly expiratory. The dense pathology was not extensive and we could not determine that there was pressure stenosis from without. The bronchoscopic examination was made before the child came to Jefferson Hospital, so that we were unable to exclude the element of trauma. Bronchial ulcers were reported present. The child was not in condition at any time for a second bronchoscopy. Even though the chest signs did disappear to some extent, the child developed a severe gastro-enteritis from which it died. One other point in the history was of importance. Ten days after

Fig. 9a.

Fig. 9b.

Fig. 9. (a) First examination revealed enlarged glands compressing trachea and right bronchus; (b) Second examination after roentgen-ray treatment shows glands reduced in size; (c) Third examination after further treatment and probable breaking down of gland and spreading of infection. Patient recovered.

admission to Dr. Jackson's clinic, the child coughed up three fragments of soft consistency which on drying became very hard. Following this, obstructive signs diminished but did not entirely disappear. We feel it is entirely possible that a foreign body was present and in part remained.

Case 41,741 was probably one of diffuse tracheobronchitis complicating a pneumonia, and the slight obstructive emphysematons signs due to thick secretions. These signs disappeared gradually after tracheotomy and removal of secretions. At the first examination we believed a foreign body was present, but changed this opinion at subsequent observations.

Cases 45,155 and 47,280 were interesting because the cause of obstructive emphysema was shown to be due to pressure on the trachea or bronchus by greatly enlarged glands (Fig. 9, a, b, c).

Fig. 9c.

Case 48,367 was especially interesting because of the positive history and the presence of roentgenographic evidence of lobar pneumonia without any characteristic signs of foreign body. The lung cleared as if by resolution, but the physical signs were atypical. Dr. Jackson was of the opinion that the foreign body had been expelled before our examination, but had caused bronchial inflammation which complicated the physical signs of the pneumonia that intervened. It is a well proven fact that bronchial foreign bodies are occasionally expelled spontaneously. Children rarely expectorate the secretions brought up by coughing, so that the organic foreign body may easily be lost.

It is not practicable to give detailed histories of these cases, even though they are extremely interesting and important, but they do support the brief analysis and assumptions shown above.

The handling of the patients is a matter of the utmost importance. They are generally dyspneic and apprehensive, and often greatly exhausted as well as toxic. Sudden shifting of the foreign body from a bronchus to the under surface of the glottis causes a violent paroxysm and may even produce sudden death, so that it is our rule to handle these children gently, I might almost say tenderly, and yet with a degree of firmness and alacrity that will permit of careful fluoroscopic study, as well as film exposures. We do not object to the child's crying, but do try to prevent struggling by holding the legs, arms and head firmly. This is especially important in making film exposures in order that the patient may be on the cassette and the exposure may be through the median line.

On the fluorescent screen one observes the movements of the diaphragm and heart, and the changes in the lung shadows due to entrance and exit of air. When the obstruction is slight, the lateral movements of the heart may be more striking than the limitation of motion in the affected diaphragm, and the heart moves away from the obstructed side at expiration. The more fixed and depressed the diaphragm, the greater is the lateral displacement of the heart. In severe cases, the affected diaphragm may be lower at expiration than at inspiration. Slight difference in transparency between the two lungs may escape detection by the screen, but be recognizable on the film exposed at the end of expiration. The screen examination gives immediate information, and one is sure to see the extremes of inspiration and expiration.

For roentgenographic study we use duplitized films and double screens. Exposures are always made at the end of inspiration and at the end of expiration, and it is sometimes necessary to repeat the exposures to make sure that they were made at the end of inspiration and expiration.

The exposures are all made with a constant tube-plate distance of about 36 inches (the greatest our apparatus will permit), in a small fraction of a second, probably one-fifteenth.

The patient lies on his back and if not entirely submissive we have nurses hold the arms, head and legs. If too quiet, and we are in doubt after the screen examination, we gently make the child cry a bit in order that we may get exposures at full inspiration and full expiration (Fig. 10, a, b, c). One must, as it were, "shoot on the wing" to get the exposure at the proper time, for rarely will the child take a full breath and hold it, or exhale and stop at one's bidding. The exposure at the end of expiration is always the important one. Exactly the same technique should be repeated after removal of the foreign body, and if the signs persist to an appreciable degree twenty-four hours after removal, a second foreign body should be accused until proven absent.

We have neither the space to include, nor the ability to describe, the physical signs and clinical diagnosis, but there are many features and variations that are unusual and puzzling to the clinician who has not had considerable experience in connection with a bronchoscopic clinic where the fortunate cases ultimately go for relief of some sort of obstruction to breathing. It is a fact, however, that in Dr. Jackson's clinic the diagnosis and localization, made from the history, physical signs, and clinical evidence, are extremely accurate. The reader is referred to the articles listed in the bibliography for information on this phase of the subject.

The roentgenologist should at least have as accurate a history as possible, not only as to the time of onset but particularly as to the nature of the intruder, and he should not on his own responsibility make a negative foreign body diagnosis, especially of such an object as a watermelon seed or other body that might be in the trachea and not produce marked obstruction. He should insist upon repeated examinations

FIG. 10*a*.

FIG. 10*b*.

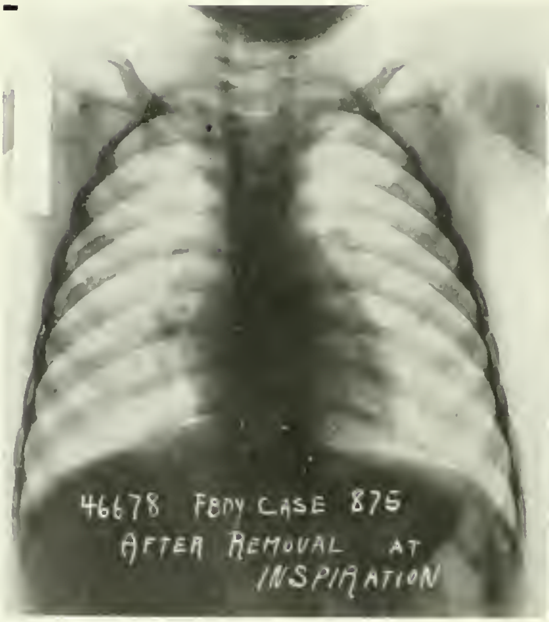

FIG. 10*c*.

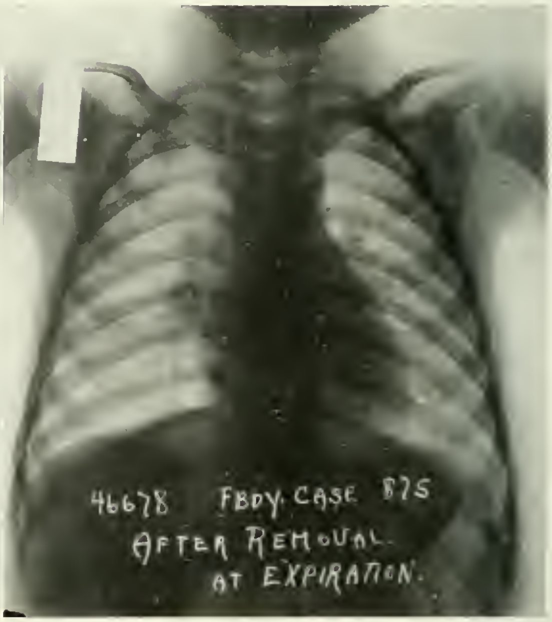

FIG. 10*d*.

FIG. 10. F. B. No. 875. This patient was unusually good and breathed according to instruction. Note that in *a* at full inspiration, aeration of the two lungs is nearly equal, whereas in (*b*) the evidence of obstructive emphysema of the right lung is striking at the end of full expiration. Compensatory emphysema of left lung is quite evident. (*c* and *d*) All signs disappear after removal of foreign body.

unless all signs and symptoms disappear, and even then have the utmost respect for a positive history because of the delusive period of calm that Dr. Jackson has described.

We believe firmly that any organic foreign body lodged in the air passages will eventually cause death if not expelled or removed, and it is most dangerous to hope for spontaneous expulsion. On two occasions to our knowledge, physicians have told the parents that the "peanut" would dissolve. This is an error as unfounded as it is dangerous.

The writer is deeply indebted to Dr. Jackson for his interest and encouragement, as well as for his permission to use the material of his clinic in making this presentation.

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DISCUSSION

Dr. Gray. I had a case recently, a child approximately two years old that gave no definite history of aspirating peanuts but had been eating them. There developed shortly afterwards what appeared to be bronchitis. I went through the procedure which Dr. Manges has described, and could find no evidence whatever either on the fluoroscopic or plate examination of obstruction. There was some blurring and some haziness of the bronchial tree and the physical signs showed bronchitis on both sides. A negative report was given, but the child continued to have trouble and began to grow rather suddenly worse after a few weeks. It was again referred to me and this time I found a distinct consolidation which proved to be pneumonia, I recall, of the lower lobe of the right lung. Diagnosis of obstruction was then made and the case referred by me to Dr. Jackson, who removed several fragments of peanut from the bronchus leading to this lobe. I account for my failure to find any evidence when the case was first referred to me by the fact that the small fragments were merely acting as irritating foreign bodies without being obstructive. Later on, when the inflammatory process had persisted to such an extent as to obstruct the bronchus, the positive signs that I subsequently found showed themselves plainly. We are entirely too prone, when a vague, indefinite history of aspiration comes to us and we fail to find on first examination any evidence of obstruction or the foreign body, to dismiss the case with the statement that there is no foreign body. This case has proven to me that we should not do that, but should keep the case under observation for at least several months.

Dr. Stewart. I feel I cannot let this opportunity pass without the Society realizing the great advantage they have had in listening to this paper by Dr. Manges, who has had a very unusual opportunity in studying these cases. We have seen his gradual development in the work and I feel now that he is one of the best authorities on the subject of foreign body in the lung that we have among us. I therefore cannot pass without expressing my appreciation of his work as he has shown it to us today.

Dr. LeWald. I would like to state that the use of the Potter-Bucky diaphragm gives one a very decided advantage in studying the bronchi on the left side. I know of a case of a pin which was missed because it was in the left bronchus behind the heart shadow. If you will look at lung plates taken with the diaphragm, you will be able to trace the branches of the left bronchus well down behind the heart, and the lower lobe bronchi on each side can be traced in a most satisfactory manner.

I advocate the use of the Potter diaphragm in all cases where the foreign body is not immediately seen.

Dr. Kann. I want to thank Dr. Manges for the kind omission of my name in one of the cases. I want to add my words of felicitation to Dr. Stewart's. I think I have learned more in these few minutes than I have in a few years. I want to thank Dr. Manges again.

Dr. Keith. Those of us who have followed Dr. Jackson's work in opaque foreign bodies know how he emphasizes the use of lateral plates. I want to ask Dr. Manges if he has found lateral plates to be of any service.

Dr. Hickey. I think this brings out the fact that examination should be more than a matter of routine. One of our oculists in Detroit, if there was any injury to the eye, always assumed the foreign body to be present until it was disproved.

I think this should be the attitude of roentgenologists when they are called in consultation in these cases. I have had the opportunity of viewing them from both sides; from operating on them and from making diagnoses. When a case comes in with a suspicious history, the only safe thing to do is to assume a foreign body is there until you are quite sure it is not.

Dr. Manges (closing discussion). First in reply to Dr. Gray. Without having my case records here I am sorry I cannot give him a specific answer. I recall very definitely two cases—one was one of the cases I referred to in my paper—in which a foreign body was not found at bronchoscopic examination although there was bronchoscopic evidence of it. It was very clear in Dr. Jackson's mind, that a foreign body of the arachidic group had been there shortly before. Another time during a bronchoscopic operation he had removed some small fragments of peanut kernel that had become loose into the muco purulent material when suddenly a fragment of considerable size shot out through the bronchoscope and landed at a distance of three or four feet from where he was standing. This shows that there is always a possibility of the child getting rid of a foreign body without your knowing it. So I would like to take this attitude for the present; that unless you can demonstrate by roentgenogram some other cause for obstructive emphysema, you are safe in assuming that there is a foreign body present. Or when a child shows signs of dyspnea and you see no evidence of solid pathology in the lung field, the fact that the bronchoscopist does not find it at the time of operation, does not prove it is not there. In another case a child was under ether for forty-five minutes and one bronchoscopist failed to find a watermelon seed which was afterward removed by Dr. Jackson. We ought to assume that these signs do indicate foreign body unless we can prove there is something else present.

In Dr. Gray's case he said the foreign body was found, whereas he got no signs. I have tried to point out that in the less violent stages of reaction, and especially after the first severe attack is over, there comes a period of more or less calm when the foreign body goes to some place and stops. Then the child soon learns to breathe easily. If not, he gets these recurrent strangling attacks. The *x*-ray signs may be comparatively slight and you must get him to take full inspiration and full expiration, even if you have to gently make him cry.

With reference to lateral plates. When we see children who are dyspneic we handle them gently; we do not struggle with them; we do not examine them in the lateral views until we are convinced that there is no evidence of obstructive foreign body. We always use the lateral position in any other group of foreign body cases.

Dr. Hickey is right in saying that we should assume, when a child has recurrent strangling attacks, with or without history, that there is a foreign body there, until we prove there is not. One must repeatedly examine children. One time or another one will catch the foreign body producing obstruction.

A PRACTICAL METHOD OF ROENTGEN EXAMINATION OF THE HEART BASED UPON A STUDY OF ONE HUNDRED CONSECUTIVE NORMAL AND ABNORMAL CASES *

BY ROLLA G. KARSHNER, M.D., AND ROBERT HELM KENNICOTT, M.D.

From the Clinic of Donald J. Frick, M.D., and Harold H. Smith, M.D.

LOS ANGELES, CALIFORNIA

THE fluoroscopic examination of the heart has been steadily growing in popularity in America, due to the perfection and precision of the method as developed in France. We feel that in experienced hands the information derived from its employment is both valuable and reliable. We have used it for a term of practically three years with increasing satisfaction. It seems unnecessary today to have to justify its position as a diagnostic aid. It is more in point to determine by actual test the value of the various interpretations. With this end in view we set out to examine roentgenologically 100 consecutive cases of normal and pathological hearts, by all the accepted methods. This procedure extended over a period of a little over four weeks. In the series are included 102 cases made up of 47 males and 55 females. Classified clinically 72 had normal hearts and 30 were pathological. The series was not large enough to include all the usual types of cardiac pathology. Little that is new is offered. Practically all the conclusions which we have reached are to be found in the excellent monographs of Vaquez and Bordet, Bardeen, and Van Zwaluwenburg.

Our procedure was first to take a standard 7 foot plate of the patient in the erect position in the manner described by Holmes and Ruggles. This method does not differ materially from the original procedure of Bardeen except that the patients were roentgenographed in the standing position. An orthodiagram was then made of each patient, the ray passing through the chest in a sagittal plane. The patient was then rotated to the left and observed in the right anterior oblique position. Finally each case was studied in the right posterior oblique position.

The area of the heart shadow on the 7 foot plate was measured by planimeter and was also computed by applying the method of Van Zwaluwenburg. The width of the chest wall of each case was measured and compared with the total transverse diameter (sum of MR and ML) of the heart according to the method of Danzer. The area of the orthodiagram was then measured by planimeter and also computed by the method of Van Zwaluwenburg.

From our comparison of the clinical value of the 7 foot plate and the orthodiagram we are convinced for several reasons that the latter is both the most valuable and the most accurate method. It enables us to establish the left auriculoventricular junction, which is the most important point on the heart silhouette. We can better outline the heart shadow and study its motion and dynamic relationship to the other organs of the chest, and are enabled to examine the heart in the oblique positions.

We shall discuss the results of our studies under four headings.

I. THE CARDIAC FORM

Roughly, we may say that the normal cardiac outline is represented by a series of curved lines. On the right side are two fairly broad curves, the lower one representing the border of the right auricle, and the upper, less well defined, representing, in most cases, the right border of the superior vena cava, sometimes the right border of the ascending arch. The latter soon becomes lost in the mediastinal shadows, to reappear on the left side as

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a semicircle representing the transverse portion of the arch. The left border of the descending arch may usually be distinguished as a straight line, approximately tangential to the shadow of the transverse arch. Immediately beneath the transverse arch one sees with greater or less distinctness, a curved line, convexity outwards, representing the ascending and transverse portion of the pulmonary arch. Its downward extension is in an almost straight line diverging slightly to the left and in some cases directly joining the left ventricle, which is the most conspicuous curve in the entire silhouette, running obliquely downward to the region of the apex beat and beyond to disappear beneath the left diaphragm. Its exact relation to the diaphragm depends upon the habitus of the patient. In slim individuals and in quiet respiration the apex may be entirely free from the dome of the diaphragm. In most normal individuals it is almost entirely exposed on deep inspiration, while in those with a high diaphragm, particularly the obese, the left ventricular border may be interrupted above the point where it reaches its maximum distance from the midline.

Interposed between the pulmonary arc and the ventricular arc in the majority of cases one sees a short straight line which represents the left auricle. It can be recognized from the ventricular shadow by the time of its contraction, its lower limit being marked by the point of minimum excursion.

The typical forms of heart silhouette, such as the drop heart of visceroptosis, transverse heart of old age and obesity, the boxing glove heart of mitral stenosis, the round heart of mitral regurgitation, snub nose or shoeshaped heart of the aortic regurgitation, the water-bottle shadow of pericardial effusion, have long been accepted among orthodiagraphers, and require no comment.

Vaquez and Bordet make use of various so-called diameters or chords to express numerically variations in size of different chambers of the heart. The basal diameter is drawn from the right auriculo diaphragmatic junction to the left auriculo ventricular junction, and corresponds to the oblique diameter of other authors. While this diameter is believed to measure the development of the base of the ventricles, in our experience we have found it of very little value. They have also introduced new diameters. The so-called left ventricular diameter extends from the left auriculo ventricular junction to the apex and it presumes to measure the longitudinal development of the left ventricle. While our experience with this diameter is limited, we see no advantage in it over the portion of the long diameter lying below and to the left of the oblique diameter. Vaquez and Bordet measure the degree of curvature of the left ventricular contour by the length of the chord of the arc which it describes. The right ventricular diameter is drawn from the right cardio diaphragmatic angle to the apex of the heart, and is presumed to measure the development of the right ventricle. The right auricular diameter joins the right cardio diaphragmatic junction to the auriculo caval junction and presumably measures the volumetric development of the right auricle. The left auricular diameter connects the most salient point of the left auricular contour with the median line, which is presumed to represent the interauricular septum. We would consider this latter diameter as of exceedingly doubtful value.

Van Zwaluwenburg's reductions of the changes in shape of the heart silhouette to a simple numerical expression have proved of extreme value in our hands. He pointed out in 1911 that the oblique diameter roughly corresponds to a dividing line between the auricles and ventricles; consequently the area above and to the right of this line can be considered an index of the auricular area, while that to the left and below represents the size of the ventricular portion of the heart. This relationship is expressed numerically by dividing the length of the auricular segment by the length of the ventricular segment of the long diameter, and is called the auriculo-ventricular (a-v) ratio, or the index of the heart. Normally it is approximately 0.55. With an increase in the auricular area its value rises. Relative increase in the ventricular size diminishes the index. While this index has many defects and varies widely, depending upon the elevation of the diaphragm in normal subjects, and is disregarded in such cases except as an index to the posture of the heart, it is of great importance in the estimation of the relative size of the different chambers of pathological hearts.

The examination of the patient in the right anterior oblique position as advocated by Vaquez and Bordet, we consider of great practical value. These authors have shown that narrowing or obliteration of the upper third of the uniform clear stripe, which represents the posterior mediastinum signifies dilatation of the aortic arch; that encroachment in the middle third means enlargement of the left auricle; and modification of the lower third spells enlargement of the right auricle, sometimes of the right ventricle.

The examination of the patient in the right posterior oblique position to determine the depth of the ventricles has proven of less uniform value in our hands in patients of widely different habitus such as make up our population.

With the data from these examinations at hand we can furnish the clinician a quantitative estimation of the qualitative valvular changes which he has determined by auscultation.

II. THE CARDIAC SIZE

Shattuck in 1916 demonstrated by roentgen-ray methods the inaccuracy of percussion in the estimation of the size of the heart.

Danzer in 1919 revived the so-called cardio-thoracic ratio as a means of estimating cardiac hypertrophy. According to this method, the heart is said to be definitely enlarged when its total transverse diameter exceeds one-half of the internal diameter of the chest. In our series practically all the normal hearts with the exception of the visceroptotics show cardiac enlargement according to this method. Naturally the method ignores variation in position of the diaphragm. It would seem from our investigation that it is more accurately an index of the posture of the heart than of the size of the heart. Attention is invited to a few specific instances. Case 02 weighing 175 pounds, by planimeter showed a heart area well within normal limits. According to Danzer this heart shows 19 per cent enlargement. Case 022 of compensated mitral stenosis complicated by mitral regurgitation by planimeter showed an area of practically 160 per cent. According to Danzer this heart showed 1 per cent enlargement. Case 056, mitral regurgitation, according to planimeter showed a cardiac area of 167 per cent. According to Danzer this heart showed 20 per cent enlargement. Case 049, myocarditis without dilatation, according to planimeter showed an area of 150 per cent. According to Danzer this heart was not enlarged. Bardeen has shown that in order to use the transverse diameter of the heart as an index of area, the diameter should be squared. When this was done the variations were so great as to be impracticable.

While it will be seen at a glance that the cardio-thoracic ratio is grossly inaccurate considered as an index to the size of the heart, it is conceivable that it might be of limited assistance in determining changes in the cardiac condition as the result of treatment. A heart whose size is estimated at a time of dilatation with enlargement of the liver due to congestion and a consequent rise in position of the diaphragm will naturally show a high cardio thoracic ratio. Such a case after treatment and relief of cardiac dilatation and engorgement of the liver will show a true decrease of the cardio thoracic ratio due to the alteration of these two factors. However, we cannot see that the method has any degree of superiority over the simple super-position of one plate over another. In our practice, we report the MR and ML merely that the clinician may check his percussion.

Claytor and Merrill in 1909 proposed a method of approximation of the heart area based upon 70 per cent of the product of the long diameter and the transverse diameter. Objections to this method immediately arise. The method makes use of the transverse diameter. The factor .7 is an arbitrary factor. Their calculations have been proved inaccurate beyond a degree of practicability. This inaccuracy is largely due to the fact that the two diameters used in computation intersect at angles of varying obliquity. In other words, the results are not independent of the position of the heart.

Holmes and Ruggles describe the method of estimation of heart size used at the Massachusetts General Hospital. The method is applicable to both the orthodiagram and the plate. The conventional MR and ML and longitudinal diameter are drawn. A line is drawn perpendicular to the long diameter extending to the right auriculo diaphragmatic junction or the most salient point on the right border. Another line perpendicular to the long diameter is drawn to the most salient point on the left border, or to a point on the border of the left auricular appendage. It is argued that the sum of the lengths of these perpendicular lines is increased with enlargement of the auricles, while the long diameter is increased with ventricular enlargement. Careful examination of the figures in Holmes and Ruggles' book lead us to believe that their perpendicular lines are not always drawn to even approximately the same points on the cardiac borders, and that consequently they are not comparing aliquot portions of hearts. They offer no method for computing the heart size. We can see no superiority of the broken perpendicular line over the greatest perpendicular to the long diameter erected in the closed cardiac outline.

Bardeen estimates the cardiac size by the use of the planimeter on a 7 foot plate. His tables of the heart size are the result of careful investigation and are fairly accurate. In our own series the discrepancy between the planimeter measurement of the orthodiagram and the planimeter measurement of the 7 foot plate has been practically constant, the average being 30 per cent. It is true, some of the figures vary widely from the constant, but these variations are due to qualities other than those of computation. In the first place our areas are uncorrected as we did not record the anteroposterior diameter of the chest in expiration. Other factors which account for the discrepancy of our figures may be mentioned. While the greatest care was exercised in taking our 7 foot plates we were impressed during the procedure with the apparent wide variation in distance of the chest wall to the plate in different patients due to peculiarities of stature and shape of the chest. Such variations naturally made considerable difference in the final computation. We believe the most important factor which entered into our error was the difficulty encountered in faithfully tracing the cardiac shadow. Our plates were technically good. However, we are dealing with a shadow of a moving body undergoing two separate and distinct types of motion, one that due to respiration, and the other due to the heart action itself. The heart is not an organ of uniform density. Often the apex which is the thinnest portion of the cardiac shadow would be lost behind a high diaphragm or diffused in the stomach bubble. In the cases of drop-heart or displacements and distortions due to pulmonary pathology, the right border was often overridden by the spinal shadow or lost in a maze of scar tissue, and it was only with the greatest difficulty that we could reasonably approximate the actual size of the shadow. These difficulties were not encountered in the orthodiagram. The very motion which rendered the outline of the apex indistinct in the plate aided the eye in tracing it before the fluoroscope. Likewise the motion of the borders and the ability to rotate the patient for a moment so as to locate the definite cardiac border in the oblique position aided in the accuracy of the orthodiagram.

The area of the heart shadow on the plate computed by applying thereto the formula for the area of an ellipse approximated the planimeter value surprisingly closely, the average error being about 2 per cent.

Naturally any accurate formula for the estimation of the size of the heart must make use of factors which are uninfluenced by the widely variable relative position of the heart. Van Zwaluwenburg has proposed that the heart be considered as an ellipsoid, and has applied thereto the formula for the area of an ellipse which is the product of the long diameter drawn through the center of the figure and the short diameter erected perpendicular thereto at the widest portion of the shadow, multiplied by .7854. The result obtained by such computation in 60 cases showed an average error of a little over 3 per cent as compared with planimeter values, the greatest variation in any one case being 8 per cent in a heart of very doubtful and irregular shape. We have compared our results obtained by this method of computation with the planimeter values and have found an average variation of 2.6 per cent with the greatest variation of 6.9 per cent, 5 of our cases checked within .1 per cent, 22 checked within 1 per cent. 45 checked within 2 per cent, 62 checked within 3 per cent, 82 cases less than 4 per cent, 91 cases less than 5 per cent, 100 cases less than 6 per cent, 2 cases above 6 per cent. We have consequently adopted this procedure as a basis for estimating the cardiac area because it introduces a practically negligible factor of error.

Bardeen has shown that a considerable portion of the left auricular appendage and presumably a portion of the base of the heart is excluded from the closed cardiac outline formed by joining the right auriculo caval junction to the left auriculo ventricular junction in a gentle curve and similarly closing the lower opening. The method of estimation consequently does not include the entire cardiac area. However, the computed area is expressed as a percentage of the normal for the individual, and it is submitted that one can accurately determine the relative size of two similar bodies by estimating adiquot portions and expressing the same in a ratio.

Since the estimation of area is expressed in percentage of the normal, the computation can be further simplified by dropping the factor .7854 which appears in both numerator and denominator of the ratio. In practice, therefore, we multiply the long diameter by the short diameter and call this product the P O D (Product of Diameters). The product so obtained is divided by the corresponding value from a table of normal PODs of the basis of body weight. Hearts falling between 100 per cent and 110 per cent are considered normal according to the table which we employ(Fig. 1). This table of normals when plotted into a curve falls very nearly on a line representing the following relationship. The area in square centimeters is equal to a constant times the cube root of the weight in pounds squared. Except as to the constant, this table is in close harmony with the values for cardiac area deduced by Bardeen and is a simple expression of the hypothesis that the weight of the heart varies directly with the weight of the body and that comparable areas on similar volumes vary as the cube root of the

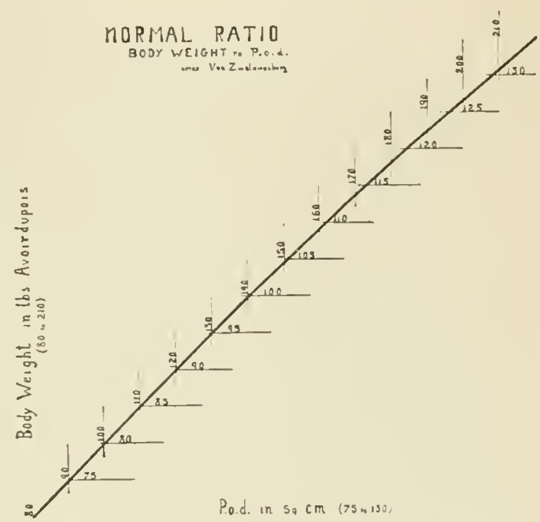

Fig. 1. Table showing relation of P O D to normal body weight. Experience has shown that this table is approximately 5 per cent too low. Consequently hearts ranging from 100 to 110 per cent of the values in this table are considered normal. After Van Zwaluwenburg.

squares of these volumes. Anatomically it has been repeatedly proven that the heart, of all the organs, is the most closely related in size to the size of the body as a whole.

While the size of the heart depends on a large number of factors including weight, habitus, position, excursion of pulsation, age, sex, and pulse frequency, it has been borne out by clinical experience, and there is abundance of proof both anatomical and roentgenological, that the weight is far the most important factor. As a matter of fact, height, sex, and age have a very subsidiary value except at the extremes where the estimation of their effect is rarely difficult. A factor which is of greater importance than any of these except weight is the pulse rate. We are in accord with Van Zwaluwenburg in the opinion that a rapid heart with an area of 110 per cent is

CLINICAL CLASSIFICATION OF ONE HUNDRED TWO CASES WITH MEASUREMENTS AND COMPUTATIONS

Normals

Case Number	Sex	Age	Weight	A-V Ratio, Orthodiagram	Total Transverse Diameter, Plate	Width of Chest Wall, Plate.	Per Cent Enlargement According to Danzer	Area Planimeter: Orthodiagram	Area Planimeter: Plate	Area Planimeter: Per Cent Discrepancy	Area Computation: Orthodiagram	Area Computation: Percentage	Area Computation: Plate	Area Computation: Per Cent Discrepancy	Per Cent Discrepancy Orthodiagram Area Using Planimeter and P.O.D.	Clinical Classification
S014	M	30	193	0.53	14.4	27.1	6	100.8	136.6	34	95.8	98	144.7	51	−4.9	Pulmonary tbc. Underweight.
S017	M	24	140	0.70	12.6	24.8	2	96.7	125.8	30	93 5	119	126.4	35	−3.3	Pulmonary tbc. Underweight.*
077	F	37	133	0.64	11.5	23.4	0	71.7	93.1	29	73.0	98	97.1	33	+3.2	
S016	M	26	141	0.42	12.2	26.2	0	92.9	126.6	36	86.4	110	127.8	48	−6.9	
026	F	25	125	0.63	10.8	22.2	0	65.5	83.2	27	68.3	102	86.7	27	+4.3	
041	F	27	120	0.54	12.5	23.1	9	85.7	99.7	16	82.5	117	97.9	18	−3.7	Member of B family.†
124	M	29	175	0.70	13.9	27.5	1	97.0	112.2	10	101.3	110	111.6	10	+4.4	
045	F	47	148	0.52	13 0	25.8	1	88.6	124.0	41	90.3	109	125 5	39	+1.9	General paresis.
073	F	54	150	0.56	13.3	24.5	8	90 5	130.5	44	89.5	109	128.7	43	−1.6	
044	M	23	135	0.70	12.3	26.4	0	82.0	123.1	51	84.8	110	133.7	55	+3.4	
047	F	50	113	0.59	11.7	22.4	4	78.0	95.0	22	77.0	110	108.5	41	−1.3	Chronic pulmonary tbc.
023	F	24	135	0 54	14.0	24.0	16	85.9	117.1	36	88.8	114	118.1	33	+3.4	Member of B family.†
021	F	38	128	0.55	11.5	23.2	0	83.6	112.1	34	80 1	109	113.0	41	−4.2	Chronic pulmonary tbc.
02	F	62	175	0.50	13.4	22.5	19	91.7	105.3	14	94.2	103	106.7	13	+2.7	
S09	F	28	150	0.57	12.1	24.1	0	85.8	114.0	33	87.9	109	115.4	31	+2.4	
016	F	35	126	0.69	11.2	23.1	0	79.1	95.4	21	80.1	110	100.0	25	+1.2	
048	F	40	185	0.50	12.9	22.7	14	89.6	117.4	31	88.0	93	115.0	31	−1.8	High diaphragm.
054	F	23	130	0 59	10 3	24.2	0	74.6	86.0	15	71.5	96	90.2	26	−4.1	
051	F	36	125	0.60	12.0	23.8	1	84.7	107.2	26	81 7	111	108.4	32	−3.5	
032	F	25	147	0 44	13.4	23.9	12	76.6	106.3	38	77.0	95	101.9	32	+0 4	Hereditary lues. High diaphragm.
053	F	34	130	0.47	12.1	22.0	10	71.2	93.6	31	71.5	95	93.3	30	+0.4	High diaphragm.
052	M	16	133	0.74	13.7	24.1	14	96.3	144.4	60	99.0	130	153.3	55	+2.8	Adolescence.
03	M	39	152	0.66	13.1	24.7	6	83.0	107.1	17	83.2	95	106.7	28	+0 2	
040	F	25	120	0.60	10.4	22.7	0	68.1	84.2	24	69.9	99	85.7	23	+2.6	
057	F	33	150	0.52	12.8	23.6	9	89.3	131.6	47	87.9	107	136.5	55	−1.5	
036	F	30	100	0.56	11.1	22.0	1	66.1	91.6	39	69.9	110	96.5	39	+5.7	
033	F	49	147	0.20	14.0	24.0	17	84.6	113.2	34	83.3	103	108.5	30	−1.5	Old luetic and luetic aortitis.
042	M	87	150	0.40	11.1	26.7	0	79.6	94.4	19	81.7	99	105.2	15	+2.6	Senile heart. Underweight.
014	F	20	125	0.40	11.5	23.6	0	70.1	107.0	52	71.5	99	108.4	51	+2.0	Marked scoliosis.
S018	M	27	130	0.50	13.3	23.6	13	97.5	135.5	38	92.7	124	137.8	48	−4.0	Pulmonary tbc. Underweight.*
S015	M	30	172	0.56	13.8	24.5	12	100.9	141.0	41	102.9	113	139.7	36	+1.9	Pulmonary tbc. Outline doubtful.
062	F	26	155	0 41	14.3	25.3	13	92.1	132.5	43	89.5	105	130.2	45	−3.0	Luetic aortitis.
S08	F	26	150	0.48	13.5	24 8	9	96.2	118 9	23	94.3	114	119.3	26	−2.0	Pulmonary tbc. Underweight.*
S03	F	31	122	0.52	9.9	22.0	0	72.9	98.8	35	74.8	102	101.6	36	+2.6	Chronic pulmonary tbc. Outline doubtful.
S020	F	24	126	0.57	10.3	21.5	0	75.1	92.2	23	74.6	102	96.5	29	−0.7	
S019	M	30	152	0.59	13 2	26.8	0	103.3	142.7	38	102.1	122	145.2	42	−1.2	Pulmonary tbc. Markedly underweight.*
S022	F	24	130	0.76	13.2	24 0	10	84.1	130.3	53	84.0	112	131.6	56	−0.1	Pulmonary tbc. Underweight.*
S023	M	34	160	0.51	13.9	25.3	10	85.5	122.1	43	81.7	95	124.4	52	−4.4	Pulmonary tbc. Underweight.
S01	F	29	125	0.61	11.5	24.5	0	90.8	104.3	14	91.1	125	104.6	15	+0.3	Pulmonary tbc. Pleural effusion.
S025	M	30	140	0.83	12.1	23.9	1	88.5	124.0	40	85.6	109	128.6	50	−3.2	Pulmonary tbc.
S024	M	25	130	0.44	13.2	25.6	3	85.8	120.1	39	86.4	116	120.0	39	+0.7	Pleural adhesion at apex.
S07	F	23	156	0.52	11.1	25.3	0	82.4	121.6	47	84.0	100	125.3	49	+1.9	
078	M	49	180	0.50	15.2	28.2	8	106.8	155.4	45	102.1	110	151.3	48	−4.4	
S013	M	25	167	0.40	15.6	27.7	13	119.4	168.0	40	113.1	127	170.2	50	−5.2	Old adhesions.
064	F	18	113	0.73	10.2	22.3	0	73.7	93.9	27	75.4	110	98.2	30	+2.3	
063	F	35	118	0 64	10.6	23.6	0	75.2	95.0	23	77.0	109	97.0	26	+2.4	Luetic.
065	F	35	118	0.69	11.4	21.1	8	75.8	97.5	28	76.2	108	100.0	31	+0.5	
060	F	19	115	0 74	9.0	22.6	0	69 3	98.7	42	71.2	103	96.8	36	+2.7	
059	F	42	155	0 55	13.7	23.4	12	94 7	134.3	46	90.0	107	137.4	53	−4.9	
S010	M	45	175	0.65	13 5	26.1	3	103 1	120.9	17	101.3	110	120.5	19	−1.7	
071	F	25	130	0.59	10 1	21.3	0	77.9	87.7	12	77.0	103	89.7	17	−1.2	Luetic.
067	F	42	125	0 50	11.6	21 9	6	76.0	100 0	31	77.0	105	104.4	35	+1.3	
029	F	50	114	0 75	11.5	23.6	0	69 3	91.0	31	71.5	102	97.5	36	+3.2	
082	M	23	150	0.70	12.4	26 0	0	93.6	132.4	41	97.0	111	136.1	40	+3.6	Mild nephritis.
055	F	34	120	0.65	11.8	21.8	8	71.2	103 6	45	73.0	103	104.5	43	+2.5	

Visceroptosis

Case Number	Sex	Age	Weight	A-V Ratio, Orthodiagram	Total Transverse Diameter, Plate	Width of Chest Wall, Plate.	Per Cent Enlargement According to Danzer	Area Planimeter: Orthodiagram	Area Planimeter: Plate	Area Planimeter: Per Cent Discrepancy	Area Computation: Orthodiagram	Area Computation: Percentage	Area Computation: Plate	Area Computation: Per Cent Discrepancy	Per Cent Discrepancy Orthodiagram Area Using Planimeter and P.O.D.	Clinical Classification
S02	F	23	125	0 78	8.1	23 8	0	61 0	62.5	2	62.8	90	65.5	4	+2.9	Pulmonary tbc. Markedly underweight.
S021	M	27	150	0 88	10 4	26.6	0	75.7	105.7	39	80.9	98	107.3	32	+5.5	Pulmonary tbc.
S05	M	32	160	0 87	11.0	26.0	0	74 0	100.6	48	78 0	89	110.3	41	+5.4	Pulmonary tbc. Markedly underweight.
01	F	24	114	0 90	9 3	23 4	0	67.0	73 6	8	71.0	104	80 7	13	+4 5	
027	F	22	100	0 87	9 4	22.3	0	62 1	74 2	45	65.8	101	76.3	16	+5.9	
028	F	20	117	0 80	11.1	23 3	0	63 7	92.6	19	65.2	95	97.8	50	+2.3	
025	F	28	110	0 80	11 2	21.9	2	70.2	90.1	8	73.8	104	105.4	42	+5 1	

* Underweight. Percentages on present weight, not average weight.

† Three members of one family, apparently normal, presented large hearts. Reason undetermined. Cases prefixed with the letter S were patients at the Barlow Sanatorium for Tuberculosis. We wish to express our thanks to Dr. Munford Smith for the privilege of examining these patients.

CLINICAL CLASSIFICATION OF ONE HUNDRED TWO CASES WITH MEASUREMENTS AND COMPUTATIONS (*continued*)

Case Number	Sex	Age	Weight	A-V Ratio, Orthodiagram	Total Transverse Diameter, Plate	Width of Chest Wall, Plate	Per Cent Enlargement According to Danzer	Area Planimeter: Orthodiagram	Area Planimeter: Plate	Area Planimeter: Per Cent Discrepancy	Area Computation: Orthodiagram	Area Computation: Percentage	Area Computation: Plate	Area Computation: Per Cent Discrepancy	Per Cent Discrepancy Orthodiagram Area Using Planimeter and P.O.D.	Clinical Classification
Athletes																
075	M	36	198	0.49	14.6	26.9	9	117.4	142.6	21	115.4	116	146.0	26	−1.7	Stanford crew.
080	M	31	165	0.67	13.3	27.8	0	102.7	111.6	9	102.1	117	120.1	17	−0.6	Wisconsin crew.
010	M	23	143	0.73	13.5	24.3	11	94.6	122.3	29	94.2	118	128.0	35	−0.4	
09	M	21	138	0.67	12.3	25.0	0	90.6	115.0	29	93.5	120	120.2	28	+3.2	
015	M	21	150	0.85	12.3	25.6	0	95.8	118.5	25	94.2	115	121.4	29	−1.6	
046	M	40	175	0.45	14.8	26.5	12	115.7	144.3	25	119.4	120	145.6	22	+3.2	Pennsylvania crew.
034	M	26	160	0.54	14.4	27.6	4	124.8	161.0	29	131.2	153	163.8	25	+5.1	Member of B family.†
S011	M	30	182	0.39	13.6	25.4	7	110.1	139.0	26	106.0	112	143.4	35	−3.7	Harvard crew.
068	M	37	148	0.60	12.7	25.9	0	103.4	109.2	6	104.4	126	114.6	9	+0.9	
S026	M	32	158	0.58	11.8	25.8	0	99.8	110.2	10	97.3	112	113.6	16	−2.5	Chronic pulmonary tbc.
Effort Syndrome																
066	F	18	123	0.74	9.7	24.0	0	63.4	96.3	52	62.8	87	87.6	23	−0.9	Pulse 150.
Mitral Stenosis, Compensated																
022	F	29	146	1.08	12.7	25.2	1	125.2	142.2	13	129.6	160	159.0	22	+3.5	Complicated with regurgitation.
018	F	32	116	1.07	16.6	23.9	39	121.9	187.1	53	122.5	178	196.1	61	+0.5	Complicated with regurgitation.
Mitral Regurgitation, Compensated																
058	F	42	163	0.90	14.0	23.3	20	109.5	135.9	24	110.0	127	139.0	26	+0.2	
069	M	54	245	0.51	17.4	24.9	40	132.0	203.5	54	132.7	113	199.1	50	+0.5	
056	F	25	128	0.73	14.4	23.9	20	125.5	143.2	14	123.0	167	145.1	18	−1.9	
Hypertension																
070	F	57	170	0.40	14.1	26.5	7	97.0	138.6	42	95.0	106	140.7	48	−2.1	
135	F	35	115	0.45	11.2	23.2	0	86.8	96.7	11	92.3	136	101.9	14	+6.3	
012	F	59	195	0.54	15.9	24.5	29	130.9	129.0	0	129.6	132	128.8	0	−1.0	
030	M	52	190	0.51	15.6	25.0	25	102.2	125.1	22	102.9	115	125.7	22	+6.0	
038	F	41	167	0.37	14.2	23.3	22	102.2	147.6	44	106.0	119	151.7	43	+3.7	
076	M	60	150	0.46	13.8	27.1	2	110.2	130.0	18	106.8	129	130.2	22	−3.1	
Myocarditis, Without Dilatation — *Senile, arteriosclerotic, angina, etc.*																
039	M	55	180	0.43	15.9	31.0	2	105.5	132.6	25	105.2	114	132.7	26	−0.3	Heart block.
049	M	63	120	0.80	13.6	21.7	0	108.6	150.8	39	106.0	150	150.2	41	−2.4	Arteriosclerosis.
04	F	60	158	0.40	12.5	23.1	8	79.4	93.7	18	79.3	94	97.4	23	−0.1	Senile, underweight.
043	M	50	165	0.42	14.9	25.8	15	109.8	130.5	19	111.5	126	127.4	14	+1.5	
081	M	69	150	0.48	15.8	28.2	12	120.0	147.1	23	117.0	142	140.8	34	−2.5	Senile, hypertension.
031	F	37	169	0.55	14.2	24.8	14	104.3	116.5	11	104.5	118	115.5	10	+1.5	Nephritis, lues.
083	M	66	155	0.57	14.9	30.0	0	104.9	142.5	35	108.4	128	139.5	29	+3.3	Angina, arteriosclerosis.
037	M	47	155	0.48	13.3	25.9	3	98.2	115.6	28	104.0	125	118.7	14	+5.9	Luetic arch.
019	M	42	132	0.36	13.8	25.1	10	90.7	145.7	60	91.9	122	147.6	49	+1.3	Luetic aortitis, tabetic.
013	M	73	150	0.50	16.9	28.5	19	115.3	165.4	34	114.7	139	167.1	45	−0.5	
074	F	56	125	0.80	11.8	22.1	7	86.0	111.9	30	87.2	120	114.6	31	+1.4	
Myocarditis, With Dilatation — *Advanced stages of valvular disease, results of nutritional and toxic causes, high blood pressure, nephritis, etc.*																
061	M	36	148	0.30	16.5	26.2	26	139.2	189.9	36	139.0	170	185.2	34	−0.2	Acute nephritis, hypertension.
06	M	36	148	0.40	16.6	26.0	28	150.1	164.6	9	150.0	184	168.1	12	−0.6	Acute nephritis, hypertension.
07	M	68	135	0.50	13.3	24.2	10	113.0	128.4	13	117.0	152	130.4	11	+3.5	Arteriosclerosis.
072	M	74	215	0.39	19.2	31.0	24	135.0	230.1	71	130.4	125	233.1	78	−3.4	Nephritis.
08	M	55	180	0.47	17.5	28.3	24	137.7	177.8	29	139.8	150	164.9	19	+1.5	Heart block, luetic aortitis.
017	M	60	147	0.38	15.3	23.6	30	103.7	137.0	32	100.5	124	136.4	35	−3.1	Nephritis.
050	M	62	175	0.67	15.4	27.4	13	113.1	130.3	15	113.1	121	131.2	16	−0.0	Old pulmonary tbc. with adhesions.

enlarged; and this is in fact a type of heart most frequently encountered in cases of toxic goitre.

III. THE CARDIAC MOTION

We are often told by the clinician that he cares little about the actual size or shape of the heart; that the presence or absence of a valvular lesion is of little significance so long as the heart is doing its work; that the prognosis and treatment depend entirely upon the condition of the heart muscle.

From our experience in repeated roentgen-ray observations of pathological hearts under treatment we are able to make fairly accurate estimates of how well the muscle is doing its work. We have seen dilated hearts come down from computed areas of 175 per cent to 130 or 120 per cent, and have noted corresponding improvement in the density of the lower lung fields, and in the shape, and particularly the motion, of the heart. Our roentgen-ray examinations are made independent of any knowledge of the clinical examination and have checked closely with the physical findings and the symptoms of the patient at the time. In fact, we have been able in certain instances to detect muscle failure twenty-four to forty-eight hours in advance of physical signs of dilatation.

Eyster and Meek by instantaneous radiographs of the heart have shown that the movement of no single border is an accurate index of its contraction, and that the whole outline is necessary for such estimation. However, to the experienced observer much information is derived from the movement of the various sectors of the heart. These are easily recognized, but difficult to briefly describe. One is first struck with the slight excursion to be seen anywhere on the cardiac border, and it is the general impression that the base of the heart is fixed and that the ventricular systole produces a wide retraction of the apex. However, the base of the heart is generally the least fixed portion of the organ, approaching the apex in greater degree than the apex approaches the base. The simultaneous filling of the auricles tends to prevent a reduction of the long diameter during ventricular systole. The lateral movement of the lower border being restricted by the diaphragm, the only margin of the heart that is free to move is the left upper border, its motion being a shortening of the transverse diameter. Another factor to be considered is the movement of the heart as a whole. Frequently the movement of a certain segment of the silhouette, as, for example, that sometimes seen in the left auricle in cases of auricular fibrillation and that commonly seen on the right auricular border, represents not the intrinsic movement of that segment but rather the transmitted motion of the organ as a whole. For this and other reasons, disturbances of rhythm are best analyzed by the electrocardiograph and proposed roentgen-ray methods, since such determinations, as suggested by Godht and Rosenthal in 1912 and elaborated by Crane in 1916, fail.

Certain features of disturbed motion are, however, subject to fluoroscopic examination. In visceroptotics where the heart lacks the support of the diaphragm and is freely suspended from its attachment in the mediastinum to the deep fascias of the neck, the base is relatively fixed and the heart as a whole moves as a result of the recoil from the expulsion of blood into the aorta. In the pathological heart one soon learns to recognize the disturbances of motion. The impulse may be excessive or insufficient; it may give one the impression of being disorganized or lacking in coordination or purposefulness. Thus the experienced observer readily notes the heaving impulse of aortic regurgitation, the total lack of cardiac movement in pericarditis with effusion, the almost total lack of movement frequently seen in myocarditis, and the shapeless flaccid outline with rather wavy, futile, poorly sustained impulses of myocarditis, this type most often of thyroid origin.

IV. THE AORTA

Consideration of the heart is not complete without a discussion of the aorta. Normally it is not a conspicuous shadow; its lower right border is usually fairly well seen but is soon lost in the shadow of the sternum. The transverse arch on the left is fairly prominent but is all but hidden behind the sterno-clavicular articulation. On the screen the left lateral surface of the descending portion is usually obscured by the pulmonary and hilus shadows, but may be fairly well studied in the radiogram.

Age uncomplicated by hypertension causes an increase in the prominence of the arch throughout. Its density is increased, and occasionally calcified plaques are noted in the portions of the wall which are viewed tangentially. The arch is not greatly widened but strikingly increased in length, resulting in a greater prominence of the transverse arch and in a downward displacement of the base of the heart. The heart resting on the diaphragm consequently assumes a horizontal position. In arterio-sclerosis the aorta approximates the senile type. In hypertension the arch may be slightly widened, the upper left segment prominent with perhaps a slight increase in density. Lues shows an early tendency toward increased width of the aortic shadow, a common picture being that of the undue prominence just above the auriculo caval junction. Frequently the dilatation extends the entire length of the visible aorta. In such types of aortic change the pulsation is not excessive. Especially in the case of lues one notes a distinct reduction of the excursion. In rheumatic aortic insufficiency, on the other hand, the arch shows no appreciable dilatation, but a wide expansile excursion.

CONCLUSIONS

One hundred two hearts were examined radiographically by all the accepted methods with the following conclusions:

1. The roentgenoscopic examination of the heart is far superior to the use of the 7 foot plate.

2. A thorough roentgen-ray study of the heart embraces consideration of four elements; the shape of the cardiac shadow, its size, its motion, and the aorta.

3. The heart form is best studied by the roentgenoscope, the patient being examined in the direct and oblique positions. Changes in shape in pathological hearts are due to relative enlargement of certain chambers of the heart as compared with other chambers, and such localized enlargement is best estimated by the A-V ratio of Van Zwaluwenburg and the use of the oblique positions of Vaquez and Bordet. The roentgenoscopic examination of valvular disease adds a quantitative estimation to the qualitative findings of the stethoscope.

4. The so-called cardio-thoracic ratio is a grossly inaccurate index to the actual size of the heart.

5. There are two practicable methods of accurately estimating the cardiac size from the orthodiagram: First, the use of the planimeter; second, the simpler method of Van Zwaluwenburg, which consists of the product of the long and short diameters of the silhouette compared with the normal, based upon body weight.

6. Expression of the cardiac area as a percentage of the normal is more satisfactory to the clinician than the statement of the actual area.

7. Much information may be gained from the study of the cardiac motion by the experienced observer. One notes the force, the tone, the organization, the coordination, the presence of excessive or insufficient motion, the intrinsic motion of various chambers, and the transmitted motion of the heart as a whole, together with its relationship to other structures in the chest.

8. The aorta, which is normally an inconspicuous portion of the cardiac shadow, takes on definite characteristics in certain cardiac pathology. Chiefly among these are the changes due to age, hypertension, arteriosclerosis, lues, and pathology in the aortic valve.

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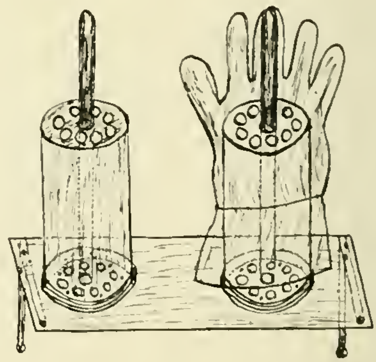
A PROTECTIVE GLOVE RACK

BY ROSCOE G. VAN NUYS, M.D.

OAKLAND, CALIFORNIA

Many Roentgenologists find it difficult to keep their protective gloves dry inside and free from offensive odor. After trying several schemes, I hit upon a very simple one which can easily be made in any laboratory, and may solve the vexing problem for some one else as it has done for us.

It consists of two 16 ounce mailing cases (without bottles). The lids are unscrewed and tacked tightly to a shelf located over a radiator or wherever there is circulating air. Holes are made through this tin lid and through the shelf. The base of the carton is also perforated. One of these perforations should be in the center of the lid and base and should be about 1 cm. in diameter. A wooden rod 16 inches long can be tightly fitted through the inverted lid into the wooden shelf. The inverted body of the mailing case may then be slipped over the rod and screwed into the lid. The glove fits over this cylinder with the rod projecting into one of the fingers. After the gloves are dry, a little powder may be used in the glove, or a



deodorant antiseptic powder may be sprinkled into loose cotton and placed inside the cylinder. A little stain adds to its appearance.

THE PRESENT STATUS OF DEEP ROENTGEN THERAPY IN EUROPE*

BY W. H. STEWART, M.D.

NEW YORK, CITY

PROMPTED by a desire to improve our roentgen-ray therapy methods, as well as by the fact that within the past two years we have continually been hearing, from reliable sources, of great improvements in the technique and results in Germany, I recently visited the most important German Clinics. My visits seemed, in a great measure, to verify these reports.

What particularly impressed me was the excellent "team-work." It was a common observance, in most of the large Clinics, to find a physicist of no small reputation working over some problem hand-in-hand with the clinician. Such united interest is, I believe, largely accountable for the recent great advancement in roentgen-ray therapy in Germany. The general interest of the roentgenologist in the subject of physics was also very noticeable. The author attended two very interesting meetings, one held in Frankfort-on-the-Main, the other in Erlangen, at which most of the presentations dealt with physical problems. Both meetings were well attended, mostly by medical men who were especially interested in deep roentgen-ray therapy and who, despite the extremely hot weather, displayed the keenest interest in all the subjects under discussion.

Although throughout Germany a great difference in roentgen-ray technique was evident, the cardinal point, namely the administration of a "death-dealing" cancer dose, was the same in practically all of the large hospitals.

The problems on which all were working can be summed up, as Friedrich of Freiburg states, under the following headings:

1. The exact measurement of the *x*-ray dose.
2. The deep introduction into the tissues of hard, filtered *x*-rays.
3. The determination of the correct *x*-ray dose.

It is generally conceded by the Germans that the problem of the exact measurement of the depth dose has been solved by using the iontoquantimeter. This instrument has been in use for at least two years, and all agree that, with the proper care, it can be absolutely relied upon. A number of different forms of the apparatus are in use, but the one which appeals to me most is that form, modified by Friedrich of Freiburg, consisting of a small ionization chamber of graphited horn which can be placed on the skin or introduced into the vagina or rectum. This ionization chamber is connected with the charged filar system of the Wulf electrometer by a flexible cable containing an insulated copper wire, which is attached to an insulated rod of graphite in the ionization chamber. The electrometer is placed behind a lead-protective screen, where it can be seen by the operator while the treatments are being given.

Friedrich has established an electrical unit applicable to the iontoquantimeter, the full excursion of the indicator in the electrometer representing 5 such units. Experiments have demonstrated that 300 units produce death to the skin, or what is called a "necrotic dose," and about 150 units, or 50 per cent of a necrotic dose, result in a reddening of the skin, known as an "erythema dose."

Knowing that the time required for one full excursion of the indicator in the electrometer is equivalent to 5 units, it is an easy matter to determine the exposure necessary to produce an erythema dose or fraction thereof. For example, if one desiring to treat a small myoma decides that permanent castration can be accomplished with about ⅖ of an erythema dose, the technician is directed to give the patient 60 units. The time required for the administration of 60 units is determined as follows:

Sixty, the number of units to be given is divided by 5, the number of units in one full excursion of the indicator in the electrometer; this equals 12, or the total full

* Read at the Twenty-second Annual Meeting of the AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

excursions of the indicator in the electrometer necessary to produce 60 units of *x*-ray. It has been ascertained that one full excursion requires eight minutes, therefore, 12 excursions would require 8×12, or ninety-six minutes. In other words, it would be necessary to give ninety-six minutes' exposure in order to administer 60 units of *x*-ray.

This method of measurement seems especially valuable as the amount of *x*-ray administered can be observed while the patient is being treated.

Another popular iontoquantimeter is that model which calls for a reproduction of the electrical conditions as though a patient were being treated; the anode of the tube being set the desired distance, for example, 50 cm., from the front surface of a water-tight box, the latter representing the patient's skin. In front of this surface is placed a lead diaphragm with an opening of the size selected for the treatment field, say about 20 by 20 cm.; over the opening in this diaphragm is placed the filter; for instance, one mm. thickness of copper. Water, representing the human tissues, is placed in the box referred to above until the desired depth is obtained, say 10 cm., and back of this is the ionizing chamber connected with the electrometer. With the apparatus set in this way, one can ascertain, with the conditions as mentioned above, how much time is required, with this particular current 1, to obtain a depth dose 10 cm. beneath the skin. Tubes vary considerably, but it has been found that under the above conditions, with 180,000 volts, an exposure of about thirty-five minutes is necessary to produce an erythema. Reliance can be placed on the dose administered by this tube for some time, but it is advisable, after the tube has been in use about fifty hours, to retest it.

Still another ingenious method said to determine the depth dose is by the use of Dessauer's curves. Dessauer has devised a series of charts covering various electrical conditions, and these curves are claimed to give the operator accurate information regarding the actual percentage of the skin dose which reaches certain depths. Thus one can estimate how many fields are required, with a certain current, voltage, distance, diaphragm and filter, to administer a dose of *x*-ray sufficient to retard the growth of the cancer without destroying the normal surrounding tissues.

All must agree, whether or not the new technique explained above is accepted, that a reliable method for the accurate measurement of the depth dose is absolutely essential.

Many roentgenologists in Germany maintain that the problem of *x*-ray dosage can be considered solved, absolute reliance being placed upon the iontoquantimeter.

Regarding the *introduction of measured, hard, filtered homogenous x-rays*—this problem calls for much discussion.

Dessauer, in 1904, published his "Law of Homogeneous Radiation for Treatment." His object was evidently to control the ray to such an extent that the intensity of the dose applied to the skin surface would be about the same as that which penetrated the tissues below the surface.

Investigations along these lines were responsible for the development of a 200,000 volt *x*-ray machine, the use of which, combined with an increase in the distance between the anode of the *x*-ray tube and the skin, the enlargement of the size of the field for radiation, and the use of heavier filters (about ½ to one mm. thickness of copper or zinc) made it possible to deliver a measured dose, which had 30 to 40 per cent of the intensity of the skin dose, to tissues 10 cm. below the surface.

Increasing the distance naturally—following the law of quadratics—assisted in achieving the above-mentioned result. In some Clinics where the so-called "distance treatment" is the use, the distance from the anode to the skin is increased to 50, 60, or even 90 cm. The size of the fields have also been increased, the larger fields allowing more scattered rays to reach the central portion treated. This rule, however, does not apply to areas larger than 20×20 cm.

There is a tendency in distance treatment to ray larger and fewer areas. When only one field in front and one behind is treated, it is impossible to give the necessary lethal dose; consequently, radium is applied to make up the required amount.

When radium is not used more fields must be treated with the x-ray in order to deliver the 110 to 120 per cent of the skin dose which is necessary to destroy the carcinoma; this often calls for the treatment of six or seven areas.

Wintz of Erlangen states that in a field 9×8 cm. 18 per cent of the skin dose is delivered 10 cm. below the surface. Therefore, seven fields being rayed in the treatment of carcinoma of the uterus, he estimates that 7×18 per cent of the skin dose, or 126 per cent is delivered into the growth, this being considered sufficient to destroy the cancer.

There is considerable difference of opinion on the subject of filtration. Some Germans are using copper and others zinc, while in a number of Clinics, a combination of zinc and aluminum is being used; all agree, however, that their object is to obtain a homogeneity of the rays which penetrate the growth. Friedrich states that the quality of the ray is not essentially changed by increasing the copper or zinc filters to more than one mm. in thickness.

The *determination of the correct depth dose of x-ray* for various lesions, both benign and malignant, is one of our most difficult problems. It is generally conceded that it is necessary to introduce into a carcinoma at any given depth 110 to 120 per cent of the skin or erythema dose in order to destroy the growth. This is estimated by multiplying the number of fields by the percentage of the skin dose, as shown by the iontoquantimeter, which reaches the required depth below each field. The establishment of a definite carcinoma dose is almost impossible because of the great variance in cancerous structures and their radio-sensibility.

This radio-sensibility is not altogether histological, the general condition of the patient being an important factor. The skin of a cachectic patient does not always show erythema when a full erythema dose is given; in fact, subjects showing a distinct cachexia are very unfavorable for roentgen-ray treatment. We must also bear in mind that all tissues are not equally sensitive to the rays, different tissues reacting differently; for instance, youthful subjects are more sensitive than those of more mature age. Malignant growths in which connective tissues predominate require a great deal more x-ray than those in which the cellular structures predominate.

Carcinoma of the breast and uterus responds more favorably to deep roentgen-ray therapy than carcinoma of other organs, although some favorable results have been reported in cases of cancer of the rectum. It was found that the destructive roentgen-ray dose for the ovarian follicle is about 30 to 40 per cent of the skin dose. Permanent and temporary amenorrhea is easily established, small myomas disappearing with this same treatment. Large myomas require 50 to 60 per cent of the skin dose. In Germany the treatment of these benign conditions is considered a "closed book," so rarely do they fail to accomplish what is desired.

Sarcoma, as a rule, does not require as large a dose of x-ray as carcinoma, although here again the location and the histological elements, as well as the condition of the patient, must be taken into consideration; as a rule, 50 to 60 per cent of the skin dose is all that is required. Some Clinics prefer deep roentgen-ray treatment rather than operation for cases of sarcoma on account of the occurrence of metastases, it having been demonstrated that primary sarcomas, as well as metastases from same, respond very favorably to the roentgen ray.

In the Freiburg Clinic carcinoma of the breast is not operated on unless it is freely movable with no glandular involvement; all other cases being submitted for roentgen-ray treatment.

Opitz states that experimental investigations prove that a given amount of roentgen ray, if applied at one treatment, acts more favorably than if the same dose is divided over a period of time. He also states that it would be necessary to give at least 25 per cent more when divided doses are given than when one full dose is administered at one sitting; therefore, the general condition of the patient permitting, the entire treatment should be given in one day; or at least every effort should be made to administer the full dose within one week. In the Freiburg Clinic it is not considered safe to repeat an x-ray treatment for carcinoma within a period of eight months. At Erlangen the treatment for carcinoma is repeated over the involved area in six weeks, providing the blood picture has returned to normal; and again in eight weeks, if the blood has regained itself.

It is difficult to ascertain during a short visit the exact clinical results of deep roentgen-ray therapy. I have found that the men, as a rule, are exceedingly conservative as to ultimate results, sad experience having taught that an apparent primary cure is often followed by an unexpected relapse; the seeming complete health of the patient not always indicating a cure.

Opitz states that he has not operated on a case of carcinoma of the uterus since 1919. His records, from January 1, 1919, to January 1, 1921, show that, in all, 60 cases of carcinoma of the cervix have been treated with deep roentgen therapy, of which 30 receded, 13 showed no improvement, 17 died, the favorable results averaging about 47 per cent. Of 30 cases of carcinoma of the fundus, 23 receded, 3 showed no improvement, 4 died, and about 80 per cent responded favorably to *x*-ray treatment.

Through the courtesy of Blumm and Warnekros of Berlin, I was able to personally examine at the University Hospital, 10 cases of receded carcinoma, 9 of the uterus and one of the vulva, all having been treated in 1913 and 1914 by the cross-fire method of *x*-ray treatment, with the old-type machine. All showed permanent skin changes at the site of the areas which had been rayed, and scarring and contraction at the location of the original lesion; none had had a recurrence.

One of the busiest clinics visited was that of Wintz of Erlangen. No statistics were at hand, that it was too early to make decisive statements about results, only two years having elapsed since the modified deep roentgen-ray treatment had been instituted. I had the privilege of examining at this Clinic one case of carcinoma of the cervix, which had received *x*-ray treatment four months previously. There was no visible evidence of the disease, the ulcerated cervix having entirely healed; considerable contraction in the left parametrium had occurred; the patient had gained weight, looked and felt well, and was free of symptoms.

Halberstadler of the Charité Hospital in Berlin gave me an opportunity to examine a number of receded cases of non-operated primary carcinomas of the breast, some of which were two or three years after roentgen-ray treatment.

Much more consideration is given to the patient than is generally supposed. It is conceded, however, that in cases of carcinoma in which the lesion calls for lengthy treatment, if successful, "the results justify the means."

In Freiburg the treatment of carcinoma of the breast requires as a rule twelve hours' exposure. The dose is divided into two day sessions; three hours in the morning, a rest of three hours and a light lunch, and three hours in the afternoon; this is repeated the next day. In some institutions, such as the Seitz Clinic in Frankfort, the patients are placed on the table in such a position that their arms are free—behind protective rubber sheeting—while the abdomen is being treated; in one instance, a patient was seen reading during the treatment. In other Clinics, particularly Erlangen, where the full dose of *x*-ray is given in one day, Pantopan-scopolamin is administered and the patient sleeps during most of the treatment. In no instance did I observe transfusion resorted to as a routine procedure.

Considerable attention is paid to the after-treatment. As Opitz states, "they are not treating carcinoma, but carcinoma-sick human beings." This after-treatment includes proper nourishment, the administration of remedies stimulating the productive energies of the body and a local hyperemic treatment of the diseased area.

In conclusion I can only state that the method of procedure, namely, the exact measurement of the depth dose, is most appealing. It is not yet safe to state that one can rely upon the iontoquantimeter entirely for estimating the correct dosage. In the hands of a responsible physicist the instrument may be reliable. It is evident, however, that future personal investigation is required before one can refuse to accept this apparently valuable method of measurement of *x*-ray dosage.

TREATMENT OF DIPHTHERIA CARRIERS BY MEANS OF THE ROENTGEN RAY*

BY PRESTON M. HICKEY, M.D.

DETROIT, MICHIGAN

IN presenting this preliminary report on the roentgen-ray treatment of diphtheria carriers, I wish, first of all, to acknowledge the active cooperation of Dr. F. N. Meader, Director of the Medical Department of the Board of Health of the City of Detroit, and also the assistance of Dr. J. Everett King, my associate, who gave personally the treatments here reported.

In the city of Detroit, during the year 1920, there were reported to the City Board of Health 4,728 cases of diphtheria. The deaths due directly to the disease and due indirectly to complications were 371. These cases were all infected by contact with those ill with diphtheria, or by contact with those who were carrying Klebs-Loeffler bacilli in their secretions but who did not present active symptoms of the disease. It is fair to assume that such statistics in varying percentages occur in many of our larger communities. Naturally these percentages vary from year to year and from season to season according to the type and virulence of the epidemic.

The efforts of the Boards of Health to reduce the number of cases and the consequent mortality consist of the treatment of those actively affected by the disease, their isolation, and measures to prevent infection from those who are diphtheria carriers by rendering their secretions free of the Klebs-Loeffler bacilli. It is found that 4 per cent of all persons in ordinary health show these organisms in the secretions of their air passages. The bacteriologic examinations of those who are associated with diphtheria cases show that 60 or 70 per cent may have Klebs-Loeffler bacilli in their nasal or pharyngeal secretions, and still present none of the clinical symptoms of diphtheria.

One of the important functions of a Board of Health, therefore, is to reduce the number of diphtheria carriers. In some communities these diphtheria carriers are quarantined as rigidly as are those who have clinical manifestations of the disease. In other communities, those of school age are excluded from attendance at school, and those whose occupation brings them in contact with food, either in its preparation or distribution, are detained from their duties. If a diphtheria case recovers and the diphtheria bacilli are found to be still present in the pharnyx of other members of the family, the quarantine on the house is raised and a warning sign replaces the quarantine card.

It requires no reflection to perceive that the treatment of diphtheria carriers and the protection of the public against these carriers constitute a difficult task for the public health officials. The administration of antitoxin does not affect the carriers, as they manifest no toxic symptoms. A great variety of local antiseptics have been experimented with, and have been employed with greatly varying successes. Of the more recent remedies, solutions of mercurochrome have proved efficacious as local applications in 60 per cent of cases. Tonsillectomy has been resorted to, but this operation cures only about 80 per cent of cases, leaving 20 per cent of a given group still a menace to the public health. There are three general types of diphtheria carriers: first, and most common, is a class in which diphtheria bacilli are found in the pharyngeal secretions; second, those in which the diphtheria bacilli are found in nasal secretions; third, those in which the diphtheria bacilli are found in the aural discharge of a chronic otitis media. Tonsillectomy has been the most efficacious of any of the lines of treatment so far employed. Still the difficulties of enforcing such a drastic line of treatment limit its use to selected cases where the consent of the patient or parent can be obtained. Naturally, among the ignorant classes, it is difficult to obtain

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30 1921.

the consent for an operation where the parent does not realize the menace to the public health constituted by a child who is apparently well.

The essential points of the foregoing problems were presented to me by Dr. Meader of the Detroit Board of Health. I advised the use of roentgen therapy in the treatment of these cases of diphtheria carriers. Accordingly, a number of cases were selected by Dr. Meader and roentgen-ray treatments were given over the region of the tonsils, nose and mastoid areas, according to the type of the case. The cases selected for treatment had all been studied by the bacteriologic department of the Detroit Board of Health, which department had conducted all the bacteriologic examinations preceding the roentgen-ray treatment.

In the throat cases, that is, those where Klebs-Loeffler bacilli were found in the pharyngeal secretions, the line of roentgen-ray treatment was similar to that recommended by Dr. Witherbee in cases of tonsillar hypertrophy, the treatment being given on each side of the neck, the central rays being directed toward the tonsils. The dosage employed was similar to what we had been accustomed to use for the treatment of tonsillar hypertrophy. In the nasal cases, the roentgen-ray treatment was given directly over the nose, and in the ear cases, over the mastoid area of the ear which showed Klebs-Loeffler bacilli in the discharge. Quite a few cases were treated which are not included in this report, as all which were found to give negative cultures within a few days after treatment were excluded, the belief being that they might possibly be classed under those of spontaneous recovery. Excluding those, therefore, which we did not really think should be classed as affected by the treatment, we found that there were 19 throat cases treated, with a definite cure in 15. This gives a percentage of 79; in the 6 nasal cases which are reported, 4 were cured, a percentage of 66. Nine cases of otitis media presenting Klebs-Loeffler bacilli were treated, with 4 cures, a percentage of 44. Of the throat cases which responded to the treatment, some received only one treatment, and others, two. Of the nasal cases which were cured, 3 showed absence of the bacilli after one treatment, and one case after two treatments. Of the ear cases, 2 responded to one roentgen-ray treatment while 2 others required two treatments each. The number of days required for the Klebs-Loeffler bacilli to disappear varied from three to seventeen.

The question then arises as to how many of these cases would have been cured spontaneously without the roentgen-ray treatment. This is a difficult question to answer, and one which can only be approached from the statistical standpoint. Fortunately for an intelligent comparison, we have some statistical reports of the Detroit Board of Health which were made in the treatment of diphtheria carriers by mercurochrome and gentian violet. In carrying out these studies of the treatment by mercurochrome and gentian violet, a number of throat cases were kept untreated. In all, 70 controls were observed, 34 per cent of which showed disappearance of the bacilli.

We can, therefore, summarize as follows: In untreated cases of diphtheria carriers, 34 per cent of spontaneous cures; cases treated with mercurochrome, 68 per cent of cures; pharyngeal cases treated by the roentgen ray, 80 per cent of cures.

CONCLUSIONS

1. From the Board of Health standpoint the efficient destruction of the diphtheria bacilli of the so-called diphtheria carriers is eminently desirable. It is desirable also that a treatment should be selected which can be easily applied and one which can be carried out with a minimum of distress to the patient.

2. Bacteriologic examinations show that the percentage of cures in a selected number of throat cases is greater by the roentgen-ray treatment than by the local antiseptic treatment.

3. The roentgen-ray treatment of diphtheria carriers is more easily carried out than a local treatment of the throat requiring swabbing of the pharynx, and is very much less dreaded than the operative procedure of tonsillectomy.

4. The results obtained in this pre-

liminary report justify the continuance of observations. These cases are reported in the hope that the results, added to those obtained by other investigators, will form a sufficiently large group for subsequent accurate conclusions to be made.

NOTE. Since the foregoing article was written, the author has received a number of unofficial reports from different parts of the country, stating that the results obtained by the use of the roentgen ray in the treatment of diphtheria carriers have been very gratifying. In one large city in the Middle West where 200 cases of diphtheria had been kept in quarantine for a considerable period of time and where various local methods of treatment of the pharynx had been resorted to without avail, it was found that the use of the roentgen ray was followed by a very large percentage of cases where the diphtheria bacilli disappeared from the pharynx in a very few days. These cases are being accurately studied to determine whether any considerable percentage shows recurrence of the Klebs-Loeffler bacilli.

It is the intention of the writer to collect as completely as possible the statistics from these cases and to report them in a subsequent article.

DISCUSSION

DR. WITHERBEE. The point I would like to make is that in the first 60 cases of tonsil hypertrophy I treated at the Rockefeller Institute, 36 were so infected. Thirty-two out of the 36 cases showed no streptococci or staphylococci four weeks after one dose. The roentgen ray has no electrostatic effect directly. This effect may be due to local pharyngitis or to some extent, improvement in drainage.

DR. LEDOUX-LEBARD. I have listened with the greatest interest because I had, during the war, some experience with the same treatment of diphtheria carriers. This was very near the end of the war, so that I did not feel that the number of cases I had treated, amounting to 9 or 10, if my memory is correct, was sufficient to warrant any publication on the subject. Still I think my results were in fair agreement with the results of Dr. Hickey. If I remember correctly, 7 of the 9 patients that were treated showed no diphtheria bacilli from a week to two weeks after treatment had been applied. These cases relate only to the treatment of the tonsils and throat. I have not tried treatment of the nose and ear, but I think this field seems very promising; and as Dr. Hickey has pointed out, we should go along in further experimentation, as certainly this technique will afford the best results with the least inconvenience to the patient. Of course the mechanism of the action can be discussed. There is not the slightest doubt that it is not direct action on the bacilli themselves, but is secondary action whatever the nature may be. Still I think the paper which Dr. Hickey has given us indicates great progress and would be helpful in every community interested in the treatment of diphtheria carriers.

DR. PANCOAST. There is another carrier almost equally as dangerous—the typhoid carrier. I would like to ask if Dr. Hickey has treated any cases of this kind.

DR. CLIFT. We have had no direct experience so far as diphtheria carriers are concerned, but have had rather extensive experience as regards the general subject of throat infections. Up to date we have had 69 cases of tonsil infection, either under treatment or finished. Of that number 40 have been discharged; 31 of those cases showed positive results and were clinically cured. The tonsils were smaller and examination of the cultures showed them to be sterile so far as pathological organisms are concerned—or they were very nearly so. The patients were all benefited as regards their clinical symptoms. As far as the question of otitis media is concerned, we have had rather limited experience with that. The few cases we have treated improved. In the remainder of the tonsil cases 63 were unimproved; 6 of them we have not been able to check up. Dr. Hickey's paper opens a very wide field; and from my experience, at least, I believe there is a great future for the treatment of infections of the throat. The cases in which we have not had good results are those which have had previous operation and those which have had a great deal of scar tissue in the tonsil.

MAJOR NICHOLS. This subject is one of considerable importance to the Service. Naturally we are on the lookout for anything which we can use in order to reduce the number of carriers in the Service—especially among recruits. I have been very much interested in this paper; it seems to open up possibly a new line of work. The only thing I would like to say is that it seems to me that Dr. Hickey possibly has underestimated the value of tonsillectomy. He said only 80 per cent of carriers were cured by tonsillectomy. I do not know what percentage surgeons and roentgenologists expect to get, but we think 80 per cent is pretty good. There is no doubt that the tonsil is the site where diphtheria bacilli usually remain after infection. I have examined several tonsils of carriers and have always been able to demonstrate diphtheria bacilli in the crypt walls, as was shown on the slide. They are distinctly in the tissue and below the surface. Surface disinfection does not reach these organisms and unless we have some method of removing the crypts entirely or improving their nutrition so that they become normal, we still have carriers. We laboratory workers think if 80 per cent can be cured by tonsillectomy, it is doing well.

There are some objections to tonsillectomy, such as the dangers of anesthesia, hemorrhage, blood infection and pneumonia. The roentgen-ray treatment is a simpler procedure, but occasionally there is swelling of the parotid gland after this treatment. It seems to me that if the roentgen ray will really do this work, it will be a better method in some cases. For the Service, generally speaking, tonsillectomy offers more promise at present. Its value is proved; there is no chance of re-infection; and speed is an object. The roentgen-ray treatments cover some time. The question is, will the roentgen ray cure carriers? In reference to the series presented, one wonders what a controlled series of cases would show—that is, a control of untreated cases. If you have a carrier and do something to him one day and he is cured the next day, it is fair to believe that he would have cleared up by himself. We occasionally pick up a man who gives positive cultures of virulent bacilli for months, in spite of any local treatment except tonsillectomy. These are the cases we are after—not the early convalescent case that may clear up of its own accord.

In the middle-ear carriers, so-called, we find organisms which seem, morphologically, to be diphtheria bacilli. In my opinion, these organisms are not virulent. They are diphtheroids, and the case is not a diphtheria carrier but a case of primary or secondary diphtheroid infection.

Detroit and its representatives are to be congratulated on starting this work.

Dr. Pfahler. Major Nichols has just brought up again this subject of the swelling of the parotid gland. I have noticed this in a number of patients treated for acne and large cervical glands and I have noticed it even when the parotid gland was covered up. Therefore, I assumed it was due to some electrostatic discharge, and for this condition I grounded the lead covering the patient.

One cannot draw conclusions very easily on this subject because only a very small percentage of patients develop this condition; probably not one in 200—certainly not over 1 per cent. Therefore the absence of swelling after grounding the lead does not necessarily prove my theory.

I would like to ask Dr. Hickey how long he followed these diphtheria carriers? How long he continued cultures after the treatment was given?

Dr. Ullman. In regard to parotid swelling due to electrostatic discharge, I found it following one application of radium, as well as by roentgenotherapy. With the radium I have marked swelling lasting ten or twelve hours.

Dr. Hickey (closing discussion). In regard to Dr. Pfahler's question, these cultures were all carried out by the Board of Health nurse. We did not have a chance to follow them up. This is a very good suggestion; and in the second series of cases we will try to have them checked up.

In regard to Major Nichols' statements about tonsillectomy. I would like to state that tonsillectomy in the Army is very much more easily carried out than in Board of Health work. Take, for instance, a Polish family of children who have bad tonsils; a child is apparently well, and if you suggest that it be taken to the hospital to have its tonsils removed you have a hard time convincing the mother that it should be done. It is a pretty difficult thing to have carried out.

In regard to Dr. Pancoast's question: We have had no experience with the treatment of typhoid carriers. That is a very different program and would require more complicated technique.

Evidently there is nothing new under the sun. When one presents something which is fairly new there is always some person who has done it before. I hear, with pleasure, that Dr. Ledoux-Lebard has done this work before me.

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LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922

Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

THE HEART, THE *X*-RAY AND THE INTERNIST

THE able and comprehensive paper by Karshner and Kennicott in this issue brings up the subject of the *x*-ray examination of the heart for thoughtful consideration. It is now more than a quarter of a century since the pulsating outlines of the heart upon the fluorescent screen first aroused the startled expectations of medical men. During this period roentgenologists have spent much time and ingenuity in developing and systematizing methods of cardiac study until today it is fortified by an extensive literature which has made available a large collective experience and a large body of accurate data.

Yet it is not a generally accepted nor much used method. Internists are perhaps superabundantly supplied with instrumental means of examining the heart. The stethoscope, the percussion hammer, the sphygmograph or polygraph, the blood-pressure manometers and the electrocardiograph somewhat deter the internist from feeling the need of another and more elaborate instrument. Many able and successful men admit the importance of these instruments for purposes of research but use the stethoscope merely as a sanitary convenience, holding that the palpating finger and the ear are the only necessary instruments for the examination of the heart. The *x*-ray, to be sure, is accepted for the detection of aneurysm and to a less extent for the estimation of the size of the heart, but the same hard-headed conservatism which impeded the use of the thermometer, the stethoscope and other instrumental methods is still as active in some quarters as it was in the days of Wunderlich and Laënnec.

In no department is the *x*-ray revision of internal medicine more inevitable and less acceptable to internists than in the examination of the chest. Barium or bismuth for the alimentary tube, oxygen or carbondioxide for pneumoperitoneum, sodium iodide or thorium for the urinary tract, suggest the technical requirements of later *x*-ray work, but the chest without any preparation excepting a full breath provided perfect conditions for *x*-ray study from the beginnings of clinical roentgenology. The work below the diaphragm has met with enthusiastic reception; the *x*-ray examination of the lungs has won a tardy recognition; but the examination of the heart by screen or plate is apparently still on trial.

Sir James Mackenzie has thrown the weight of a mighty reputation into the following statement in "Oxford Medicine," of which he is senior editor: "The inspection and palpation of the movements of the heart and the percussion of the heart's dulness give a far more valuable indication of the size of the different chambers of the heart than an *x*-ray examination. Indeed I am doubtful if any *x*-ray examination of the heart has ever thrown the slightest light upon any cardiac condition." ("Oxford Medicine," II, pp. 456–457). Such a sweeping and unqualified condemnation by one of the foremost of English-speaking internists in one of the very latest and most extensive works on general medicine compels us to pause and consider whether or not the *x*-ray examination of the heart is really worthwhile and whether or not we can justify the faith that is in us.

A little investigation in several fairly recent books on the heart which happen to be at hand, shows that Mackenzie is not alone in his opinion. Four of these books, all well known and authoritative, quietly and almost completely ignore the *x*-ray. One is embellished by a number of *x*-ray plates of the heart which are not referred to in the text. A fifth work, however, one of the recent systems of practice, contains an extensive section on the heart in which the *x*-ray findings are incorporated with other diagnostic data under each cardiac affection. This is done with a discrimination and knowledge that does much to restore our confidence in the final recognition of the *x*-ray in this stronghold of the internist.

A very brief general survey may help us to understand the attitude of authors both for and against the roentgen-ray method of examination. To this end we may assemble the well-known signs of heart disease and specify those which may be demonstrated by the *x*-ray tube. We may then ask ourselves, which of these signs can be demonstrated only by the *x*-ray; which can be thus demonstrated best although also detectable by clinical methods, and which of these need *x*-ray confirmation? We may further ask in what cases the *x*-ray may be unnecessary because less expensive methods reveal, equally well, the cardiac signs; and finally we must answer the ever-repeated question, Is the *x*-ray sufficiently available so that the internist can rely upon it in his daily work?

We believe that these questions may be answered fairly in favor of the *x*-ray method, but we cannot, in the limits of an editorial, do more than indicate by outline what such answers would be. The familiar signs of heart disease are the alterations of size of one or more chambers, the location of the apex beat, the presence of murmurs, clicks, bruits, pain, palpable thrills, irregularities of the heart beat, alterations of "blood-pressure," changes in electrical potential, fluid in the pericardial sac, pericardial adhesions or calcifications, the reaction of the cardiac muscle to forced exercise, dyspnea, the character of the respiration, the color of the skin, the size of the liver, and edema of the extremities. It is at once apparent that the *x*-ray cannot claim to be a substitute for a clinical examination, and any argument against the *x*-ray, based upon an assumption of such claims is most unfair. The *x*-ray is to be used in conjunction with the clinical examination on the same terms as the stethoscope. It is obvious that heart tones and murmurs can be studied only by the ear; a thrill can be detected only by the sense of touch; dyspnea and pain can be realized only by the patient; blood-pressure, electrocardiograms and other tracings can only be obtained by special instruments; and that the character of the respiration, the size of the liver, edema of the extremities and cyanosis are properly matters of clinical observation. This leaves for possible *x*-ray study, alterations in the size of one or more chambers of the heart, the form of the heart silhouette, the position of the heart within the chest, the movements of the heart, fluid or gas in the pericardial sac, adhesions or calcifications and also aneurisms of the arch or dilatations of the thoracic aorta. These last are included because the condition of the aorta is inextricably interrelated to heart disease. The scope of the *x*-ray examination is in reality somewhat larger because congestion of the lungs resulting from cardiac decompensation, pulmonary infarct from emboli and tumors within the chest, confusing cardiac dulness, may at times require *x*-ray assistance.

The heart signs which can be demonstrated only by the *x*-ray are the form of the heart, the pulsation of each chamber separately, calcifications of the pericardium or aorta, small aneurysms and dilatations of the thoracic aorta. The accurate determination of the size of the heart can be made only by x-ray methods. It is not too much to say that the clinical estimation of heart size is grossly inaccurate by comparison. A study of the paper by Karshner and Kennicott or of the monograph by Vaquez and Bordet will convince the reader that the determination of heart volume is exclusively an x-ray problem. The earlier papers of Van Zwaluwenburg and Bardeen had already given us practicable clinical methods.

The study of the form and movements of the heart is much more complicated and less perfectly developed than the determination of size. The recognition of characteristic forms indicative of various cardiac affections requires not only a large roentgenological experience but also training in the diagnostics of internal medicine. Heart form varies with the plane of the silhouette, with the posture of the patient, with the extent of the respiration, and with each point in the cardiac cycle. Instantaneous exposures timed by the pulse have added to our powers of interpretation. A succession of such views analyses both form and motion. A selection of views to complete a cardiac cycle have been used to gain a cinematographic effect. The direct screen view of the heart is a perfect moving picture, but a proper film which could be "slowed down" would be of inestimable value in the study of auricular fibrillation, heart-block and other arrhythmias. We believe that such cinematographic films will be possible when a sufficiently large lens of lead glass can be placed between the moving picture camera and the fluoroscopic screen so as to gather and concentrate the relatively feeble light of the screen upon a suitable lens system in the camera. Possibly a large reflector such as is used in telescopes could be adapted to the gathering and concentration of the fluorescent light.

A study of "slowed down" heart movements may be effected in another way which has already been demonstrated experimentally. This is by the slit tracings first described by Gocht and Rosenthal. The heart is covered by lead excepting for two or three slits at right angles to pulsating edges of the heart shadow. The speed of the film as it travels over these slits determines the elongation or "slowing down" of the resulting tracings. Such tracings are records of pulsating muscle movements and give a different set of factors from polygraphic tracings which record variations of tension within the chambers, or from electrocardiographic tracings which record variations of electrical potential at the two poles of the heart. Simultaneous tracings from opposite sides of the heart, as, for examination, from the right auricle and left ventricle, distinguish mass movements from pulsation movements. The adverse criticism by Karshner and Kennicott of x-ray slit tracings seems to us to be prejudgment delivered theoretically in advance of any proper clinical investigation. Such an investigation can only be made after some manufacturer has provided us with a suitable type of instrument; and until this is done a final verdict should be withheld.

However, without borrowing from the research of the future, the roentgenologist today is able to interpret his screen observations of form and movement in much the same way that the internist interprets the sounds heard through his stethoscope.

We do not mean that the x-ray screen can or should replace the stethoscope. On the contrary, the best screen work can only be done in collaboration with auscultation. The practice of listening to the heart sounds while making a screen observation should be routine. A series of sign-complexes for heart affections, similar to the Holzknecht symptom-complexes for diseases of the stomach, were outlined by the writer some years ago.* These were based on a combination of auscultatory and x-ray signs, as for example:

Group with Systolic Murmurs
- Dilatation of right auricle.
- Ventricular type of the right auricular pulse.
- Hypertrophy of the right ventricle.
- Venous pulse in the right jugular.
- *Diagnosis:* Tricuspid regurgitation. (Murmur absent in most marked cases.)

X-ray signs of heart disease are of course not infallible. Murmurs also are not

* Roentgenology of the Heart. Amer. J. Roentgenol., Nov., 1916.

always significant of disease. This is especially true of murmurs heard over the left base of the heart—that area called by Balfour the region of "auscultatory romance." Doubtless many an able man, during the World War, was rejected for military service because of a questionable murmur. If, in such a case, the *x*-ray had demonstrated an enlargement, then the murmur could have been considered pathological. Also if the pulsations of the left ventricle were found of sufficient grade and were seen to be synchronous with the ventricular beat, then the murmur must have been due to mitral regurgitation. Examples could be multiplied. Thus the *x*-ray may endow old signs with new significance and add new determining factors to the cardiac symptom-complex.

It cannot be disputed that there are certain cases of heart disease where the *x*-ray examination will add nothing to the diagnosis. This, however, cannot always be predicted. Certain complications already mentioned cannot with certainty be excluded excepting on the *x*-ray table. In chronic cases it will be rare that the *x*-ray does not add or confirm some sign of value. In reaching this conclusion we are giving our answer to Mackenzie and others who would deny to the *x*-ray any place in the examination of the heart. We do not undervalue clinical methods, but such is the supremacy of the eye and such the importance of things seen that the roentgen-ray image will take an assured precedence as diagnostic evidence.

The question of expense or availability of the *x*-ray in affections of the heart has been fully and practically answered by cases of pulmonary and gastro-intestinal diseases. We doubt if patients with heart diseases are any less willing to be examined than those with tuberculosis or peptic ulcer who now make up so large a part of the roentgenological clientele.

The paper by Karshner and Kennicott should be read by clinicians as well as by *x*-ray specialists. The dissemination of such knowledge will increase the frequency of consultations on equal terms between internists and roentgenologists. The precision of instrumental methods must not obscure the larger fact that the recognition of a valve lesion, a myocarditis, or an enlargement is not the practical end of a diagnosis. Efficient therapy requires the etiological factors. Is it a thyroid heart, a luetic heart, a toxic heart or is it the result of a focal infection, a nephritis or an arteriosclerosis? These and similar factors must be sought but they will not be found by the stethoscope alone or the *x*-ray alone or the electrocardiograph alone. A competent clinical survey requires a reliable case-history, which is, in the last analysis, the fundamental document of diagnosis.

A. W. Crane.

The following letter by the late Dr. Van Zwaluwenburg is so characteristic of the man and so intrinsically valuable that we believe it will be of general interest. This letter is a model of what correspondence between men of science should be but rarely is in these practical days. To be the friend of such a man was indeed a privilege.

Department of Roentgenology,
University Hospital, Ann Arbor, Mich.

My Dear Dr. Crane:

I am so little satisfied with the outcome of my criticism of your excellent paper, that I am writing you somewhat at length, not so much in apology as in explanation. The time was so limited and I felt so much the need for brevity that I perhaps was not entirely clear in what I said.

My main criticism is not with the method for the determinaton of the size of the heart, but with an examination that is limited to the determination of the size, whether the area or its linear dimensions. The work of the French, especially, has been very valuable, and includes the observation in the oblique positions, the determination of the angle of disappearance of the apex behind the vertebral shadow, the mobility of the apex and the diaphragm, and a study of the action of the heart itself. The estimation of the size of the left auricle in the oblique position gives us a pathognomonic picture for mitral stenosis, for instance; a diagnosis that is most problematic by any other means. The study of the arch of the aorta also is perfectly feasible and very productive. But, I need not go into a detailed discussion of the method to you. I should like to refer you to the latest edition of the monograph of Vaquez and Bordet—"Le Coeur et l'Aorte." The advantages of a thorough roentgenographic study of the heart is there well discussed, and I can testify from personal experience covering a number of years, to the value and accuracy of the method.

Now as to the accurate determination of the size of the heart, in my opinion one can very well carry that to unnecessary refinements. After all, you and I know that the heart is subject to numerous and sudden changes in size under various conditions, besides the normal personal variation with age, weight, stature, occupation, etc. Moreover, in the estimation of any diameter or area, one need not have the absolute value in order to reach conclusions of real value. It is perfectly satisfactory to determine some value that presumably varies as the value with which we are seeking and comparing it; a "norm" that one has reached by the examination of a sufficient number of healthy individuals. So, if the length of an individual can be satisfactorily estimated by measuring the length of the femur—and this is the more convenient procedure—there is no real and serious reason why the femur should not be accepted as the yard-stick for the individual. Hence, it does not matter so much whether the area as described by Bardeen actually represents the projection of the sagittal optical cross-section of the heart, as whether that value is increased or otherwise modified in comparison with the norm which we have determined by an actual calibration of the method.

In case I concede that Bardeen's outlines more nearly represent the outline of the heart, let me call your attention to the fact that their construction is more difficult than the usual one as practiced by the fluoroscopic method. On the screen the upper border of the left ventricle is easily followed for some little distance into the median shadow above the base of the heart. The faint shadow above this line represents a comparatively thin section of the left auricular appendix, one that represents relatively more of the area of the heart than of its volume, and one that is of little interest to the examiner. Why include a faint shadow in the area of the heart rather than in its volume, and why include it when it is of little interest to the examiner? Why include it in the area under consideration? There is a very good reason for excluding it.

In the fluoroscopic examination one can always determine the junction of the ventricle and the auricle on the left side, a point which is most important in judging the relative distentions of the two. On the plate, this identification is usually quite impossible and always somewhat uncertain. But if we exclude this area from the determination, the shape of the heart is almost an ovoid, easily reconstructed, and its area can be estimated without the use of an expensive planimeter, by simple calculation. This estimation has an error of not more than 5 per cent of the total, an error that is well within the normal variations and therefore probably negligible.

As to the possibility of comparing the orthodiagram and the teleoroentgenogram, I can only say that I have never had any sort of success at it. It may be that I see something quite different on the screen than appears on the plate. It is a matter of sad experience that I have never succeeded in teaching a student to inscribe the same figure that I see. To be sure, I have never had a student who would stay by the job long enough to learn to discriminate, although I have had at least one man who had excellent heart training in internal medicine. At first a man "goes wild" on the numerous shadows of the lower thorax, all of which are moving in synchronism with the pulse beat, but in time he learns to see a figure that for him at least is normal. Whether or not this is the actual outline of the heart is another question. But for practical purposes and by comparison with other figures they probably have a similar value with my own. I have to admit that the method is not without its subjective elements.

I have repeatedly tried to duplicate my figures by the long distance methods and failed. I do not know why. Even at 9 feet, the shadow on the plate usually exceeds that of the orthodiagram by from 6 to 15 per cent. The same error appears in the outlines of the chest wall. I am inclined to think the discrepancies are due to slight differences in the position of the patient with reference to the plate, and of the stage of the diaphragmatic excursion. I have not been able to make the antero-posterior agree with the plate in the opposite direction. I have attempted to simulate exactly the same inclination of the thorax to the vertical and to the plate.

I may tell here of the difficulty Dr. Hewlett and I had with an "Arbeit" we undertook some two years ago. We ran the patient on a bicycle fitted with a friction drum in an effort to produce a dilatation of the heart under strenuous exercise. The plate was strapped to his chest which was fixed by rigid supports. We passed a wire about his chest to insure a similar respiratory position; we made one second exposures with the breath held, and then we had so many factors to consider that we were never sure we had produced a dilatation. As a matter of fact, the average of several sets of plates seemed to show a reduction in the area and in the linear dimensions of the shadow during the stage of severe dyspnea, but the individual variations were much in excess of the average and both ways of the rule. We were inclined to attribute the apparent reduction of size to the tachycardia produced. It is, of course, an old observation that the increased rate is associated with a demonstrable reduction in the area of the heart. (This, by the way, is a factor not considered in the work LeWald showed us.)

As to the reconstruction of the heart figure by the method you proposed, I still maintain that it is not a mere matter of mathematics, if you insist on a rigid interpretation of your findings. First, it will be necessary to make your plates with the body rigidly in the same position with reference to the vertical, not leaning against the plate. Next the two plates will have to be rigidly orientated with reference to the normal ray, or your corrections, while in the main correct, will still produce some distortion in the reconstructed figure. Lastly, a reference to the enclosed rough sketch will show that you record the tangential rays, which intersect at B and B′ at a point outside the true figure (in this case a circle), and at a distance of AB and A′ B′ in excess of the true diameter. The error is not large, to be sure. But in addition, one must remember that the heart is not spherical, but under pathological conditions may vary considerably from the "round," under which circumstances the error would be greater. How shall we compare this with the transverse?

I realize that this criticism is a refinement that the conditions do not justify, and as an approximation your method has many things to recommend it. It would ill become me to criticize, anyway. It may interest you to know that three of the four American articles quoted by Vaquez, were (1) Crane, (2) Van Zwaluwenburg and Warren, and (3) Bardeen.

I think my irritation is altogether in consequence of the failure of the medical profession to recognize the value of this method of cardiac examination. Undoubtedly men have not wished to take the time to learn the trick or to do the work when other more immediately profitable work was at hand. Besides, few roentgenologists have the necessary preparation in medicine to interpret their findings when they get them. The electrocardiogram has a more limited application, and furnishes less information than the orthodiagram, but is universally accepted as a necessary means of diagnosis, while the orthodiagram is so little known that the medical examiner at Camp Custer confused it with the electrocardiagram, and it went through three medical hands without detection.

I have been much amused at the attitude of the men who have come to our clinic from elsewhere. When they first arrive, they are always skeptical of the method; their opinion being that it is good enough to show the students and to correct the percutory findings, but not really contributing to the sum total of our knowledge of the case. After they have been here a while, the number of cases increases; cases are referred that have no cardiac condition, etc., in the natural sequence of events. Ultimately they all come to the conclusion that the method adds more value than any other laboratory method to the examination of cardiovascular conditions.

Usually the men want to see for themselves, but after a few attempts on their part conclude it best to take my word for it. Dr. Newburgh is enthusiastic, and Dr. Farr spent four weeks with me to study it.

I know you will not think me impertinent for writing you this, which, after all, is a very unsatisfactory exposition of my opinion in regard to the method. I should like nothing better than an opportunity to discuss it with you and a few others, "in camera," with sufficient time to really cover the subject. I should like to show some of the orthodiagrams I have on file, to illustrate the limitations as well as the applications of the method. I feel that what we need is not so much a refinement of the method as a more thorough application of the means already at hand and a more thorough understanding of the logical inferences. Maybe I'm wrong!

I have not had opportunity to express the pleasure I experienced at the Detroit meeting. It was one of the most enjoyable I have attended. I only regret that I could not stay to see the lantern-slide exhibit finished. Let me also thank you for the courtesy of advancing me on the program so that I could catch my train. As it was, I just made it with nothing to spare.

Practice is heavier and more exacting than ever and I am regularly working overtime. I hope to find some relief this summer.

Yours sincerely,

VAN.

March 28th, 1919.

CANADIAN RADIOLOGICAL SOCIETY CONSULTATION BUREAU

The Canadian Radiological Society has established a Consultation Bureau where any and all questions pertaining to *x*-ray and radium may be submitted for information, suggestions, or advice.

We quote from the announcement:

"One of the chief objects of the Society is the maintaining of a thoroughly ethical standard in this special branch of medicine in Canada, and providing any practical assistance that they can offer toward that end. This is being done cheerfully and entirely without charge, and in doing so it is of course obvious that there is no mercenary motive whatsoever. The idea underlying the establishment of this bureau is that the members of the society, being specialists in this branch, are best able to assist you in these matters,—so therefore, whether it be the selection of apparatus, difficulties in operation, or other points of a technical nature or otherwise, the resources of the society are being offered to you for the asking."

As we go to press, word is received of the death of Prof. John S. Shearer at his home, Ithaca, N. Y., May 16th, 1922.

TRANSLATIONS & ABSTRACTS

Barjon. Radiodiagnosis of Pleural Symphysis. (*Paris méd.*, February, 1921, ii, 6.)

By symphysis is meant the adhesion of the two laminae of the pleura to each other, which leads to a certain amount of fixation of the lung and thoracic cavity, either total or partial. It is the cicatrix resulting from inflammation of the pleura or lung, and the process of inflammation may be still active or extinct. It is found in the most varied inflammatory and neoplastic conditions, but is itself silent, giving rise to no clinical manifestations. In physical diagnosis it gives rise to diminished resonance and vocal fremitus and lessened breathing. If the subjacent lung be healthy, there will be no reason to suspect pleural adhesion; while if it be diseased, the signs of the affected lung tissue mask its presence. In extreme cases of adhesion and cicatricial retraction the thorax is deformed and retracted, with or without deviation of the heart.

Pleural symphysis is often looked upon as a conservative effort of nature rather than as a disease, for it may, for example, prevent the perforation of a cavity. Chiefly in connection with the operation of artificial pneumothorax is it advantageous to know whether the pleural laminae are adherent, for this constitutes a contraindication. Hence the use of radiography before this operation. In the routine use of the rays in the diagnosis of tuberculosis it is also of importance to note the presence or absence of adhesions. In radiographic diagnosis the bases of the lungs are most readily studied for the presence of adhesions. If these are present, the sinuses will be effaced while the diaphragm may be fixed.

The author has studied 24 cases of adhesions from this double viewpoint. The costodiaphragmatic sinuses may be completely or only partially obliterated, or normal. In the first case there is seen on the plate total opacity of this portion of the pleural cavity. There may be a certain amount of exudate as a result of the inflammation which has produced the adhesion. This, little by little, will push back the pulmonary lamina until it is completely dislodged, as a result of which the sinus is the seat of total opacity with loss of its contours. At times the diaphragm loses its convexity, for fixation of the external border to the parieties of the chest has deprived it of mobility. Nearly always in such cases the lung preserves towards its base a certain luminosity, and a clear band is defined immediately above the diaphragm. The opacity of the sinus is due to the fact that the lung has been dislodged from it. It is necessary in these cases to exclude the possibility that the opacity could be due to a lesion of the base of the lung. In pleural exudation, the shadow is much more compact and homogeneous, with complete obliteration of contours.

If the sinuses appear perfectly normal on the screen we cannot exclude the presence of adhesions, for in 25 roentgenoscopies of apparently normal individuals symphysis was later shown to have been present in 10. A positive result on the other hand is conclusive. The importance of immobility of the diaphragm for the diagnosis of symphysis is not great, because this condition occurs under a variety of circumstances. In 20 cases of symphysis the diaphragm was immobilized in but 3. The author concludes that the disappearance of the image of the sinus has great, and at times pathognomonic, value, especially when the symphysis is partial; although negative image does not imply absence of symphysis. The author emphatically denies that with a clear base, normal sinus and mobile diaphragm, one may be certain of the success of an artificial pneumothorax; cases undoubtedly exist in which symphysis is present, despite these findings.

W. E. Lower. Diverticula of the Urinary Bladder. (*Arch. Surg.*, July, 1921.)

The author describes the structure and location of diverticula, discusses the etiology and gives the views of various writers, as well as his own, on diagnosis of the condition. There is a consensus of opinion that a fairly accurate diagnosis can be made by the aid of the cystoscope and cystography. Howard uses a 10 per cent thorium nitrate and Rathbun a 25 per cent sodium bromide solution for cystography. Cystograms should be made in two diameters and stereoscopically.

Treatment consists in excision, and relief of any obstruction that is present. The writer describes the method of excision in use in his clinic.

The prognosis, as a rule, is favorable. Immediate mortality rate should not be great if the patient is properly prepared by clearing of infection, and the kidney function assured.

Radical operation furnishes so much greater relief than palliative measures that the former is always the method of choice.

A. C. C.

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THE MODE OF RADIATION UPON CARCINOMA*

BY JAMES EWING, M.D.

Professor of Pathology, Cornell University Medical College, New York City

THE early observations of the effects of radium and roentgen rays upon carcinoma disclosed a certain specific effect of these agents upon many tumor tissues, in the sense that much smaller doses were required to induce degeneration and disappearance of tumor tissues than of normal tissues. Information derived from clinical and experimental sources led to the conclusion, adopted by many, that tumor tissues were from four to eight times as susceptible as normal tissues; but it cannot be said that these figures represented anything more than a careful estimate, since they involved factors which were not susceptible of accurate physical measurements.

Increasing experience soon disclosed, however, that there is a marked but usually not extreme variation in the reaction of the skin in different subjects, and gradually it has become apparent that the different organs exhibit different grades of susceptibility to radiation, not only as regards their structural integrity, but especially as measured by the resulting functional disturbance. Thus the skin is far more resistant than the buccal mucosa, which itself resists far more than the rectal mucosa. I find recurring evidence that the bladder mucosa is notably susceptible to radiation. Brain tissue has revealed itself as unexpectedly resistant both in structure and function. Normal lymphatic tissue I have repeatedly found to be surprisingly unaffected by heavy external radiation which had completely inhibited or largely destroyed the growth of invading squamous cancer, while inflammatory, granulomatous, and neoplastic overgrowths of lymphatic tissue melt down rapidly.

The experienced radiologist learns to take careful account of the susceptibility of the normal tissues that may be exposed to radiation in the course of treatment, and to vary the dosage accordingly. Age, also, is an important factor in determining the reaction of normal tissues, the susceptibility diminishing with increasing age.

Comparatively little attention has been paid to the effect of associated pathological conditions, but it is obvious that such conditions may be of great importance. Anyone accustomed to examining sections of human tissues under the microscope, is not surprised to find pronounced grades of vascular lesions, arteriosclerotic or luetic, in organs and tissues where their presence was unsuspected. I have little doubt that such associated alterations of structure have been responsible for many anomalous results of radiation which surprise and disturb the operator. Such tissue lesions are so common after forty years of age that they should always be sought out and demonstrated if possible, and taken into account in calculating the resistance of normal tissues to radiation. Disturbances of circulation such as result from anemia or cardiac diseases, as well as disturbances of the temperature must also

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 26–28, 1922.

be considered as affecting the reaction of tissues to radiation, but very few data regarding their influence are available.

Now while these considerations do not alter the fact that in general the different tissues maintain within certain limits a uniform reaction to radiation, they are sufficient to show that anything like a uniform standard reaction of the tissues does not exist. On the contrary, they compel the conclusion that the different tissues behave in a rather variable manner toward radiation, and that this behavior may be greatly altered by previous structural changes and other pathological conditions. Therefore the radiologist must deal with the question of dosage as regards normal tissues, not from the standpoint of pure physics, but rather from a broad, alert, and strictly medical point of view. These considerations seem to me especially pertinent when they concern the state of the tissues immediately adjacent to a tumor that is to be radiated, since upon the reaction of such adjacent tissues the result of the radiation will largely depend.

Considering the reaction of tumor tissues to radiation one finds remarkably wide variations in their behavior, some of which could hardly be predicated on previous knowledge of their structure and physiology. Indeed it may almost be said that the first principle of radiotherapy is the variability of different tumor tissues to radiation. With increasing experience we are able with considerable assurance to arrange the different tumors in series according to their susceptibility. Some of them, like neurofibrosarcoma seem almost, if not quite, as resistant as any normal tissue. Others like hornifying squamous carcinoma are very resistant, yield immediately only to the caustic action of radium or soft roentgen rays, and slowly lose their growth capacity only after repeated heavy dosage of hard rays. Some embryonal tumors, that is, those derived from cells which have never fully differentiated, such as the numerous group of basal cell carcinomas, probably deserve the next position, being relatively susceptible, requiring rather strong dosage, but receding as a rule under a radiation that does not injure the surrounding normal structures. An intermediate position also is occupied by many benign or relatively benign tumors, as myoma, angioma, adenoma, and adenocarcinoma. There is much variation in this group, but in general they require vigorous treatment, respond only to strong or repeated dosage, recede slowly, and finally yield their vitality reluctantly, if at all. The therapeutic goal varies with many complicating circumstances, and each case becomes a study in itself.

The cellular, anaplastic, clinically highly malignant, rapidly growing and disseminating tumors, derived from previously adult cells, are generally very susceptible to all forms of radiation. Upon this demonstration is based the belief that all such tumors are better treated by radiation than by attempts at removal, although on account of their rapid dissemination the prognosis is always unfavorable. This group includes diffuse carcinoma of the breast, stomach, and other organs, and many forms of sarcomas. Of equal susceptibility are the various cellular carcinomas of the testis, but this organ gives origin to many relatively adult teratomas which are quite resistant. There is no better illustration of the necessity of accurate knowledge by the radiologist of the structure of tumors, and of the great variations in structure among tumors of a closely related group, than is found with testicular growths. The surgeon can remove from the scrotum with equal facility a chondro-adenocarcinoma or a round cell carcinoma, but the radiologist will be completely blocked when he finds the chondro-adenoma quite resistant while the carcinoma melts away rapidly, and he will be further mystified when he sees the shrunken carcinoma promptly recur in the abdomen, while the resistant chondro-adenoma, its epithelial structure rendered inactive, gradually recedes and gives no further trouble. The abdominal metastases of testicular tumors also vary greatly in structure and reaction. Some time ago I performed autopsies on the bodies of two cases of this type which had received heavy deep *x*-ray and radium therapy. One of them died with rapid collapse a few days after treatment with symptoms which were interpreted as *x*-ray and radium intoxication. Examination disclosed a very large abdominal tumor, extensively necrotic, and containing about one quart of fluid blood lying in a central cystic cavity and throughout the tumor, from which the patient had bled to death. The radiation had caused collapse of the delicate vascular system with hemorrhagic infarction of the entire tumor.

In the other case the tumor had resisted all efforts to reduce its bulk, while the patient succumbed with edema of the lower half of the body. Autopsy showed that we had to deal with a highly fibrous tumor and that the cicatrization induced by the treatment had resulted in nearly complete occlusion of the aorta and vena cava. In the first case the very cellular tumor was of rapid growth; in the second it had grown slowly for several months.

These observations are of interest in view of the rapid development of deep high-voltage *x*-ray therapy. They indicate that unless the operator combines with his powerful physical machine a considerable knowledge of the pathological anatomy of tumors, he may have many surprises and disappointments, and may sometimes do more harm than good.

Most susceptible of all tumors is the lymphomatous group which usually recede rapidly under moderate dosage. Here may be grouped the cellular types of Hodgkin's granuloma, leukemia, lymphosarcoma, thymic tumors, and myeloma. Yet again it is necessary to recall that in some cases of Hodgkin's disease there is very marked proliferation of endothelial cells and much fibrosis, which are resistant to radiation, and that in late stages of all cases this resistance, due to structural peculiarities, is pronounced.

Certain general factors enter prominently into the question of tumor tissue resistance. It is believed that the dividing nucleus is more susceptible than the resting nucleus, and certain therapeutists have undertaken to fractionate the dose so as to catch the cells at their supposed periods of division. The results do not support the hypothesis, for increased resistance is generally encountered in such experiments. If one relied on attacking dividing cells to destroy a tumor, one would seldom succeed.

Richly and delicately vascularized tissues are invariably susceptible to radiation, while the striking decline in bulk often exaggerates the real effects of the dosage. Since the vascular supply of all cellular malignant tumors is very unstable, its disturbance is probably the chief mechanism in bringing about the destruction. Disturbance of a delicately balanced circulation has often been revealed as the modus operandi of many cancer cures, as well as of many spontaneous regressions.

On the other hand, the presence of much intercellular substance, especially if mucinous, fibrous, or hyaline, effectually prevents much decrease in bulk of radiated tumors. At this point I beg to warn most urgently against the common assumption that diminution in bulk is a reliable criterion of effective radiation, or increase in bulk a proof of growth. Often reduction in bulk means merely absorption of fluids, slowing of secretion, draining of cysts, or closure of vessels with central necrosis while peripheral cells remain intact.

In and about certain carcinomatous tumors which are increasing rapidly in bulk there is extensive infiltration by lymphocytes often associated with granulation tissue, both of which elements contribute largely to the bulk of the tumor. It is difficult to say whether this lymphocytic exudate is to be interpreted as a primary defense reaction or as a secondary result of the diffusion of chemotactic tumor proteins. Radiation will surely cause a sharp reduction in the bulk of such tumors, but whether the real therapeutic effect is equally pronounced seems much less certain. Whatever their source these lymphocytes certainly act as a barrier against the progress of the disease, and one may well question whether their destruction is a wise procedure. In such cases I should be much interested in attempting to treat the case after the plan suggested by Murphy,—by stimulating the production of more lymphocytes; but I am not aware that a local accumulation of lymphocytes can be secured by *x*-ray therapy.

Often the clinical observer is alarmed by increase of bulk following radiation and immediately concludes that the tumor is growing more rapidly. On such crude conceptions are based most of the so-called stimulations of tumor growth by radiation. When a tumor swells following radiation it is generally due to hyperemia, swelling of tissue cells, and exudation of serum, blood, and leucocytes. In certain tumors mucinous degeneration follows treatment and causes a rapid uniform swelling. Hemorrhages have a similar effect. Bulky serous exudates are often revealed as the source of alarming increase in the size of radiated tumors. Most frequently in my experience it is bacterial infection that has occurred in the highly susceptible radiated tumor tissue and led to the erroneous assumption of increased growth. When all these sources of increased bulk are eliminated, little remains of the so-called stimulation of tumor growth by therapeutic radiation. I have never seen anything that could be clearly interpreted as the stimulation of tumor growth by radium or roentgen ray, and I have not been able to find any properly attested record of such an event.

It thus appears that the reaction of tumor tissues to radiation is extremely variable. This reaction depends on tumor structure, and since the structure of tumors is one of the most extensive and complex fields in pathology, it is obvious that the reaction of tumors to radiation must be equally complex. These conclusions have been fully borne out by clinical experience. They represent the main fruits of the close clinical study of the effects of radiation of the past decade, and they are of the first importance to the sound progress of radiologic therapy.

Nevertheless, in the face of this experience, won with much difficulty, and at the expense of much suffering and loss by our patients, we are confronted with the proposition that tumor dosage shall be standardized. It is proposed to establish a standard cancer dose and a standard sarcoma dose. Formulae prepared with mathematical accuracy in the physical laboratory are to replace the medical sense of the clinician, the principles of oncology, and the experience of the radiologist.

There is doubtless a broad field of research in the closer calculation of the various physical factors that enter into dosage. Much progress has been made along these lines, rendering physical therapy a comparatively safe and dependable method, which we gratefully credit mainly to the physicists. But the idea that anything approaching a uniform dosage can ever be established for all the various forms of cancer, or all the varieties of sarcoma, can be entertained only by those who deal with a few common types of cancer which they imperfectly observe, or by those whose work is confined to the experimental cancer laboratory. This attempt to substitute physics for biology and medicine can only prove an obstacle in the way of sound progress in radiotherapy.

The conception of a standard dosage seems to emanate mainly from the notion that radiation cures cancer by killing cancer cells. The idea is an inheritance of the old surgical point of view, that the cancer must be extirpated, root and branch. Thus the experimentalist places a fragment of cancer tissue in a dish, exposes it to radiation, transplants it back into an animal and calculates the killing dose when it fails to grow. This type of experimentation has a definite and somewhat important place, but as an adequate basis of clinical deductions it has seldom escaped criticism when presented before scientific bodies. It has repeatedly been pointed out that such experiments wholly fail to take account of the reaction of the living tissues, which is the main element in the selective cure of cancer by roentgen ray and radium. We are therefore compelled to review our knowledge of the mechanism of the action of these physical agents in causing the regression of cancer.

1. When a practitioner possessing a small amount of radium applies it to a rodent ulcer in repeated small doses over a period of weeks he usually observes the disappearance of the tumor and very often it never recurs. Meantime the skin shows little reaction and the scar is small or absent. Exactly what he has done no one knows, but he has not killed any cancer cells. Sections taken at intervals through tissue so treated, show hyperchromatism of nuclei and hydropic swelling of tumor cell bodies, followed by gradual atrophy of the cells. At the same time the surround-

ing tissues become active, leucocytes emigrate, lymphocytes and plasma cells appear, capillaries proliferate, and all these invade and replace the tumor mass. A slow regressive process with degeneration of tumor cells, and a progressive process with exudation and proliferation of normal tissues are set going, and as a result of these processes the tumor is cured.

2. When larger amounts of silver-filtered radium are inserted over a cervical carcinoma in sufficient dosage to effect a cure of a superficial lesion at one application, much the same course of events is observed. Some superficial tumor cells may suffer immediate necrosis, but tissue sections show that the bulk of the tumor is removed by a very rich exudate of lymphocytes and plasma cells, and by active growth of new capillaries which surround and compress much of the deeper parts and mechanically extrude the outer layers of the degenerating tumor cells. In many cases of this type I have failed to find many killed or necrotic cells, but have been able to trace all stages of the atrophy of degenerating tumor cells in the mass of reacting proliferating tissue. It is clear that the reaction of the tissues is an essential factor in the curative process. Under some circumstances, when this reaction fails, no amount of radiation succeeds in killing the tumor cells. I have seen recurrent rodent ulcer very heavily radiated, with necrotic stroma tissue supporting well stained and apparently viable tumor cells. Every radiologist is familiar with those indolent reactionless cancerous ulcers which resist all efforts at cure and have to be excised or burned out.

3. When radium emanation needles are inserted into a bulky squamous tongue cancer, a method which Regaud condemns as not true selective radium therapy, much tumor tissue is killed, but the cure, if it occurs, results from the more distant gamma ray effects which excite a wide tissue reaction and which render radium in this form the best caustic ever devised for cancer.

4. When deep bulky tumors are subjected to 2 gm. radium packs or penetrating roentgen rays, larger masses of tumor tissue may be killed, but not by the direct effects of the radiation. Almost always it will be found that the necrosis is due to occlusion of delicate blood-vessels, leading to anemic infarction and secondarily to death of tumor tissue. Direct killing of deep tumor cells is probably never accomplished by external radiation. It is an important law of pathology that necrosis of tissue cells usually results from failure of the circulation. This law has few exceptions in radiotherapy.

5. When a radium pack or deep roentgen rays act through the abdomen on a large uterine myoma, the myoma often disappears completely. The mechanism of this action is as obscure as it is surprising. Probably several factors are concerned, but the killing of the resistant muscle cells apparently plays no part. Tumors thus treated, become soft, cystic and flabby, and some appear to undergo anemic infarction with liquefaction necrosis. Others show mainly hyaline change with only partial atrophy. A primary effect on the blood-vessels is highly probable, but it may very well be that a temporary or permanent inhibition of the functions of the ovary acts indirectly in diminishing the nutrition and vitality of the tumor cells.

I have thus reviewed several of the more familiar conditions under which the curative action of roentgen ray and radium is observed. These do not exhaust the peculiar problems which confront the radiologist who proposes to secure nicely adjusted results by this, the first rational treatment of cancer ever devised. Yet in all of them the most detailed knowledge we possess indicates clearly that the curative action is not the result of a direct effect exclusively upon the tumor cells, but involves especially a peculiar reaction of the normal or invaded tissues. In this reaction are doubtless included many fundamental physiological properties of the tissues which, under the term "inflammation," have deeply engaged and invariably baffled the master-minds of medicine. We need a Virchow, a Waldeyer or a Weigert, to solve these riddles. None of these men, to whom we owe most of our knowledge of inflammation, ever saw the highly peculiar tissue reactions of radium. They are specific and reveal hitherto unsuspected properties of irritated tissues.

Modern research has sought a clue in the chemical changes, the ferment actions, the vitamine content of radiated tissues, etc., but without definite results. Personally I am content to record in familiar morphological terms the histological changes observed in tumor cells and reacting tissues, fearing that here as elsewhere, ultimate knowledge of the nature of these processes, such as the chemist and the physicist boldly seek, will always be denied us. Moreover this simple morphological interpretation reveals the highly important fact that in treating cancer by physical agents we are not merely killing cancer cells, in the sense of the physicist, nor extirpating it entirely, according to the surgeon's plan, but rather are calling upon Nature's forces to accomplish the cure. On this account we may assert that physical therapy, although still lacking some essential elements of an ideal method, is to some extent a rational therapy of cancer so far as we know the disease.

If we may accept the results of certain experimental studies of lower animal cancer, then the absorption of tumor tissue within the body, such as follows radiation, is an additional feature of a rational therapy. For the most definite experimental evidence of artificial immunization against cancer has been secured from the regression of tumor tissue within the body. It has often been noted, as recently stated by Regaud, that extirpation of a primary tumor is often followed by immediate appearance of metastatic growths in lungs or elsewhere, suggesting that latent cell emboli were released from growth restraints by the extirpation of the primary tumor. The body seems capable of producing only so much tumor tissue at a time, and it is better to have it all at one point than scattered through the organs. From this point of view primary tumor tissue may be regarded as a safeguard, a noli me tangere, which the surgeon often removes with disastrous results, but which, when slowly absorbed under radiation, may yield some increased immunity to the body.

Whether or not these speculations are in any degree valid, it is certain that the rational and successful pursuit of radiation therapy calls for a thorough study of the mechanism by which physical agents affect neoplastic diseases. It is also obvious that the mechanism, being highly complex, is not mainly a matter for physical measurements, but involves many principles of physiology and pathology. The introduction of radiation therapy by forcing attention to these new phases of tissue reaction, and demanding a detailed knowledge of the symptoms, clinical course and pathology of tumors, has introduced a new era in the study of cancer.

Radiotherapy will progress more soundly if it follows the spirit of this era, avoids rigid procedures and blanket rules, and makes full use of the new knowledge which the development of this branch of medicine has both rendered necessary and placed at its disposal.

REPORT OF CASE OF EPITHELIOMA OF THE CORNEA*

BY D. Y. KEITH, M.D. AND J. P. KEITH, M.D.

LOUISVILLE, KENTUCKY

MALE, aged sixty-four. Family history negative for new growths, or tuberculous or luetic infection.

Patient has never had a severe illness except a malignant ulcer of the left temple seven or eight years ago, at the age of fifty-seven, which is described in detail as a footnote.[1]

Present History. Seven months ago he noticed a redness in his left eye which persisted for several days. As this redness began to disappear he noticed that his vision was gradually failing. Within sixty days' time it appeared to him as if he was in the moonshine during the day; he was unable to see well enough to chop wood, and could see only from the outer lower quadrant of the left eye. At about the three month period his family and friends began to notice that the eye was becoming of a milky color. When first seen by us the entire cornea was of a milky white or limestone color, being much denser over the inner and upper half of the cornea; the extreme lower outer quadrant near the limbus was of a much fainter density. The new growth was limited to the cornea with no extension to the bulbar conjunctiva. Sight was so much impaired that he could not recognize a bright light except when placed upon the floor or beneath the eye.

No section was removed for microscopical study. The diagnosis of an epithelioma of the cornea had been made clinically by Dr. J. C. Daniels and confirmed by Drs. C. T. Wolfe and A. O. Pfingst. All agreed that nothing could be done surgically except an enucleation of the eye, which they recommended done as early as possible, unless the patient wished to try one application of radium. This was urged by Dr. Daniels.

On March 30, 1921, after cocainization of the left eye, a self-retaining lid retractor was inserted and an application of 50 mgm. of radium unfiltered was applied to the nasal and to the temporal half of the left eye at a distance of 1 cm. A total of 42 mm., however, was applied to each side of the eye. No attempt was made to protect the lids. The radium was distributed in 4 gold needles of approximately 12½ mgm. of radium element each. The patient's local ophthalmologist, who saw him every few days, says the radium reaction in the cornea was hardly perceptible and was at its height at the end of the third week. On May 12, 1921, six weeks after the radium application, all the macroscopic evidence of the limestone color of the cornea had disappeared and it was difficult to detect which eye had been affected. He was last seen five months after the application of radium, with no evidence of return. His sight has been completely restored.[2]

As no microscopic diagnosis was made in this case, it may have been benign. The rapid growth to cover the entire cornea in seven months is against this view. There was no macroscopic involvement of the bulbar conjunctiva. Was this an epithelioma of the cornea, or should it be classed as a new growth of the cornea, probably benign in character? From the few brief descriptions of corneal growths obtainable we believe it to be malignant. There is no question of the malignancy of the left temple, described in a footnote.

We believe this case teaches us that the

[1] In September, 1914, this patient was referred to us by Dr. W. C. Dugan with the clinical diagnosis of malignancy of the left temple area with metastasis into the cervical glands. His history was, that two months previously he had stuck a beard of wheat into a little pimple which had failed to heal. For three weeks he had been having a great deal of pain referred to the ear, mastoid and cervical glands.

On examination a small malignant ulcer, 1½ cm. in diameter, was found anterior to the ear on the left side. The glands in the neck, five or six in number, were about the size of olives.

He was given three doses of *x*-ray, using an air cooled gas tube that would back up about 8 inches and was run until the resistance was reduced to a 6 inch back up. The other factors were 8 inch skin distance, 5 ma. current, nine minutes' time, 3 mm. of aluminum. This was repeated in two weeks.

After the third dose the patient had a great deal of skin reaction and refused to return, though he reported to his doctor.

The roentgen-ray irritation and healing were over in about four weeks; at present the only evidence is a small white scar, 1 cm. in diameter.

Eight years have elapsed since the malignancy was first noticed, and seven and two-thirds years have elapsed since *x*-ray treatment was given.

[2] Fourteen months have now elapsed since the patient was treated and he remains perfectly well. No evidence of recurrence is present, and the sight is perfect.

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cornea is more resistant to the rays of radium than are the surrounding structures. How many cases have you seen of marked corneal irritation?

In New and Benedict's report,[1] they say, "It is desirable that the cornea shall be protected in treating lesions of the lid in order to prevent a severe reaction, but we have not seen any serious effects on the cornea from the use of radium. For this we have used a screen of lead 2 mm. thick." Their technique is by cocainizing the eye, having the radium placed in a lead applicator for protection to the nurse, who holds the radium in place fifteen to twenty minutes, in direct contact with the lesion; an area of the radium is exposed of the size of the lesion to be treated.

"The American Encyclopedia of Ophthalmology" gives the following brief description: "Although not as rare as true carcinoma, corneal epithelioma is a most unusual neoplasm. Primary epithelioma of the cornea is probably unknown. It occurs as an extension from the limbus where the conjunctival epithelium changes into corneal. The dense fibrous tissue of the cornea does not readily become infiltrated and therefore resists the invasion to a marked degree." Reports of seven cases are to be found in ophthalmic literature, made by the following observers: Snellen, Stellwag, Colsmann, Galezowski, Bossalino, Lagrange, and Treacher Collins. Of this neoplasm Parsons says: "The cases, therefore, of true corneal epitheliomata are extremely rare, and are all open to more or less doubt. It seems probable, however, that the corneal epithelium is capable of malignant proliferation, and that it has

Fig. 1. Fig. 2.

Pictures made four months after application, showing absolutely no evidence of the epithelioma of the cornea. Speculum in place shows method of holding the lids apart during treatment.

but slight tendency to extend deeply (Lagrange). It is rare for epibulbar growths to invade the interior of the eye; epithelioma of the cornea apparently never does. The substantia propria offers some resistance to the invasion, setting up a barrier of embryonic connective tissue around the epithelial cells. The fact that the canal of Schlemm and the anterior perforating vessels lie under the conjunctiva accounts for the fact that the growth never becomes intra-bulbar; added to the fact of the intra-ocular pressure which prevents the growth from bursting through elsewhere. Like all tumors, they grow in the direction of least resistance, which in this case is forwards and peripherally."

"It is extremely noteworthy that no epithelioma of the uninjured cornea has ever been observed." (J. D. L.)

"Bossalino[2] studied an epithelioma which involved more than two-thirds of the corneal surface, in a man of seventy-six years. From microscopic study of the enucleated eye, and from consideration of the views of other authors on the same subject, the following conclusions are reached: To epitheliomatous invasion corneal tissue offers greater resistance than do other tissues. The power of resistance resides especially in Bowman's membrane. The prerequisite for deep extension of such tumors is a transformation of Bowman's membrane into a fibrillary structure."

In the literature at our command we find seven cases spoken of in "The American Encyclopedia of Ophthalmology"[3] which should cover the literature up to 1914.

In more recent literature we find the reports of 6 cases which have been treated by radium or mesothorium with excellent results in all; the dates and authors are as follows:

1. Agricola[4]		1913—1 case
2. Koellner[5]		1917—1 case
3. H. H. Janeway[6]	Nov.,	1919—2 cases
4. G. B. New and W. L. Benedict	March,	1920—1 case
5. T. Collins		1915—1 case

Janeway's first case was given 42 mc. of emanation unfiltered which was applied by a brass cone at a distance of 1 cm. from the lesion for 20 minutes. Nine months later a report from the ophthalmologist stated that the lesion had undergone continuous retrogression and that there was no evidence of disease.

His second patient had shown evidence of a tumor 12 years before, though there had been no increase in size until one and a half years before treatment. Two months before the application of radium it had been excised and a microscopic diagnosis of epithelioma was made. Four roentgen-ray treatments were given after operation, but the tumor promptly recurred, the recurrence being in two isolated areas about the size of a grape-seed and on the scleral conjunctiva external to the corneal margin. Five treatments were given between Sept. 19th and Dec. 15th. The dosage was as follows: 30 mc. filtered by .5 mm. of silver applied at a distance of 1 mm. in an applicator made of dental modeling compound, for one hour. One month later 100 mc. were applied in the same manner for fifteen minutes. On the other dates 20 mc., 46 mc. and 38 mc. respectively were applied at a distance of 1 to 1½ cm. in cones for twenty minutes. The patient was seen again one year later with no evidence of disease and no evidence up to the time of his report in Nov. 1919, which was twenty-six months from the time of the first application. Janeway says, "Such treatments as these are therefore efficacious in destroying epithelioma and do the retina, cornea or the rest of the eye no harm."

He now recommends an applicator made with a hole approximately .5 cm. by 1 cm. in diameter, cut into lead of 2 mm. thickness, one or two radium tubes being placed over the center and fastened to it by paraffin, the eye being fixed on a spot in the wall so that the orbital conjunctiva at the site of the tumor occupies the highest position in the middle of the speculum over which the applicator may be placed.

His recommendations are: silver filtration and two applications, at relatively near dates, of 30 mgm. hours each.

The total number of cases found in literature up to the present time are 13, 6 of which have been treated with mesothorium or radium, the first one being in 1913. From a review of these cases and the one we have observed it is our belief that the application of radium to tumors of the cornea or the bulbar conjunctiva far excels operative procedure. Several cases were studied in which the patient had had from three to six operations, many of which reported recurrence within two or three months. Should we have a recurrence in the case we have treated, we shall be glad to report it first to this society. There will probably be some criticism as to the dosage we applied, since we used 42 mg. hours to each half of the eye and appreciated that the central portion received enough cross-firing or "splashing over," which accounts for more radiation to this portion of the eye. However, there have been no ill effects, and we would not hestitate to use the same dosage or more on a similar case, as there was no reaction that caused any inconvenience or distress to the patient.

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A SIMPLE PASS BOX

BY CHARLES B. REED, M.D.

NEW YORK CITY

BELIEVING that a simple and safe device for the passing of exposed *x*-ray negatives into the dark room or unloading room will be of interest to roentgenologists, I am submitting the accompanying design.

The box was designed for the Fifth Avenue Hospital, New York City, York & Sawyer, Architects, 50 East 41st Street.

It is 72 in. square, inside measurement, which allows the largest size cassette to be handled with ease. The depth below the opening is 4½ in. allowing for a good number of exposed negatives but this can be increased if desired without any change in design.

The sliding door with lead lining offers perfect protection in the dark room from light and *x*-rays. And the construction makes it impossible to open but one door at a time, thus eliminating any chance of accidental exposure in the dark room.

The doors are mounted on metal guides which run easily and close by their own weight, avoiding the need of complicated stops and counterweights.

The box may be set flush on either side, or projecting, as desired. The height should be determined by the dark room counter and the wishes of the operator. The box can be built by any carpenter, and is very simple to operate.

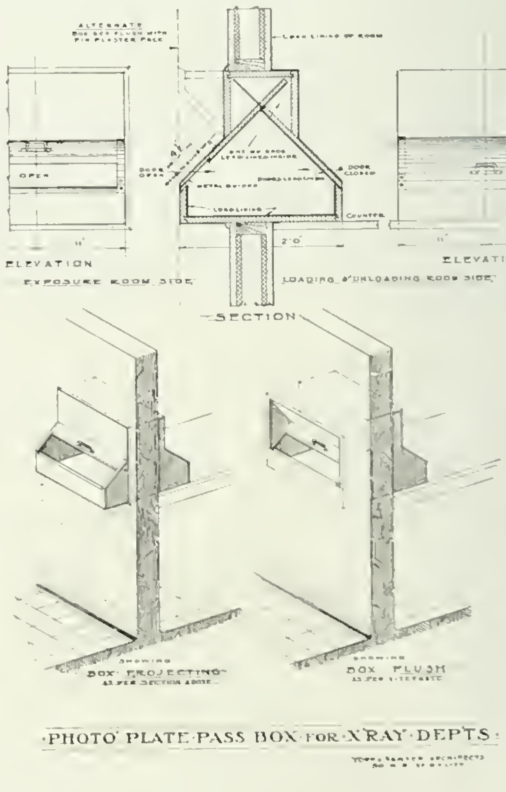

PHOTO PLATE PASS BOX FOR X RAY DEPTS

THE UNDERLYING PRINCIPLES IN THE RADIOTHERAPY OF MALIGNANT TUMORS AT THE SURGICAL CLINIC OF PROFESSOR SCHMIEDEN OF THE UNIVERSITY OF FRANKFORT*

BY HANS HOLFELDER, M.D.

University of Frankfort

FRANKFORT-ON-THE-MAIN, GERMANY

BEFORE entering upon the scientific part of my paper, I desire to express my deep appreciation for the invitation to present it before this distinguished society. The reestablishment of scientific communication between the various countries of the world is one of the most important tasks of reconstruction. It was with this feeling that my respected chief, Professor Schmieden, made possible my trip to America. The courtesy which this society has extended to me and to my colleague is greatly appreciated.

During the last few years, the roentgen-ray treatment of malignant growths has made important strides in our country. The extensive use of radiation in the treatment of malignant tumors originated in Germany with the gynecologists, but in the last few years the surgeons have found it necessary to adopt this method of treatment, and find it an invaluable and important aid. So great has the interest of surgeons in *x*-ray therapy become, that at the surgical congress held in April of this year at Berlin, an entire day was given over to the subject of *x*-ray treatment of surgical diseases. The extensive use of modern *x*-ray therapy is now made in all the principal surgical clinics of the hospitals of Europe, in most instances following the lines laid down by the Universities of Frankfort, Freiburg and Erlangen.

In developing my subject I desire to stress five essential points:

1. A far-reaching improvement in apparatus and tubes now permits the production of roentgen rays in sufficient quantity and of a sufficient power of penetration to solve many surgical problems.

2. The improvement permits also of a relatively constant output of rays. The successful application in practice of these newer developments in tubes and apparatus has been made possible by the development of a technique of measuring employing the electroscope and the iontoquantimeter.

3. With the means at hand we have learned that uniform results and permanent success can only be accomplished when every single cell in the whole area of growth receives sufficient and equal dosage. To accomplish this, the aim of technique is to secure an evenly distributed dose of sufficient quantity throughout the entire bulk of the growth. The dose must be neither too small nor too large, but lie within fixed limits, and when of this character is called the "carcinoma dose."

4. The development of powerful roentgen-ray apparatus has taught us the danger of radiating extensive portions of the body and certain vital organs where the full carcinoma dose is employed. We must, therefore, attempt to localize our dosage as nearly as possible to the seat of the disease and its immediate surroundings. The application of large fields has called definite attention to secondary and detrimental results of prolonged radiation.

5. The determination of the lapse of time in which the *x*-ray reaction occurs in the radiated tissues is of the greatest importance. To accomplish this, it is desirable that the whole dose should be applied at one time, and that intervals of necessary length should elapse between radiations in order to permit the biological reaction to run its full course.

6. It is necessary that in the development of this science there should be intimate and thorough cooperation between the physicist and the *x*-ray therapeutist

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

on the one hand and the *x*-ray therapeutist and the surgeon on the other. Only in this way is progress in the right direction possible.

As Professor Lédoux-Lebard and Professor Dessauer in their wonderful papers have already laid down the details of *x*-ray apparatus and the instruments employed in the study of high voltages and quality of *x*-rays, I shall pass over this phase of the subject.

It is necessary for the roentgen-ray practitioner to understand the various factors which determine the penetration or activity of a cone of *x*-rays projected into the human body. The amount projected below the surface decreases by absorption, a certain proportion of the rays in relation to their hardness or penetrating qualities being stopped by the tissue. A further loss occurs by the geometrical divergence of the cone of rays, the loss in this case being as the square of the distance from the focus; this may be called the loss by divergence. These two factors of loss are in part corrected by a small gain through what are known as scatter rays. A simple analogy is the relation of light to an opaque body like milk. The human body is opaque for *x*-rays, hence the rays do not pass straight through; a part of them is dispersed in the tissues in all directions. The amount of scattering rays is dependent upon the bulk of the tissue radiated, and this is dependent upon the size of the cone of rays. The larger the field radiated the greater the percentage of scatter rays, and the less the field the smaller the number. It will thus be seen that the percentage of penetrating rays at a given depth, without altering the quality of these rays and with the loss by absorption remaining constant, may be varied by changing the focal distance between the tube and the skin, and by altering the dimensions of the field radiated. Thus the percentage of rays at a given depth is influenced by the quality of the rays, the size of the field upon the skin, and the distance between the focal point of the tube and the skin.

In order to determine the number of rays which penetrate to a given depth, Wintz has introduced to roentgen therapy the idea of the percentage depth dose. This is the proportion of the surface dose compared with the depth dose measured by means of a phantom with the iontoquantimeter at a depth of 4 inches below the surface and expressed in percentage of the surface dose. The formula is as follows:

The percentage depth dose =
depth dose at 4 inches x 100
(divided by) the surface dose

The percentage depth dose fixes two points in a curve representing the activity of a given cone of *x*-rays. As we have seen, the value of the percentage depth dose can be improved by changing the distance

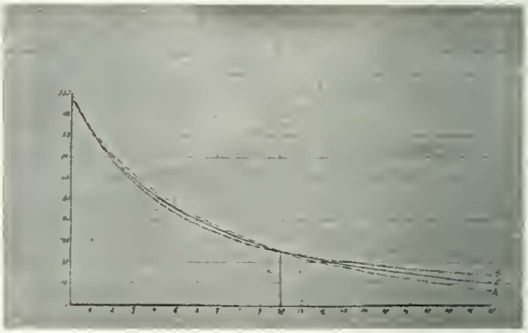

Fig. 1.

between the focal point of the tube and the skin. This may be represented by curve A (Fig. 1). This can also be done by enlarging the field, which would give us curve B. But the difference between curve A and curve B lies well within the field of practical error, so we may therefore content ourselves with a compromise curve lying between these, as curve C. With accurate physical measurements at our disposal, we must determine their value in biological terms before they can be used in practice, and to do this they must be expressed in terms of effect upon the skin. The unit of biological activity in Germany is the so-called skin standard dose (*Haut-Einheits Dosis* von Seitz und Wintz), and is relatively the same as the erythema dose of this country. In practice it is taken to mean a certain degree of reddening, practically what is called a burn of the first degree, upon the abdominal skin of a patient of middle age. This unit has to be determined by experimental radiation; and having determined the amount of radiation under given conditions necessary to this end, we then adjust our measuring instruments, usually the iontoquantimeter, thereto.

While measured physically, therapeutic doses are expressed in terms of the erythema dose. Thus it has been determined that the so-called carcinoma dose lies between 90 and 125 per cent of the standard skin or erythema dose.

As it is destructive to apply more than the full standard skin dose upon any one area of skin, and as the cone of *x*-ray decreases in percentage value with the increasing depth, it is only possible to secure the necessary dosage in the depths of the tissue by attacking them with cones projected through individual areas of skin, the so-called cross-fire method. In this method the treatment of cancer becomes an artillery problem, the difficulties of which are increased in surgical cancer by the extent and frequently eccentric position of the lesion.

In treatment of cancer of the uterus the problem is relatively simple because the uterus is centrally placed and can be radiated from four or six sides with the assurance that the limited growth in the uterus will receive sufficient and homogeneous dosage. In surgical cancer the problem is usually much more difficult. The irregular extension of the disease and the eccentric position require, in every case, a special and accurate study to determine the proper solution of the problem. If the growth is extensive, the center may have received the proper dosage, whereas the deeper portion may have received too little and the superficial portion too much. It is essential that the growth should receive uniform and sufficient dosage; and the problem is often complex.

To make possible a graphic study of each problem we have constructed in the Frankfort clinic a device which we have named a field selector. This consists of a box illuminated with electric bulbs from beneath. Over it is placed a translucent plate of glass upon which are printed certain figures which are used as signals. They are printed in one color with the different symbols in percentages of strength of color. A drawing upon a glass plate representing a cross section of the body and showing the location of the vital organs and the location of the growth is now placed over the illuminated plate on which the symbols are printed. We have prepared a series of celluloid dummies representing beams of *x*-ray produced at different voltages and through different values of filters at different distances from the body and of different dimensions of field, on which are shown by decreasing intensity of color starting with one hundred at the surface, the percentage depth dose at varying depths. These are stained with the same color as the symbols printed upon the plate, and when two or more of these dummies are laid upon the diagram in such a way as to cover the lesion, one observes whether the different symbols are visible or whether they have become invisible, when viewed through the superimposed celluloid films. The triangles disappear when 30 to 40 per cent of the standard skin dose is reached in the color values of the dummies. The quadrangles disappear at 60 to 70 per cent of the standard skin dose, and the points at 105 to 115 per cent. The danger signals which are represented by the double dots should at all times be visible. When they are no longer visible, then the dose has exceeded 135 per cent of the standard skin dose and represents an amount of radiation which will cause a burn.

By means of this apparatus one may work out the various combinations of beams of different values, with the possibility of detecting whether we have secured a sufficient dose in the area desired and whether there is, at any point, danger of causing a burn.

I desire to illustrate this method by a picture showing two fields so placed that they overlap each other so that in the center the double points are no longer visible. Obviously here we should have a burn (Fig. 2).

These two fields placed in opposition to each other avoid the possibility of a burn, but one sees that the disappearance of the symbols is of an irregular character and a homogeneous dose cannot be obtained by this combination (Fig. 3).

The next slide illustrates a method by

which three fields are tested. Here also a homogeneous dose is not accomplished and at the margin of the beams where they overlap one sees that there is again danger of burns (Fig. 4). If we remove the beam at the side, we avoid the burn, but the dose at depth is insufficient (Fig. 5). This can be overcome by readjusting the field as shown in the following slide, where, at last, we have a graphic representation of the solution of the problem in this instance, the dose being homogeneous in space and covering uniformly the entire area of the growth.

Fig. 2.

Fig. 3.

This result has been accomplished by using a most penetrating beam upon the skin area nearest to the growth, crossing this cone from the rear with other cones of less penetrating values.

Occasionally the growth lies very superficially, as in cancer of the breast, and here we often find it necessary to apply but one field from in front, obtaining a sufficient and homogeneous dose in the growth by employing large fields and a long focal distance.

These are but a few examples of the uses to which the field selector may be applied, but I trust they are sufficient to demonstrate its usefulness. It gives us a graphic method of solving individual problems, keeping constantly before us the various features which must be considered in the solution of the problems. I should be pleased to explain any further details of its use after the lecture to anyone who is interested.

Fig. 4.

Fig. 5.

As I have stated under Point 3, with the advent of powerful x-ray apparatus we have learned that it is harmful to radiate large areas of the body with homogeneous dosage of high percentage value. This is due largely to the effect upon the circulating blood. Through the assistance of the field selector we seek to limit the high dosage to the tumor and its immediate surroundings and to avoid vital organs as much as possible. In treating cases of cancer of the stomach we found that injury to the adrenals was almost unavoidable, and the result was that transverse radiation of the stomach had to be abandoned. In seeking to solve this problem Peiper and I have radiated the suprarenal bodies of guinea-pigs with narrow *x*-ray cones, and have found that this organ cannot receive a full carcinoma dose without permanent injury. With this in mind we have made a topographical study of the position of the stomach in relation to the adrenals from which it appears that it is impossible to radiate transversely without injury to the latter. As a result of this knowledge we now radiate from in front and below upward and backward in a slanting direction, and the reverse direction in the same plane from behind forward and downward. This only permits effective radiation of that portion of the stomach included in the lesser curvature, but we can in this way avoid the adrenals. By this method, in the last few months, we have successfully radiated a number of cases of cancer of the lesser curvature of the stomach.

Study of the effect upon individual cells in a growth indicates that certain cells are more profoundly influenced by an *x*-ray dose than are others. Furthermore the length of time between the treatment and the full development of the biological reaction is also variable, so that we have a variation in the amount of reaction produced and in the time factor. As it is difficult to estimate the length of time required for the development and cessation of the biological reaction, it is extremely desirable to simplify the problem by applying the full dosage at one sitting. Where divided dosage is employed, there is danger of cumulative effect and difficulty in determining when the full therapeutic dose has been delivered. The biological reaction in the cells following radiation is sometimes as late as two or three months after treatment, and in sarcoma this is frequently the case. It is not unusual to find a sarcoma after treatment that rapidly increases in size and presents all the characteristics of rapid growth, this reaction only subsiding after six or eight weeks, when regression may set in and complete healing follow. In such cases one is likely to err by repeating the treatment or deciding that the case is one for amputation.

From these facts we may deduce the following main rules: Full radiation at one sitting; long intervals of from eight to twelve weeks between treatments. And where the dose is repeated the full dosage should be given, and between the second and third dose a longer period of from twelve to twenty weeks, followed by an interval of six months; in each instance giving the full dosage.

The improvement in technique in surgical roentgenotherapy could not have arrived at its present development without the intimate cooperation of the physicist, the roentgen specialist and the surgeon. The rôle of the physicist has been sufficiently explained. I desire here to emphasize the importance of the surgeon. Surgical diagnosis is necessary in determining the location of the seat of the disease and its extension. To render this possible, Professor Schmieden and I have prepared a great collection of sagittal, frontal, cross and oblique sections of the body in natural size, showing the relations of the vital organs to the surface. It is only with such cross sections available that one can apply deep therapy with topographical accuracy. These constitute the collection of maps of the general staff on which one bases the detailed artillery plan studied on the field selector.

In certain surgical types of cancer one can only determine the exact location of the lesion by surgical means, as, for instance, in cancer of the stomach. In such a case an exploratory laparotomy should be made to ascertain the seat and extension of the growth. In other cases it is necessary that the organ in which the disease has developed should be put to rest, as in cases of cancer of the rectum, where an artificial anus is frequently made for the period of the treatment. In many instances a combination of surgery and roentgen-ray treatment is the most advisable procedure, and this can only be done where the deep therapy plant is in immediate connection with the surgical hospital. Furthermore, only by close and sympathetic cooperation can the indication be determined as to whether radiation or operation is the most desirable.

Although the effect of radiation in many types of surgical disease is extremely gratifying, n fact, in many instances quite astounding, the results are yet not sufficiently uniform to justify abandoning surgical operation in operable cancer except under special conditions. Time will not permit an analysis of these exceptions.

In a few closing sentences I desire to set forth the present status of our clinical experience and the indications which determine our handling of cases at the surgical clinic in Frankfort.

1. Every operable cancer, with few exceptions, is operated and in addition receives prophylactic radiation afterwards. This radiation is carried out exactly as if the growth were still present.

2. Besides prophylactic after-radiation, radiation before operation is generally practiced, and is considered of great importance.

3. All inoperable cancers and all recurrences are radiated unless too advanced. In a certain proportion of cases, clinical healing will result in a further improvement sufficient to permit operation to follow the treatment, and in many cases the danger of bleeding, ichor and pains will be diminished or disappear, and the chance of metastasis be diminished.

4. Where the primary growth is operable but there are remote metastases in other organs, as, for instance, a primary cancer of the rectum with metastases in the liver, the primary growth is removed by operation and the metastases in the liver are treated by *x*-rays alone.

5. Epitheliomata of the skin are exclusively dealt with by *x*-ray treatment.

6. The great majority of sarcomata are treated by radiation alone. The time has passed when amputations for sarcoma are made any longer in the Frankfort clinic. Apparent increase in size of growth following radiation should not lead to discontinuance of treatment or amputation.

7. Our methods have been mainly based on the technique of Seitz and Wintz. We have attempted to adapt their method, by means of the field selector and topographical sections of the body, to the field of surgery. We have enjoyed the privilege of close cooperation with the Physical Research Laboratory of Professor Dessauer.

8. Improvement in the techinque of *x*-ray treatments must be based upon careful and accurate observations and practical experience carried over a long period of time, involving careful studies and adequate records.

9. The aim is to secure a homogeneous radiation of the whole seat of the disease, the dose to be determined by the biological qualities of the case.

10. Unscientific and improper radiation will gravely complicate any case and make ineffective suitable procedures applied afterward. The prognosis of improperly radiated cases is extremely bad.

11. Once a case has been radiated in a given institute it should pursue the treatment only at this institution and under the same responsibility. Surgical cooperation is of greatest importance.

12. The frequent changes in technique and continual advances in the field of radiotherapy make it impossible to distinguish statistically between the value of operative and radiative treatment. We shall continue at the Frankfort clinic along the lines indicated in this paper until the relative value of both methods is finally decided.

DISCUSSION OF PAPERS ON DEEP ROENTGENOTHERAPY BY PROFESSOR DESSAUER, DOCTORS STERN, STEWART AND HOLFELDER

Dr. Stern. How long before operation do they give pre-operative treatment?

Dr. Schmitz. I wish to fulfil a promise that I made, and that is to discuss this paper. Two points of greatest importance to be taken from Dr. Dessauer's paper are: 1, radiation must be of homogenous quality; by that he means that the healthy and diseased tissue must be struck by the same kind of radiation, otherwise it is impossible to compare the biological results on the surface with those in the depth, because rays in the depth differ from the surface: 2, radiation must not only be homogeneous qualitatively but also quantitatively; by that is meant the entire diseased area. Practically all of the body which is within the radiation cone must be struck by radiation of homogenous intensity. The question arises in our minds, how this is brought about. In the following way: First place, select proper focus skin distance. We should never say 50 or 30 cm. but we should select for each case individual focus skin distance to be used in that particular case. In order to increase the homogenous radiation qualitatively and quantitatively, you must make the depth dose practically as intense as the surface. You certainly must use a filter which will cut out the undesirable radiation; that is, the soft long rays. Selection of the proper filter thickness and the kind of filer is very important. If you are radiating any benign condition, such as a bleeding uterus where you should cause with the *x*-ray a cessation of menstruation, you need only practically 35 per cent of an erythema skin dose. In cancer of the uterus you need 100 per cent. In cessation of menstruation it is only necessary to strike the ovaries and it only takes 35 per cent of an erythema to obtain results. The selection of the number of ports of entry and also the size of the ports of entry are very important.

It is almost incomprehensible that any one can say they can obtain better or the same results with the old gas tube than with the Coolidge tube. The same conditions can never be reproduced with the gas tube as with the Coolidge tube.

Dr. Levin. Mr. President: Allow me to congratulate you on the wonderful program of the meetings of yesterday and today. The lecture delivered by Prof. Lédoux-Lebard was particularly interesting to me. There cannot be any doubt in anybody's mind that the more perfect the construction of the *x*-ray machines, the larger the quantities of radium employed, and the more perfect the methods of application and measurement, the better will be the therapeutic results. None the less, the biological and pathological conditions within the organism of the patient are so complex that uniform results cannot be expected, all the assertions to the contrary notwithstanding.

The following 2 cases of lymphatic leukemia, in both of which the same quantity of radium was applied for the same number of hours to the spleen, bear out strikingly this statement. In one case the total leucocyte count was reduced from about 180,000 whites to about 32,000, the lymph-glands diminished in size and the general condition of the patient improved. In the other patient the total white count went down from 280,000 to 1,000, and notwithstanding several blood transfusions the patient died in seventy-two hours after the irradiation. This remarkable difference in the action of the same quality and quantity of radiation on two patients suffering apparently from the identical disease, must serve as a warning against the indiscriminate use of the so-called carcinoma dose, sarcoma dose, castration dose, etc. Every cancer cell is an organism in itself which constantly takes in food and secretes products of its own metabolism, which later again may serve as food to the cells of the neighboring tissues. Local and temporary differences in such metabolic inter- and intracellular activities may well account for the differences in the results of an identical amount and quality of radiation. Three patients with carcinoma of the breast, one of which is a strong woman of twenty-eight, the second over eighty years of age and the third a woman fifty years old and suffering from diabetes besides the cancer may well react differently to the same carcinoma dose of *x*-rays.

The work of the physicists contributes greatly to the progress of the science of radiotherapy and the high voltage *x*-ray machines will add to the efficiency of the work, but a great deal of thought and care should be exercised in the use of these powerful engines.

Dr. Pfahler. I appreciate this excellent presentation by those who have studied the clinics in Europe. Dr. Levine has already sounded part of the thought that I intended to sound,—or a warning if you please. We get the impression from these reports that the first essentials are that we have an instrument that will deliver 200,000 volts; that we have a patient to work on; that we use the technique and be sure to deliver sufficient dosage into this patient. Now all this discussion so far seems to have lost sight of the fact of the patient being a living human being with a will of his own, with a lot of friends—and some with lawyers. Do not forget the last mentioned gentlemen. With this new technique which is unfamiliar to most of the men in this room, if you go ahead and try to do offhand, by your own experience and your own knowledge, what has been done in these carefully controlled clinics in Europe, where a physicist stands by your side and where a surgeon has made a preliminary examination and helped to control the progress of the case, and where a trained roentgenologist or radiologist has given the treatment—if you attempt to repeat offhand without the same amount of knowledge and support, what they have done, there is going to be trouble. Hundreds of law suits will result from this enthusiasm. We must be careful and go into this new technique carefully or we are going to do harm. As a practical point, I want to ask a few questions from these men who have made observations in European clinics.

What is done over there to prevent radiation sickness? the general symptoms of the patient which already bother us even with our "play" radiation? Tell us what they are doing to overcome it, or prevent it. They do not repeat radiation until the blood has returned to normal. Will Dr. Stewart tell us how far the blood has gone abnormal and what we should look for in the abnormality of that blood?

Will they tell us what is being done for the skin of these patients in which Dr. Schmitz has already told us that he intends to bring about a dermatitis? Tell us what to do. In some states *x*-ray dermatitis is prima facie evidence of negligence.

Dr. Pariseau. Just in an offhand way I shall give you a few of the reflections that have come to my mind. I think it is not absolutely necessary to sound any more alarms. The voice of common sense has been heard several times within the last forty-eight hours; heard in very liberal and very forceful language. Whatever the form of it, whether it be elegant or impoverished, I think it is the voice of common sense speaking.

Nevertheless, I have been thinking a good deal about what I should do to perfect my technique. I wondered what I could do to make my present 9 or 10 in. technique a little better. I gave before the Canadian Radiological Society at Niagara Falls in June what I called "Basic notions of physicis and elementary mathematics" which we have too often forgotten. When a man says "I am at present using an 8 in. target skin distance, but if I used 6 in. I would certainly shorten the exposure," he evidently said a truism; on the other hand he was admitting an error in technique, since, as he was getting nearer to the patient he was losing what we need very much—homogeneity. I gave what they were worth, these basic notions. I have been thinking ever since what I could do. One thing is sure; our measurements need to be as well standardized as possible. If I had to put it in tabloid form I should say, "The measure of our progress is the progress of our measures." As a great Frenchman said, the notion of measurements must penetrate all of medicine. We must use a given spark gap and not say "between blunt points." When we get these basic notions of elementary mathematics, etc., it seems to me that there are a good many other things we want to acquire. Among them is skill in handling machinery. We have heard how many have failed to direct the central ray. I have often done in a slipshod way radiation of the ovary and uterus. Now it is true that with a large port of entry the misdirection of our ray will have less effect because we can count on the scattered ray, at any rate, reaching the organ we want to treat, but it is quite evident that the real primary concentrated ray is the one we want to get there.

With a cardboard box, I have at home evolved a method, not new, and which I tried once at the hospital. It is not easy in cancer of the cervix, for instance, to know just where the cervix actually lies. Make a pessary and put it down into the cervix and fluoroscope your patient. You will get somewhere on the abdomen the spot, which you can mark with ink, where your perpendicular ray from the tube strikes. Shift your tube sideways and get another spot. Now you have something which you can materialize.

Regarding the ionization chamber, Villard tried to construct one, but could not have it done in Paris on account of the indifference of his French mechanics, so he had it constructed in Germany. I think that first, if we are to use it, we must choose a small one that can be put into the cavity. An ionization chamber of aluminum would give very grave discrepancies on account of the characteristic radiation which would be emitted inside the chamber. I understand that Dr. Friedenwald modified his aluminum ionization chamber and now uses one composed of an organic substance, lined on the interior with graphite, which has not characteristic radiation worth mentioning; so it would seem to me that we are jumping into a problem without having, perhaps, sufficient knowledge of the fundamentals.

Dr. Case. I want to ask a question of the gentlemen who have recently been to Europe. We understand from their remarks today that the trend of surgical opinion in Germany is away from surgery and toward radiotherapy in dealing with operable cases of cancer of the breast and pelvis. I am perfectly willing to believe that this is true in the clinics in which these gentlemen visited. I would like to ask, however, whether or not they have made wide inquiry in many clinics regarding the general trend of surgical opinion in Germany as to this question. I really wonder if it is true that surgeons as a rule have adopted this method as much in toto as we might believe from the very encouraging reports.

As regards locating the cervix, if one combines radium with *x*-ray, naturally one applies the radium first, and it is a very simple matter to fluoroscope your radium capsules in position and determine from what angle the *x*-rays are to be applied. If no radium is used, it is a simple matter to insert a small metal pessary, which can be fluoroscoped and then removed.

I have been interested in the question of deep therapy for about six years. In 1915 we had constructed for our laboratories one of the larger Peerless machines, with a large rectifying switch. This we used for treatment work as early as 1915 with copper filters, but at that time we did not attempt to employ more than a 10 in. air gap voltage. The war came on and the question was dropped until the year 1919 when I found that our apparatus would give us a much higher voltage. Through a series of fortunate circumstances I was placed in possession of a Coolidge tube of the new type about seven months ago, and we were able to start treatment with it and to measure with the sphere gap our voltage, which varied between 180,000 and 196,000. We had not the slightest difficulty in the running of the machine.

About a month ago we got our new machine, which gives upwards of 200,000 volts. We have been using 220,000 volts in a number of cases, and can work as high as 280,000.

I have been asked to express my opinion of the new treatment and its results. I feel reluctant to put myself in evidence after only six or seven months' experience with the higher voltage. You are familiar with the results we have been obtaining through months back with the ordinary technique. I have been very definitely impressed with the fact that since we have increased the voltage and have been using copper filters, upwards of 1 mm. thickness, increased the dose, and increased the focus skin distance, we have thus far secured temporary results in cancer cases which are certainly infinitely superior to any we have heretofore seen. We cannot talk about these patients as cured; it is almost beyond belief that we have attained anything like that. But very extensive recurrences have melted away at a hitherto unseen rapid rate; tumors have subsided after a single application; unusually prompt and marked relief from pain has been noted in a number of cases. In benign cases we have secured amenorrhea more quickly than before, just as we have secured quicker diminution of the metabolic rate in hyperthyroidism. In malignant cases we have seen improvement at a far greater rate than we have ever seen before. We are very much encouraged and very hopeful. We have received encouraging surprises. I am glad to say that so far we have not had any bad results. We have had no patients who have been extremely sick; the sickest patient was a Hodgkins case.

We have given areas about 15 to 20 cm. square; the longest treatment was 600 ma. minutes with upwards of 200,000 volts at 50 cm., using 1 mm. and sometimes more of copper, plus leather. We gave 5 ma. for two hours at one sitting. However, the average dose is somewhat less than that. With one exception, no patient was sick longer than a day or two. In fact, they are no sicker than after the old method of treatment.

Dr. Coolidge. There is just one point I would like to bring out; namely, that there is a difference between, on the one hand, merely using an ionization chamber with some form of electroscope to determine absorption curves and, on the other hand, using it, as in the case of the iontoquantimeter, to measure dosage. I do not think that difference has been clearly brought out. In the latter case it has been customary to take the instrument on faith and to measure dosage with it. It is like taking a milliammeter on faith. This is probably done a great deal, but it is not good practice. The milliammeter, no matter who made it, should be calibrated and this should be done frequently, and it should preferably always be used in series with a second milliammeter. Exactly the same thing applies, and with equal force, to the matter of the iontoquantimeter. If it is to be used in body cavities to measure dosage delivered, it seems to me that the instrument should be calibrated frequently, by the Bureau of Standards or some other capable and reliable institution.

Frequent calibrations can be safely dispensed with, only when such an instrument is used for getting *relative* values, as in measuring the output of one tube in terms of another, or in making absorption curves, or in measuring percentage depth intensity.

In connection with the use of the iontoquantimeter for measuring dosage, it should be remembered that expression of the dose delivered, in electrostatic units, says nothing whatever about the quality of the radiation.

If Dr. Friedrich is right in concluding from his experiments that the quality is unimportant, and that regardless of it, biological effect is proportional to ionization as measured by a suitably designed ionization chamber, it might be sufficient to merely state the dose of radiation, as expressed in electrostatic units, delivered at various points. Until this important conclusion of Dr. Friedrich has been adequately verified by others, however, it would seem much safer, even for those who want to measure dosage with an iontoquantimeter, to measure and record also the voltage, as measured by sphere gap, the milliamperage, and the time, together with the factors of distance, filter, port of entry, etc.

Dr. Shearer. There is very little I can add to what has been said by Dr. Coolidge and others. I do want to emphasize one or two points. Observation of work with ionization chambers by fairly good physicists during the last ten years makes me feel very doubtful of the value of such instruments for actual therapeutic dosage where neither working conditions nor the training of observers are favorable to reliable work. Inaccuracies due to stray or parasitic radiation, leakage, characteristic rays due to *x*-rays striking the walls, gradual failure of insulators, etc., are so probable and so serious that I am quite frank to say I would not permit a member of my family to be subjected to deep therapy as here described on the basis of such measurements alone. I would much rather depend on even crude voltage measurements and those of current, time and distance.

The quantimeter gives you a fraction of the amount of radiation that goes through the tissue but not always the same fraction as you raise your operating voltage. You may compare that received with the amount which falls on the skin, but unless you have other information you still do not know the real distribution of that radiation through the various layers of tissue. For that you must depend on one of two things; you must either take measurements worked out on a rather elaborate experimental scale or you must go back to the method mentioned.

Dr. Sittenfield. About a year ago I had the pleasure of presenting to you the newer technique of radiotherapy as I observed it abroad. I was so impressed at the time with the advancement that I brought over an apparatus, and followed up their technique. However I was disappointed that I did not get quite the results they obtained, and in order to check up my own results with theirs, I went abroad this year again. I found that the shortcomings in my results were purely my own; that the technique as used over there is very technical and highly specialized, and can not be repeated by any one with a big apparatus, an increased spark gap, and a high voltage tube.

Personally I have given from two to four hours of radiation at one sitting without any untoward results. My guide for repeating the dose is necessarily the blood reparation. The blood, as you know, generally suffers after severe radiation, the lymphocytes suffering most. Besides, there is considerable reduction of red blood cells, and with it, also, loss in the number of leukocytes.

Abroad, the treatment of intensive radiation consists not only of raying, but of keeping in touch with the patient, if necessary, for several weeks after radiation. This is a most important point to bear in mind. They lay as much stress on the treatment after the raying, as on the radiation itself. The whole crux of the situation is not the apparatus, the tube, the focal distance, nor the portals of entry, but the dosage itself. How you are going to arrive at an accurate dosage depends upon your own calculation and upon the situation of the tumor.

Personally I agree with Drs. Stern and Stewart. I am going to continue along that line. I have worked with Dr. Dessauer's measurements and those of Dr. Friedrich. Dr. Friedrich has devised a simplified apparatus for measuring the radiation that a nurse can handle. I am not going into the question as to whether it is physically accurate or not; for all practical purposes it works well. I have seen hundreds of cases treated with this new technique, and have not seen a burn. My cases do not fare any worse than before the newer therapy.

Dr. Dessauer (closing discussion). The physicist cannot do the work of the biologist. He can only take care of the physical side of the problem. The biological side must, of course, also be taken care of.

It is not surprising that there have been many fatalities. It is rather surprising that there have not been more. It is often found that the rule has been to measure after instead of before giving treatment. It is not possible to handle all kinds of deep therapy with the voltage corresponding to a 10 in. spark gap; the good results reported by Dr. Pfahler might have been still if he had had higher voltage to work with; the physical means must be adequate for the work to be done. Eventually, when we reach a point where we are sure of our voltage and milliampérage and other physical conditions, and then have, as we now have, our equal intensity curves, it will probably not be necessary to use the iontoquantimeter or any other means of controlling the kind or amount of rays. At the present time we have not reached that point, and it still seems desirable, at least occasionally, to control the character of radiation by direct measurement, as with the ionization chamber.

It is to be hoped that it will not be necessary for you in this country to cope with all the difficulties that have had to be overcome in getting to the point where we are now in our deep therapy in Germany, and it is with this thought in mind that I have come here to tell you about our work.

In closing let me point out that the surgeon spends a long time in the study of his profession. The same thorough preparation is needed for the practice of radiation if the best possible results are to be obtained.[1]

Dr. Stern (closing discussion). This meeting takes me back to the time when Dr. Coolidge first presented his tube. At that time warnings came from all directions about the terrible calamities that would surely follow the advent of this powerful tube. As far as I know nothing dreadful really happened. In fact I feel sure that it put roentgenotherapy on a much safer basis. We realized the power we were dealing with, and took precautions accordingly. It will be the same with this apparatus. I predict that you will have no more trouble in working with 200,000 than with 120,000 volts. Simply realize that you are working with greater power, learn the technique and be careful.

I am getting one of these machines, and expect to do a little experimenting with it, before deciding as to what technique to adopt. I am sure that we can play absolutely safe, and still do a great deal more for our patients than we are doing at present. We do not have to begin with a seven-hour treatment, but may begin with one of the milder forms of technique that I described to you, and gradually work up towards the safety limit.

[1] Translation by Dr. Coolidge.

As for radiation sickness, I found that some clinics were getting a great deal of it, especially those that were giving the entire dose in one or two days. The stand they took was that this was a radical treatment, intended to take the place of a radical operation in an effort to cure malignant disease, and that the constitutional disturbances following the treatment were no greater than those following an operation. In other clinics they assured me that by taking proper precautions they got very little radiation sickness. Dr. Kohler claims that by giving these patients two uzara tablets one-half hour before the treatment, and repeating the dose after the treatment, he practically avoids radiation sickness altogether. These tablets contain no opiates and are considered perfectly harmless. As regards skin reactions, they all aim to get some erythema; some more, others less: but this should always disappear in a week or two.

Dr. Case asked whether all surgeons have stopped operating on breast and uterine cancers. They have not. The majority are still operating. They have only stopped in gynecological clinics, where the surgeon in charge has also charge of the roentgenotherapy department. And it makes no difference to him whether he operates or radiates. He says he prefers radiation, because he gets a larger percentage of cures. I predict that five years from now we shall be assembled at another meeting, discussing the dangers connected with the operation of a 400,000 volt machine.

Dr. Stewart (closing discussion). I have not had any personal experience with the 200 kv. machines. My paper was simply my observations made in Germany this summer, on deep roentgen-ray therapy. The iontoquantimeter is considered a very reliable instrument and apparently is simplicity itself. The nurse in charge of the treatments determines by this apparatus when she has given the prescribed dose. No doubt adjustments and care of the apparatus are necessary. It certainly is a great advantage to have a trained physicist to watch out for the pit-falls in the use of the ionizing chamber for measurement of dose.

Dr Stern has answered Dr. Case with reference to surgeons in Germany. The situation of the gynecologists in relation to this question is much the same as the attitude of the nose and throat men toward the treatment of enlarged tonsils by the *x*-ray. There is a certain percentage of them who are not in favor of it.

The question was asked as to the method of treatment of the 10 cases I saw in Berlin. In 1913 and 1914 they were not using such heavy voltage. All the cases showed permanent skin changes, indicating cross-fire treatment, with full erythema doses. Many of them used radium in conjunction with x-ray.

Dr. Pfahler referred to the blood picture. If I remember rightly the white cells drop from about 7,000 down to about 2,000, the hemoglobin dropping correspondingly. They would not give another treatment until the blood picture had returned to normal.

Dr. Holfelder (closing discussion). If the patient is to be treated before operation, we treat him three or four weeks before. Patients get more sick after heavy treatment than after a light one.

1. My Studies on the Physical Foundations of Deep Therapy Treatment. By Prof. Dr. Friedrich Dessauer, Director of the Institution for the Study of the Physical Laws of Medicine, University of Frankfort, Frankfort-on-the-Main, Germany. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. Am. J. Roentgenol., Oct., 1921, viii, 578.

2. Intensive X-Ray Therapy as seen Practiced in the Clinics in Europe. By Samuel Stern, M.D., Radiotherapist to Mount Sinai Hospital, New York City. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. Am. J. Roentgenol., Dec., 1921, viii, 739.

3. The Present Status of Deep Roentgenotherapy in Europe. By W. H. Stewart, M.D., New York City. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. Am. J. Roentgenol., May, 1922, ix, 315.

4. The Underlying Principles in the Roentgenotherapy of Malignant Tumors at the Surgical Clinic of Prof. Schmieden of the University of Frankfort. By Hans Holfelder, M.D., University of Frankfort, Frankfort-on-the-Main, Germany. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. Am. J. Roentgenol., June, 1922, ix, 344.

PYELITIS OF PREGNANCY*

BY FRED M. HODGES, M.D.

From the Urological Service of Dr. Joseph F. Geisinger, Stuart Circle Hospital

RICHMOND, VIRGINIA

Pyelitis of pregnancy was first described by Smellie in 1752. Reblaub in 1892 discussed the subject more in detail, reporting several cases with their treatment. The majority of writers (Danforth, Braasch, Geisinger, Walker, Kelley, Baughman, and others) believe that the condition is due to pressure of the pregnant uterus on the ureter, especially the right, at or near the brim of the pelvis. Weibel in a study of 100 normal pregnant women, found that 40 per cent of primip. and 34 per cent of multip. showed definite interference in the ureteral flow.

Aynesworth, however, due to the fact that the majority of his cases began in the early months of pregnancy, does not believe that the uterus is an important factor in the etiology of pyelitis. In the first few months of pregnancy, however, before the uterus has lifted itself out of the pelvis, the pressure on the ureters is greatest, except when the presenting part is in the pelvis.

It has been argued that since the specific gravity of the uterus is the same as that of any other intra-abdominal organ, there can be no pressure on the ureters. This argument, however, does not take into consideration the definite traction exerted by the lower uterine segment. The general concensus of opinion is that it is largely a unilateral disease, the right side being nearly always affected.

Harris in 32 cases found the right kidney involved in all, and both kidneys in 6 cases. Pollack in 35 autopsies found 18 bilateral cases, and 17 involving the right side alone. Albeck (quoted by Vineberg) in 125 cases found the right kidney affected 91 times; the left kidney 22 times; and both kidneys 10 times. Opitz in 69 cases found the right side only, affected in 50. Chace in 42 cases collected, found the right side affected 37 times, the left 4 times.

The frequency of right-sided hydronephrosis is due to the uterus passing before the mesentery and being deflected to the right. Francke and Mirabeau believe there is a direct communication between the lymphatics of the ascending colon and

* Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921.

the right kidney capsule, making an additional factor in the frequency of the right-sided infection.

Case I. Fig. 1, eight months pregnant.

The assumption of practically all writers at present is that the infection is a hematogenous one, but some still adhere to the ascending route theory. Eisendrath believes there is a direct communication between the bladder and kidney, by way of the perivesical lymphatics. Cabot and Crabtree, in a very thorough piece of work were, however, unable to agree with this assumption. They do not consider ascending infection likely, without dilatation of the ureterovesical sphincter, or obstruction at or below this sphincter. They believe infection from the bladder enters the perivesical lymphatics, reaches the bloodstream, and then the kidneys. Draper and Braasch could obtain ascending renal infection only by maintaining a high pressure over a long period of time.

The colon bacillus is the direct cause of pyelitis of pregnancy in from 75 to 90 per cent of the cases. Bugbee found 75 per cent bilateral infection. The staphylococcus, streptococcus, and other organisms play a minor rôle. The symptoms are usually pain and tenderness in the affected kidney, in the corresponding costovertebral angle, and along the lower ureter; fever, possibly chills, leucocytosis, urinary symptoms, pyuria, and the demonstration of the infecting organism.

We have studied 15 cases of pyelitis of pregnancy, but will report very briefly 7 cases only. These show the characteristic changes occurring in the renal pelvis and ureters.

Case I. Fig. 2, eleven days after delivery.

Case I. Fig. 3, five weeks after delivery.

Case I. Mrs. J. T. D. Age 24 years. Past history negative. One healthy child, normal delivery. Was eight months pregnant at time of examination. Chief complaint, nausea, vomiting, tenderness over both kidneys, especially the right, and

Case I. Fig. 4, five months after delivery.

fever. There was slight leucocytosis and pus in the urine. Cystoscopic examination showed right side pyonephrosis. After

Case II. Fig. 5, eight months pregnant.

five irrigations which extended over a period of fifteen days, a pyelogram was made. This showed marked dilatation of the right pelvis, calyces, and ureter, both ureters being rather tortuous, but no distinct strictures. On Nov. 19th, or at about eight and a half months pregnancy, a normal child was delivered. Pelvic lavage was continued for eleven weeks, the patient continually improving during this time. Seven pyelograms were made at about two-week intervals, these showing a gradual return of the pelvis and ureters toward normal. The right pelvis and ureter, however, have been too much damaged ever to show a normal pyelogram, though the urine and function show nothing abnormal. In this particular type of case, future pyelograms may present bewildering evidence, unless the roentgenologist goes carefully into the past history.

Case II. Mrs. J. M. C. Age 25 years. Past history negative. Two healthy children, one miscarriage. Wassermann negative. The last menstruation was from June 26 to July 1, 1919. With normal urine until Feb. 23, 1920. At this time she was suffering with nausea, vomiting, pain in the back and over the right kidney. Catheterized urine showed pus, and colon bacilli from both sides. Pelvic lavage

Case II. Fig. 6, after delivery.

relieved the majority of the symptoms, though the pyelogram showed marked dilatation of right pelvis, calyces, and ureter, with moderate dilatation on the left side. Ten days before the calculated date of delivery, she again had some nausea which was relieved by pelvic lavage. The computed time was so near that labor was induced and a healthy child delivered. Two weeks after delivery, pelvic lavage was again followed by progressive improvement in all symptoms. On July 8, a catheterized specimen showed no pus nor casts. The size of the kidney pelves gradually became smaller; but the right side in this case, in spite of a normal

Case III. Fig. 7, six and a half months pregnant.

function and urine, will probably never again show a normal pyelogram.

Case III. Mrs. R. C. H. Age 26 years. Past history negative. No children. Last menstruation June 1 to 5, 1919. Probable date of delivery around March 7, 1920. On Nov. 14, she had pain in the back and right side, temperature 104, leucocytes 16,000, polys 90 per cent. The urine showed pus and colon bacilli from both sides. Immediate improvement followed pelvic lavage. After the sixth treatment, a pyelogram showed marked dilatation of the right pelvis, calyces, and ureter; moderate dilatation on the left side. On Jan. 19, 1920, immediately after an irrigation with 2 per cent nitrate of silver, this patient went home contrary to advice. After a restless night, labor pains began, and the next day an eight months baby was delivered. This died the same day. This was the only case where a live and healthy baby was not delivered.

Case IV. Mrs. R. T. A. Age 23 years. No children. Pregnant four months. Chief complaint, pain in right kidney area, and fever. The urine from both sides contained the colon bacilli and pus, usually more pus coming from the right side. A pyelogram revealed a moderate hydronephrosis on the right side, slight hydronephrosis on the left. She has been markedly benefited by lavage, and has recently had a normal delivery.

Case IV. Fig. 8, five months pregnant.

Case V. Mrs. J. M. Age 29 years. Three children. Past history negative, except gave history of pyelitis at time of pregnancy five years ago. Cystoscopic examination showed a right side hydronephrosis; no pus or bacilli. There was no obstruction, a No. 9 catheter passing without difficulty. The pyelogram showed a dilated pelvis and tortuous ureter. The left side was not examined.

Case VI. Mrs. W. Age 31 years. Five children, one miscarriage. Gave history of pyelitis at time of her last pregnancy five months ago. Has had some pain in the right side since that time. The urine shows pus, and the colon bacilli from both sides. No obstruction in ureter. A pyelogram showed a dilatation of both pelves and ureters. The symptoms were relieved and urine cleared of both pus and bacteria by lavage. An earlier diagnosis and treatment in this case would in all probability have prevented several months of invalidism and, to some degree, the amount of pathology later found.

Case VII. Mrs. S. B. B. Age 62 years. Five children, youngest 30 years of age. Past history negative. When cystoscoped, No. 9 catheters could easily be passed up to either kidney. With an absolutely negative history, and no spasm, stricture, or other obstruction in ureters, we believe the bilateral hydronephrosis probably followed ureteral obstruction during pregnancy.

The symptoms, laboratory findings,

Case VII. Fig. 9. See case history.

cystoscopic evidence, and pyelographic data in these cases are all very similar. In every instance except one, the colon bacillus was found on both sides. In one case the staphylococcus was also present. In every case the lesion was bilateral, but more marked on the right side. The lymphatic connection of the right kidney capsule with the ascending colon may more promptly add infection to obstruction on the right side; but since the infection was bilateral in practically every instance, the greater obstruction, together with certain anatomical peculiarities on the right side may be entirely responsible for the greater pathology on this side, with no direct relation to the route of infection.

It is generally assumed that coccal infections, since they largely affect the cortex of the kidney and not the tubules, do not give a marked lowering of the kidney function; but that colon bacillus infections, on the other hand, where there is a primary lesion in the tubules followed by pelvic infection, do give a marked lowering of the renal function. We have not found this to be the case in pyelitis of pregnancy, even though the infection is nearly always due to the colon bacillus; kidney function, though variable, has rarely been very low. In a few instances the function has been above normal; in a good many others, practically normal; in none of the cases was it as low as would be expected from the amount of pathology present.

Pelvic lavage using silver nitrate, mercurocrom, or formaldehyde was done by Dr. Geisinger. This unquestionably was of marked benefit. It was followed by very little reaction, but by early relief of symptoms, a decrease in the amount of pus and bacteria in the urine, and improvement in the patient's general condition. Nephrotomy or nephrectomy, as advocated by some, E. P. Davis, etc., is probably very rarely, if ever, justified; while induction of labor is rarely indicated.

The technique for obtaining a good pyelogram in a pregnant woman is of some importance. In our more recent cases, the following technique has given almost perfect satisfaction. The usual kidney cone; film with double screen; 40 ma; 5 inch gap; ½ to 1½ sec. exposure. Only one side is examined at a time, the pelvis being slowly filled under fluoroscopic control. When the examination is made in this way, the patient is subjected to practically no discomfort or reaction, while a good pyelogram is obtained.

This subject being still under investigation, any conclusions can only be tentative, but we believe the following summary is probably justified:

1. Pyelitis occurring during pregnancy is probably uniformly secondary to obstruction due to pressure on the ureter by the enlarging uterus.

2. Usually, due to the rotation of the uterus to the right, the greatest pressure is exerted on the right side; but, contrary to the usual assumption, the left side is

in nearly every instance also affected, but to a lesser degree.

3. Be the source and route of the infection what it may, obstruction unquestionably exists, since in every instance immediate improvement followed evacuation of the uterus.

4. Measurements of the pelvic capacity usually give most of the desired information, but the evidence furnished by the pyelogram is conclusive, serial pyelograms giving a permanent record and graphic data which is of value in treatment and prognosis.

5. The true pathology of the condition is graphically demonstrated by the pyelogram and consists mainly of dilatation of the renal pelvis and dilatation and kinking of the ureter. The dilatation varies greatly. The lesser and medium grades will entirely recover, but the more severe grades with atony of the pelvic musculature only partially recover.

6. In women having borne children, a dilated pelvis and ureter, especially if the right side, may be a normal condition, the kidney forming normal urine and having a normal function.

7. The colon bacillus is usually the infecting organism, but others may occasionally be primary or engrafted on the colon infection.

8. The early diagnosis and treatment of pyelitis of pregnancy may be the means of avoiding serious, if not irreparable, damage to the kidney.

9. Pelvic drainage and lavage is of marked value, adding little, if any, risk when properly done.

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FAILURES AFTER GASTRO-ENTEROSTOMY TURNED TO SUCCESS BY THE KNOWLEDGE FURNISHED BY X-RAY EXAMINATION*

BY A. HOWARD PIRIE, M.D.

MONTREAL, CANADA

FROM time to time the operation known as gastro-enterostomy turns out a complete failure. The reason for its failure is not easily found. An excuse for the failure has been stated to be a vicious cycle; i.e., the food passes out at the opening and instead of going on towards the lower end of the bowel it returns to the stomach through the pylorus carrying bile with it, and soon after, the patient vomits and brings up bile. This is purely a theory and has no definite roentgen-ray observations to bear it out. A better explanation is that afforded by roentgenogram, when it is seen that the stomach does not empty itself, though it makes violent efforts to do so, and finally ends by rejecting all its contents. A little bile in the vomitus does not prove that there is a vicious cycle. One sees frequently during routine examination of the stomach the food forced through the pylorus and the cap filled up and this cap's contents pouring back into the stomach. In other cases one sees the food in the second part of the duodenum moving to and from the cap. It requires no stretch of the imagination to think that during the violent effort of vomiting some bile was forced out of the duodenum and into the stomach, which later was found present in the vomitus; and that thus a vicious cycle was inferred.

I have looked for the vicious cycle with x-rays and have never been able to see it. What I have seen, however, in cases of vomiting following gastro-enterostomy is that there is gastric delay and that vomiting is due to the stomach being unable to get rid of its contents any other way. I have never seen a case of vomiting where the gastro-enterostomy opening was near to the pylorus, but only in cases where the opening was far away from it. When one begins to examine a case of gastro-enterostomy one should sacrifice the plate for the information given by the screen. The main mass of useful information is obtained in the first thirty seconds after the patient swallows the barium. He is examined in the upright nostro-anterior direction. He comes with an empty stomach and no barium in the intestines. As soon as the barium reaches the gastro-enterostomy opening a little goes through and is seen entering the small intestine.

The patient is then at once turned to the left lateral position and the examination is continued, to note the position of the gastro-enterostomy opening from the side. It may be said to be an anterior or a posterior gastro-enterostomy by the surgeon, but it is usually very near the greater curvature when the patient comes for roentgen-ray examination.

In all cases whether successful or not, barium escapes almost at once. It may then continue to rush out, till, in about ten minutes, the stomach is empty. In such a case the stomach is practically functionless and assumes an appearance accordingly; that is, it is small and shrinks in size upward towards the cardiac end, so that the gastro-enterostomy opening becomes its most dependent part, and the stomach becomes practically a tube through which the food passes without gastric digestion. I have seen several such cases. One told me that he had gained seventy pounds after his operation, seven years before, that he was in perfect health and never felt as if he had a stomach. Too quick evacuation of stomach contents is no bar to digestion, as the small intestine can do the work.

Another form of successful case is that in which one sees the barium escaping quickly at first and later quite slowly. It seems that the gastro-enterostomy has a sphincter action and allows the food to escape at nearly the same rate as the py-

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lorus does. It should be distinctly understood that the food does not escape from the stomach by drainage, but only by tonus and peristalsis. If, therefore, there is a gaping gastro-enterostomy opening in the stomach and no peristalsis and no tonus, the stomach will not lose any of its contents any more than a rubber bottle with the cork out will lose its contents when turned upside down in a water bath. Barium would drain out, but the bulk of our food is lighter than water, therefore does not drain out of a stomach.

The third kind of gastro-enterostomy opening is that which at first lets the barium escape, then allows no more to pass. It is usually found too near the cardiac end of the stomach, so that the waves of peristalsis either do not reach it, or begin just at its location. This kind of case benefits from roentgen-ray examination. A description follows:

Case I. Female, brought to me in an ambulance, so weak she could hardly stand for examination. She had vomited after every meal for three months following the operation of gastro-enterostomy. She was wasted and pale. Having found out the exact position of the opening by seeing the first rush of barium through it as the drink descended to the lowest part of the stomach, having examined it anteroposteriorly and laterally, and seen that the opening was nearer the greater curvature and above the peristaltic part of the stomach, I told the patient to lie on her left side, and with much pleasure I saw the stomach begin to empty. She was instructed to lie on her left side for an hour after every meal. After about a week her husband came to me in delight to tell me that she had not vomited again. Three months after, she had vomited only twice; once when she had not followed instructions and once when she had been much worried by other causes.

Case II. Female, symptoms similar to those of Case I. To my disappointment I found that the food did not escape when she lay on her left side. While I watched her, thinking what to do next, she rolled over on her stomach pressing on a doubled blanket as she did so. At once there was a squirt of barium through the gastro-enterostomy opening. I made her do this time after time till the stomach was nearly empty. I then told her to lie on her left side after each meal, place a pad for herself on which to roll over, and continue to move as she had been doing on the x-ray table. The result was that she ceased vomiting from that moment, and grew strong and well. I heard from her after about six months and she was then in the best of health.

There is only one indication for gastro-enterostomy, namely, retention of food in the stomach for seven hours or more. The contraindication is a duodenal ulcer without obstruction, because the contents of the stomach prefer to go out through the pylorus when it is patent rather than through a gastro-enterostomy. A gastro-enterostomy does not close after it has been established. I have seen only one case which refused to allow barium to pass; but at operation it was found still patent, with adhesions so firm around it that nothing could pass it.

When a gastro-enterostomy opening is functioning well and the patient continues to have pain and no gastric delay, an ulcer at the opening should be suspected. Tenderness on pressure over the gastro-enterostomy tends to confirm the diagnosis. There is no sphincter developed in a gastro-enterostomy. It is the tonus of the stomach which produces an effect which simulates the presence of a sphincter.

There is little or no peristalsis seen when escape takes place freely through a gastro-enterostomy.

SUMMARY

1. Vomiting continuing for weeks after a gastro-enterostomy is usually due to retention of food in the stomach.

2. The gastric delay is due to the stoma being placed too far from the pyloric end.

3. Roentgen-ray examination not only may disclose the cause, but provide the remedy.

4. *First* case of vomiting after every meal for three months following gastro-enterostomy cured by lying on left side after meals. *Second* similar case cured by lying on left side and rolling over a pillow on stomach.

A STUDY OF RICKETS WITH REVIEW OF RECENT LITERATURE

BY ROY G. GILES, M.D.

X-Ray Department, Massachusetts General Hospital

BOSTON, MASSACHUSETTS

RICKETS is a chronic acquired disease, occurring most commonly during the first two years of life. Its etiology has not been established, but various hypotheses have been suggested to account for its occurrence. Among the causes suggested are a deficiency of fat, an excess of carbohydrates (or a combination of both), a deficiency of calcium, heredity, poor hygienic conditions, etc.

Howland[1] says, "It is roughly proportional to the density of the population and it seems directly dependent upon bad food, lack of fresh air, poor care and filth. The difference between the disease in the well-to-do and the poor is in its severity." Findlay[2] carried out rather extensive research into the conditions,—hygienic, dietetic, etc.—of actively rachitic and non-rachitic children belonging to the same social class. The most important observations in order of significance were improper housing, lack of facilities for fresh air and imperfect parental care. McKay's[3] observations confirm the general belief that rickets commonly occurs in children receiving a diet high in fat and low in carbohydrates. Howland thinks breast-feeding usually protects against severe rickets, though he has seen some of the most severe types in breast-fed negro babies. Artificial foods tend to produce the condition.

Winters[4] believes tuberculosis, syphilis, poor hygiene, etc. predispose but do not cause rickets. He says, "The sole essential factor that can cause rickets is food. Under the worst hygienic conditions, a child nursed exclusively by a healthy young mother never becomes rachitic." Pritchard[5] thinks that practically all varieties of malnutrition occurring during infancy and early childhood tend to terminate in rickets, provided they are sufficiently severe or long enough continued.

Braden-Birks[6] reports a case weighing 10 pounds and 7 ounces at 17 weeks having symptoms typical of rickets, in spite of the current belief that the disease does not occur so young.

Mellanby[7] in his recent investigations on puppies states that the probable cause of rickets is a diminished intake of anti-rachitic factor, which is either identical or somewhat similar to fat-soluble vitamin. A. Hess[8] does not believe that rickets can be caused merely by a deficiency of fat-soluble. A. Hess and Unger[9] say that "the fat-soluble vitamin is not the controlling influence; that infants develop rickets while receiving a full amount of the principle, and do not manifest signs although deprived of this vitamin for many months at the most vulnerable period of their life."

The recent experiments of Sherman and Pappenheimer[10] show that "on the particular diets used rickets uniformly appeared in the absence, and was uniformly prevented by the presence, of the added potassium phosphate, but this does not imply that in these cases the cause of rickets was necessarily a deficiency either of potassium or phosphorous."

McCollom[11] and his associates from their recent experiments with a series of faulty diets fed to rats say: "It seems possible to infer from our experiments that the development of rachitic-like changes in the rat, induced by diets deficient in fat-soluble A and the phosphate ion can be prevented by the addition to the diet of phosphate containing salts; and that conversely for rachitic changes to develop in the presence of a deficiency of fat-soluble A in the diet, the diet in other respects being optional, a low content of the phosphate ion is essential. The experiments indicate further that in the production of rachitic-like conditions in the rat, fat-soluble A cannot be the sole factor concerned . . . Studies on the effects of feeding cod liver oil to rachitic children have led to similar conclusions."

Most writers classify as early evidence of rickets such symptoms as sweating of the head, muscular weakness, laxity of ligaments, delayed dentition, spasmodic manifestations, tendency to catarrhs and the tossing of head from side to side, often rubbing the hair off the occiput. The flabbiness and softness of the skeletal muscles is most striking. The abdomen is often prominent. The child is pale and may have anemia of the secondary type.

According to MacCallum,[12] the epiphyses of the knees, ankles and wrists are much enlarged, and swelling occurs at the costochondral junction. Scoliosis, fractures and a peculiar flattening of the pelvis are due to a general softening of the bones. In normal bone, the outer surfaces of the line of ossification is sharp, even and narrow. In rickets it is replaced by a wide irregular band of rather gray translucent tissue. The enlargement of the epiphysis is due to sluggish ossification rather than to the excessive production of cartilage. The output of calcium in the feces during the florid stage is high while the proportion is lowered in the urine. Healing is preceded by a hyper-retention and a relative increase in the output of calcium in the urine. The proportions are normal after healing takes place. The deficiency of calcium is an important factor. Some deem it necessary to assume there are specific changes in the bone-forming tissues which make them unable to retain the calcium.

Fig. 1. Anteroposterior view showing scoliosis due to rickets.

Fig. 2. Lateral view showing scoliosis due to rickets.

Rickets probably affects all the tissues of the body but the chief pathological lesions are represented in the long bones. The normal bone consists of 63 parts of inorganic and 37 parts of organic matter. Winters[4] states that rachitic bone is composed of 79 parts of inorganic and 21 parts of organic material. Also that the specific gravity of rachitic bone is only $\frac{1}{7}$ to $\frac{1}{8}$ that of normal bone. He considers that "exuberance of cartilage cells and sparsely scattered islets are the anatomical signs of rickets."

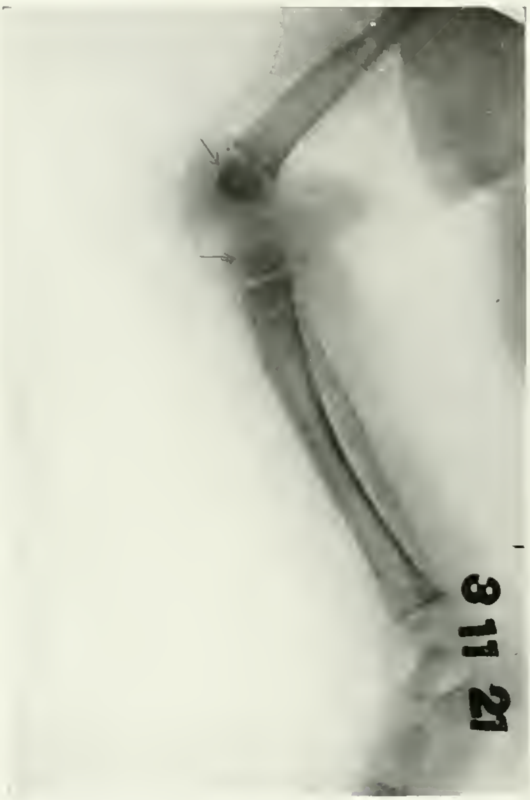

Fig. 3. Note the rather large shadow normally cast by the epiphyses before calcification has taken place.

Rickets shows itself in the skull by delayed ossification between the parietal and occipital bones. Many writers believe that craniotabes, which manifests itself as round spots of localized thinning in the skull, is an early symptom of rickets.

Elsasser[13] first published his observations on craniotabes in 1843. Schwartz[14] examined 4,944 infants of which number 734 (approximately 15 per cent) showed evidence of soft spots during the first months of life. After one year the number decreased regularly as the children grew older. Examination of 760 infants by Levinson[15] showed 162 with craniotabes (21 per cent). In his cases, there was no relation between craniotabes and the general condition of the infants, most of the children with craniotabes having been in good condition.

Fig. 4. Shows flaring and widening of the diaphyses, rather marked cupping of the epiphyses in rickets, and slight bowing of the shaft. A very large cartilage is seen, especially around the knee-joint.

Hatfield[16] believes rickets may be a very important causative factor in the development of malocclusion. Dentition is delayed and the deciduous teeth are lost early. There may be faulty development of bones of alveolar process, and of the bones of the mandible and maxilla.

In the thorax the enlargement of the costochondral junctions, the so-called "rachitic rosary," has long been recognized. Of 4,944 infants examined by Schwartz,[14] 35 per cent showed beading of the ribs, and 13 per cent of these during the first month. He believes practically all infants will show this condition if examined regularly during the first year. Hess and Unger[17] found that beading of the ribs occurs very often in cases of infantile scurvy, and disappears rapidly with the recession of the other symptoms, when an antiscorbutic food stuff is given. Park and Howland[18] have published observations on 22 negro babies showing marked evidence of rickets in the thorax as well as other parts of the skeleton. The manubrium is prominent and appears elevated, as does the whole chest. The deformities of the chest are often asymmetrical. The ribs were very soft and pliable in the autopsied cases. The forces bringing about the deformities they enumerate as follows: negative pressure existing during inspiration, elasticity of the lungs, the pull on the diaphragm, various voluntary muscles passing to the thorax from the abdomen and the neck, gravity and intra-abdominal pressure. These forces all work during inspiration, except gravity, and the normal thorax is able to overcome them. The lungs become small as a result of these deformities, and frequently atelectatic.

Fig. 5. Osteogenesis imperfecta. Note the greatly enlarged cartilage around the knee-joint below the femur and above the tibia. In addition to the fracture shown in the middle third of the femur, there was a total of ten fractures in the long bones in this case. There is some periosteal proliferation and evidence of callous formation about the fractures. The bones show diminution in density, apparently due to absence of lime salts. The epiphyses are widened and irregular.

Fig. 6. The bones are thin with rather coarse trabeculation. There is marked bowing of the shaft with thickening of the cortex on the concave side, and absence of periostitis. The epiphyses are widened and cupped with irregular, jagged edges. Cartilage is not visible.

The writers describe the roentgen-ray findings as characteristic. The ribs are slender, bent, porous and have lost their normal inclination and parallel arrangement. Fractures are difficult to demonstrate. Scoliosis is visible when present. The heart appears enlarged for the size of the chest. Longitudinal shadows are seen on both sides of the heart, with indefinite outlines, and are caused by the atelectatic lung beneath the costochondral junctions. The costochondral junctions cast shadows when healing begins, and take part in the formation of the longitudinal shadows. The lungs have an uneven, hazy appearance external to the longitudinal shadows caused by the scattered areas of atelectasis. The characteristic roentgen-ray findings are mistaken frequently for tuberculosis.

The spine may show deformities such as kyphosis and scoliosis which are detected easily when present. The pelvis may show thickening of the crista ilii, as well as narrowing of the pubic arch.

The lesions of rickets are probably best seen and studied in the extremities. The epiphyses of the lower end of the radius and ulna are often enlarged sufficiently to be apparent, and less often in the upper end of the bones and the humerus. The cartilaginous epiphysis of the knee is often prominent to palpation. The lower end of the tibia and fibula present quite characteristic changes. Enlargement of the femur is less frequent.

The most important changes are shown on the roentgenogram in the region of the epiphyseal line of the long bones and neighboring joints. The entire joint may be slightly swollen, hazy and cloudy. The limitation of motion, due to the painful joint, is partially responsible for slight atrophy occurring in the bone. Normally the diaphyseal end is smooth, clear-cut, sharp and narrow, while in rickets it spreads outward and its edges are irregular and jagged. The centers of ossification which normally should be readily seen are small and often absent. The process of ossification is delayed.

In reviewing a large number of plates we have observed that the epiphyses cast a shadow on the roentgenogram before calcification takes place. There is noted frequently an apparent increase in the size of the epiphyses as compared to the shaft end of the bone in rachitic conditions. We believe this shadow may be seen fairly constantly in plates of good quality, and may have some bearing on the diagnosis of rickets. These epiphyseal shadows are studied best in the knee joints.

There is often a white line extending transversely across the shaft, near the epiphysis, due to the deposit of calcium in the diaphyseal end of the bone as the result of proper treatment. The shafts of the long bones, more especially the lower extremities, are frequently bent, showing a thickening of the cortex on the concave side of the curve, whereas in syphilis the thickening is on the convex side.

Periostitis may be seen in rickets. The bones are weaker and more yielding, and deformities may be the result, such as knock-knees and bowlegs. Fractures may be incomplete and are single or multiple. Baetjer[19] has reported as many as 18 in a single case.

SUMMARY

Rickets is a chronic acquired disease occurring most commonly during the first two years. Many views have been advanced to account for its occurrence, among these, heredity, improper hygiene, infections of various natures, dietetic conditions, etc.

All the tissues in the body may be affected in rickets, but the principal pathological lesions are seen in the osseous tissues. The cranial bones may show changes in shape and delayed ossification. Scoliosis and kyphosis may be detected in the spine. Dentition may be delayed. Enlargement of the costochondral junction, the so-called "rachitic rosary," manifests itself in the chest. The ribs are bent, porous, slender and have lost their normal inclination and parallel arrangement. The lungs are frequently small and atelectatic. Periostitis may be seen. Fractures may be single or multiple, and are often incomplete. The cartilaginous epiphyses are enlarged and frequently show on the roentgenogram. The diaphyseal end of the shaft spreads outward and its edges are irregular and jagged. The most important changes radiographically are seen in the epiphyseal line of the long bones and neighboring joints.

In conclusion, I wish to thank Dr. George W. Holmes for his guidance and assistance in the preparation of this paper.

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HIGH TENSION ELECTRIC SHOCKS IN ROENTGENOLOGIC PRACTICE*

BY WILLIAM F. HEMLER, M.D.

Clinical Professor of Roentgenology, Georgetown University Medical and Dental Schools; Roentgenologist, Washington Asylum Hospital

WASHINGTON, D. C.

THE scientific installation of roentgen-ray apparatus, to provide safety as well as efficiency, is of utmost importance to roentgenologists and to patients alike. It is also of vital concern to hospital authorities and to architects who design buildings or rooms where such work is to be done.

In many roentgen-ray laboratories, including the offices of physicians and dentists who have roentgen-ray machines, there has been too little thought devoted to the study of safety. Simple and well known laws which govern electric currents have been overlooked or disregarded generally by the manufacturers and installers of apparatus and by roentgenologists themselves.

ACCIDENTS

Our report of accidents covers six cases. All were due to grounds. In two cases the operator was grounded through the low tension wires of a foot switch (in practically all foot switches on the market today, the distance between the low tension wires and the operator's foot is so short that high tension currents will easily spark across). In three cases a concrete floor furnished the ground and in one case the patient was grounded through a grounded metal table. The source of the high tension current in five cases was unguarded high tension wires or tube terminals; in the sixth case the current jumped across a defective Coolidge transformer. The high tension current would not have injured a single one of these persons however, if the apparatus had been properly installed to afford protection against grounds. Although none of these accidents were fatal, there were a number of fatal accidents throughout the country last year, as reports heralded broadcast by the newspapers indicate. A perfectly justifiable apprehension on the part of the public is the result.

REPORT OF CASES

Case I. The writer was personally shocked from a high tension current by being grounded through a *concrete floor*. An assistant closed the switch to test tube

* Read before the Medical Society of the District of Columbia, Oct. 19, 1921. Owing to the forthcoming report of the Committee on Safety, portions of this paper have been omitted as covered in that report.

readings, while the *high tension wires* were being adjusted. A severe shock and some painful burns were received, but as the duration of the shock was short the effects were not very serious.

Case II. In the service of a colleague, a 220 pound negro orderly approached too close to one of the *live terminals* of a transformer. He was standing on a *concrete floor* which furnished a ground. The shock he received caused the giant negro to crumple to the floor like a quivering leaf.

Case III. A patient was being given deep therapy with 9 inch gap and tube overhead, while lying on a *grounded metal table*. He moved and was sparked from one of the *tube terminals*. This made him squirm into closer contact with the live wire. Fiery flames shot into his body from the tube terminal and inspired an awe, never to be forgotten. A clean cut hole was burned through a thick leaded rubber which was being used over him as protection against the roentgen rays.

Case IV. At another time the writer accidentally came within sparking distance of a *high tension wire* while using a *foot switch*. The shock which resulted was felt for the most part in the leg resting on the foot switch. This foot switch was similar to those in general use, the low tension service wires being within sparking distance of the operator's foot. Thus low tension wires are excellent grounds for high tension currents and the foot switch was the cause of this accident.

Case V. "Dr. F. V. M., was severely shocked through a *concrete floor* ground by the high tension current *breaking* across the *Coolidge transformer* to the Coolidge service wires. The doctor grasped hold of the service cable of this line to disconnect it as he saw the insulation burning. The high tension current then short circuited through his body to the concrete. He fell to the floor still holding the cable as he was unable to release it It was several minutes before a nurse arrived who turned off the main switch. The doctor received numerous third degree burns on his back and hand from sparks to the concrete and to the cable which he was grasping" (Rohrer).

Case VI. "Dr. S. C. was using a horizontal *metal fluoroscope* with a *foot switch*. An anesthetist was leaning over the metal fluoroscope and brought his leg into contact with the *high tension wires* beneath. The current passed through the body of the anesthetist to the table, then to the hand of the roentgen operator by way of the shutter levers and through his body to ground by way of the foot switch. Both men were thrown to the floor unconscious, but the circuit was broken by their fall and the shock was thus of very short duration and both men recovered" (Rohrer).

EXPERIMENTS

Our experiments were performed on young dogs and are presented herewith in tabulated form. In each experiment a dog was attached to one or both of the high tension lines. Ordinary insulated lamp cord was wrapped about him so as to form the necessary collar, belt or anklet electrodes. We used a 10 kilowatt transformer with both terminals developed, the secondary windings being grounded in the middle. A kilovolt meter and milliammeter were in circuit. There was a rectifying disk delivering unidirectional current to a Coolidge tube, a control consisting of a rheostat of twenty steps and an inductance selector of six steps. The range of voltage with rheostat out was from 40,000 to 100,000 volts corresponding to a spark gap of from three to nine inches.

In the *first* series of experiments the *dog was insulated* from all grounds and from the opposite terminal and his collar electrode was attached to either one of the high tension lines, first to the positive and then to the negative. In spite of the fact that his collar was charged with as much as 50,000 volts, he remained unharmed and comfortable throughout all of the experiments of this series. Thus coming in contact with one high tension line will not injure a patient if he is properly protected from grounds and from the opposite terminal. (See tabulated Exp. 1 and 2.)

In the *second* series the *dog was grounded* and at the same time attached to one or the other high tension line. He was grounded by being placed either on concrete or on grounded metal. In Experiments 3 and 13 the dog was separated from the grounded metal table by about 2 inches of wood; at 9 inch gap the current burned a hole through the wood just as clean cut as though bored with a gimlet. In these and every other experiment of the series the dog was severely shocked or burned. (See tabulated Exp. 4 and 5.)

In the *third* series the body of the *dog formed a short circuit between the two high tension wires or the two terminals of a Coolidge tube*. The effects were even more severe than in the second or ground series. Grounding a dog that is being shocked between two terminals (Exp. 12) seems to lessen somewhat the severity of the shock, but nevertheless the dog is severely injured. (See tabulated Exp. 6 to 14.)

DEDUCTIONS

From the foregoing accidents and experiments and from the literature, we obtain many interesting and important data concerning the effects of high tension currents on animals, the sources of danger, and remedial measures which should be adopted.

EFFECTS ON ANIMALS

Heart and Respiration. Prevost and Batelli experimented broadly to determine the effects of electric currents upon the living animal. They state, "currents of sufficient amperage and of voltages measured in hundreds kill by cardiac fibrillation, voltages in thousands kill by respiratory paralysis." Our experiments show that currents sufficient to be of any use in *x*-ray work cause respiratory paralysis which lasts for nearly a minute after the current has been removed.

Current Time, Asphyxiation, Burns. In lethal electrocutions currents of about ten amperes at 2,000 volts cause respiratory paralysis and the current must be continued for seven to ten minutes. In other words *death is by asphyxiation* and the current must be continued until the heart stops beating. As the currents used in roentgen-ray work cause respiratory paralysis they will cause death if they are continued long enough. Current time is an important factor also in the *severity of burns* inflicted. A current lasting less than one second does not burn the animal appreciably even with all of the amperage and voltage which the transformer is capable of delivering under the conditions of our experiments (Exp. 11, 12 and 13); the respirations may be stopped, however, with currents of even less than one second duration (Exp. 13). In two seconds some burns were inflicted especially by the negative electrode, in ten seconds quite severe burns (Exp. 9), and in thirty seconds very severe burns indeed, even with the smallest amount of current which the transformer is capable of delivering—currents too weak to be of any use whatever in roentgen-ray work (Exp. 14).

Burns are produced, partly no doubt by contact of the skin with the superheated gases of the spark gap, partly by the resistance of the tissues to the current flow but chiefly by chemical action. Burns at the negative electrode, in the line attached to the filament end of the Coolidge tube, bleed freely and this is generally recognized to be due to alkaline action; burns at the positive electrode are charred and dry and do not bleed on account of the presence of acid.

Remote Effects on the Tissues. Tousey cities the case of a lineman who short-circuited two live wires carrying 5,000 volts at high amperage. The workman was not killed instantly but was severely burned and died about a week later. One of our dogs (Exp. 13) was shocked in every conceivable way and with all strengths of current within range of the transformer, but in no case for more than one second. He was not burned but was rendered breathless a number of times, yet he soon recovered and is now as healthy as any of the other pups of the litter that were not subjected to the experiments. Most experimenters believe that there is some form of tissue disorganization, but do not attempt to specify the nature of the changes, except the collection of acid and alkali at the opposite electrodes.

Effects Depending on Position of Electrode. When the electrodes are applied to the neck and body the effects are more severe (Exp. 6, 7, 9, 10) than when applied to the ankles (Exp. 8). The strongest

EFFECTS ON DOGS, FROM HIGH TENSION ELECTRIC CURRENTS USED IN ROENTGENOLOGIC PRACTICE

Series No.	(1) Dog Insulated		(2) Dog Grounded			(3) Dog Forming Short Circuit Between Two High Tension Lines								
Experiment No	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Position of dog														
From grounds														
Insulated from grounds by air, inches	10	10	wood 2″	..	.	10	10	..	10	10	10	..	2 to 10	10
Grounded on metal	..	..	..	..	.	..	...	yes	...	..	...	yes	yes	..
Grounded on concrete	..	..	..	yes	yes		....	....	.	....	....	....	yes	..
Electrodes														
A = anklet, B = belt, C = collar, P = positive, N = negative.	PC	NC	PC	PC	NC	PC & NB	PC & NB	PA & NA	PC & NB	PC & NB	PC & NB	PC & NB	All	PC & NB
Switch settings														
Rheostat button No. (total 20)	0	0	0	5	10	5	10	9	10	5	20	10	5 to 20	2
Inductance button No. (total 6)	6	6	6	1	1	1	1	6	2	5	3	2	1 to 6	1
Readings														
Gap, inches, normal Coolidge tube in circuit	0	0	0	3	3	3	3	0	4.5	8.5	5.5	4.5	3 to 0	2
Milliamperes, normal tube in circuit	5	5	5	5	30	5	30	5	35	5	40	35	5 to 40	5
Gap, inches, dog plus tube in parallel circuit	0	0	0	0	0	0	0	0	0	0	2	0	0 to 2	0
Dog, milliamperes (limit of meter 150)	5	5	?	?	?	90	150+	150+	150+	100	150+	150+	150+	?
Duration of current, seconds	30	30	2	1	3	3	2	2	10	6	$\frac{1}{2}$	1	$\frac{1}{2}$	30
Effects upon dog														
Harmed, yes or no	0	0	yes	yes	yes	yes	yes	yes	yes ++	yes	yes	yes	yes	yes much +
Breathless, seconds	0	0	30	0	40	30	35	0	40	40	0	0	0 to 40	0
Unable to crawl, minutes	0	0	3	0	5	3	4	0	5	5	0	0	0 to 5	0
Burns, at positive electrode	0	..	sl.	0	..	0	0	0	sl.	sl. bad	0	0	0	yes bad
Burns, at negative electrode	..	0	..	..	sl.	sl.	sl.	sl.	yes	yes	0	0	0	very

currents applied to the ankles did not cause respiratory paralysis, but they were of short duration—two seconds.

SOURCE OF ELECTRICAL DANGERS

Martin states that "currents of high voltage and high amperage are always dangerous; currents of high voltage but low amperage are not necessarily fatal unless the subject forms a *short circuit to ground or between two high tension wires.*" Currents used in roentgen-ray work are of very high voltage, but of amperage measured in thousandths of an ampere—very low. Accordingly the source of high tension dangers in roentgenologic practice are: (1) grounds and (2) unguarded wires and tube terminals.

Grounds. The problem of grounds and how to avoid them is not as simple as one might suppose. It requires a consideration of not only what will happen when everything goes right, but also what mistakes the operator is liable to make, what movements it is possible for the patient to make, and what accidents may happen to the apparatus to cause a charging of low tension wires, switch handles and metal apparatus with high tension currents.

Purposeful Grounding of Apparatus. Many roentgenologists purposely ground detached overhead tube stands, fluoroscopes, switch control boxes and even metal tables. This is done to get rid of annoying static sparks and to deflect the high tension current to earth in case it becomes short circuited to the metal of the equipment. It must not be forgotten however that the high tension current may jump directly from wire or tube terminal to the patient or operator. Now if it is possible for a person so charged to come in contact with grounded metal all conditions will be fulfilled for him to receive a dangerous—perhaps fatal—shock. Such static sparks are never dangerous and the charging of metal equipment will do no harm as long as there is no possibility of completing the circuit.

Other Dangerous Grounds. In such a list there should be included radiators, heating and water pipes, electric conduits; electric light wires (in spite of the small amount of insulation around them) including *cable drop switches* for dim lights or other purpose; *all foot switches and their cables*, and transformer supply cables crossing the floor; in a word, all low tension wires and all grounded metal constitute conductors for high tension currents.

Concrete Floors as Grounds. It has been loosely claimed that dry concrete is not a good conductor. It has been our sad experience that concrete laid on the ground is an excellent conductor even when (apparently) perfectly dry. The floor where our experiments were performed is so dry that it is always very dusty. Yet a dog standing on this floor was shocked just as severely as if grounded on metal connected to the water pipe. Concrete floors above the first floor, are reinforced with metal; so the only safe rule is to consider all concrete a dangerous ground.

Tousey calls attention to the extreme danger from even small currents, when the subject is well grounded. He cites the numerous instances of persons being killed while taking a bath, if while immersed in the water, they catch hold of the lamp socket with wet hands and thus ground an ordinary 110 volt lighting current. During last summer two fatal accidents of this kind were reported in the newspapers. I have before me one of these reports. A girl of City Island attempted to fasten a bulb into a lamp socket in the basement of her home. She had just come from a swim. The water was dripping from her bathing suit and formed a pool on the concrete about her feet. Her dripping hands short-circuited the current to her body and she received a shock which proved fatal (as "low tension currents act upon the heart").

INSULATION

Guards Around High Tension Lines and Grounded Conductors. It should be made impossible for any person in the roentgen-ray room to come in contact with or approach within sparking distance of any high tension wire or tube terminal, or any grounded conductor including radiators, pipes, electric conduits, wires or switches. Guards should be built about such dangers. The guards should be made of wood, fibre or other non-conductor. The air insulation thus obtained should always be more than the full sparking to ground capacity of the machine in use and not merely that for the work being done. For all radiographic machines, six inches is a safe air distance. Notwithstanding the fact that under ideal conditions an insulated person may touch one live wire without danger of serious injury, the likelihood of the circuit being accidentally completed is too great to take a chance. In any case a spark is received by a person until the potential of his body is equalized with that of the high potential source.

We find on the market today shielding screens of metal mesh, which are to be grounded and placed between the patient and the high tension wires. These constitute grounds, however, and as such are potential dangers in the same ways as other grounds. Most of the apparatus as made and installed today presents innumerable traps with circuits complete for high tension currents except at one place. The body of the operator or patient or a piece of stray metal furnishes the needed link, and a dangerous accident results.

CONCLUSIONS

The sources of high tension electric dangers are:

1. Concrete floors in roentgen-ray exposure rooms.

2. Metal tables, tubestands, fluoroscopes, or switch cabinets within sparking distance of anyone who might approach high tension currents, especially if such apparatus is or may become grounded.

3. Any grounded conductor within the room or under the floor unless guarded. This includes all low tension wires, cables to main or Coolidge transformers, foot switches, swinging cables of light switches, all wires of lighting system or wires for any purpose, and radiators, pipes and conduits.

4. Unguarded high tension lines and tube terminals.

The writer wishes to take this opportunity to thank Dr. C. A. Pfender, Professor of Roentgenology at Georgetown University, for kindly advice and assistance; also Dr. J. A. Gannon and Maj. W. Patterson of the Washington Asylum Hospital for the facilities afforded to do this work.

A NEW APPARATUS

BY CHARLES M. MING, M.D.

OKMULGEE, OMAHA

THE accompanying illustration depicts an immobilizing device designed by myself and found to be most satisfactory for complete fixation of the head in roentgenographic work.

The apparatus consists of a heavy flat iron bar which is bent to form a right angle at one end. To the other end there is affixed an adjustable clamp. This is secured with a winged nut. When clamped into place the bar is quite rigid. The headrest is attached by means of a bolt inserted into a hole which has been drilled in the center of the bar.

My apparatus is fitted on a Victor Potter Bucky diaphragm using a Kelley-Koett headpiece. Straps, rubber bags, etc. are thus eliminated and the cone need not touch the head.

Bag compression can be used if desired.

STANDARDIZATION OF THE MEASUREMENT OF TUBE POTENTIAL*

BY FRANK RIEBER

SAN FRANCISCO, CALIFORNIA

IN measuring the radiation given off from an *x*-ray tube we can do one of two things. We can measure what comes out of the tube in the form of *x*-rays. Or we can measure what we put into the tube, in the form of electricity, and then, from our experience with this tube, we can *predict* or estimate what is coming out of the tube in the form of rays.

The first method—that of measuring the rays themselves—was at first tried in various forms with pastilles, radiometers, and other measuring instruments. The Coolidge tube had not been introduced for therapeutic purposes at this time, and the gas tubes which were used were extremely unstable.

The various radiometer measurements did not check accurately in all cases with the therapeutic results. Their use was continued only because it was so thoroughly difficult to maintain a gas tube in constant operation long enough to make a measurement of the electrical energy being put in.

The advent of the Coolidge tube has resulted in a great decrease in the use of direct methods of measuring the rays. We can now set the electrical input at any desired value, and maintain it there indefinitely to as great a degree of accuracy as we may require.

It has therefore become very much more convenient to refer to radiation in terms of the milliampères passing through the tube, and of the potential or voltage impressed across the tube.

It must not be forgotten, however, that the choice of this method is one of *convenience*, and we must expect to sacrifice a certain degree of accuracy in determining the quantity and quality of our radiation when we use such measurements.

When we speak of input in terms of milliampères and kilovolts, or, as is more frequently done, milliampères and parallel spark gaps, we are defining two characteristics of the electrical energy we are putting into the tube.

If we are applying electricity to the tube in the form of a definite and *constant* potential, giving rise to a definite and constant current flow, the input to the tube becomes a simple electrical quantity and can be defined in terms of its two dimensions—potential and current.

If, however, we do not excite the *x*-ray tube at a definite and constant electrical potential, we make it impossible to define the electrical energy which we put into the tube accurately with *two dimensions only*. For example, an *x*-ray tube excited by a pulsating current is not excited at any one potential only. At some time during the pulse the tube has impressed on it every possible value of potential from zero to the very maximum or crest value.

In other words, where the electrical energy applied to the tube is pulsating, we are forced to deal with three factors if we wish to describe the energy we are putting into the tube. These three factors are potential, current and *wave form*.

So far we have merely predicted what *might happen*. As a practical matter, we often find instances of two machines which, if they are both operated at the same spark gap and the same milliamperage, will produce entirely different results from the same *x*-ray tube.

There are only two possible explanations for this discrepancy. Let us deal with the first and dispose of it. It might be that the measuring instruments on one machine, namely, the milliammeter and spark gap, do not coincide in reading with the measuring instruments on the second machine.

We can easily check up this factor by taking the identical milliammeter and spark gap we used for measurements on

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 26–28, 1922.

the first machine, and transferring them to the second machine. We can also use the *same tube*, ruling out possible changes from this source.

If now we deliver to the tube from the second machine the same milliampèrage at the same parallel spark gap that we used on the first machine, and if we then find that the radiation obtained with the second machine differs remarkably from that obtained with the first machine, we can assume that *something else* which we *have not measured* has caused this difference in radiation.

As a practical matter, this test has been performed a number of times by different people. In many cases, they have established the fact that the two machines in question, for some reason, produce different radiation from the *x*-ray tube when the electrical energy as measured by the spark gap and milliammeter was identical and in some cases the radiation was delivered from the identical *x*-ray tube.

The explanation for this difference that has ordinarily been given is that the two machines delivered a different "wave form." This explanation is undoubtedly correct, but until we understand exactly what we mean by different wave forms, and until we understand fully the magnitude of the possible errors that may be caused by such differences, we are in danger of making grave errors when we use milliampères and spark gap as a universal measure of *x*-rays.

If we were putting uniform direct current into an *x*-ray tube, the whole matter would be simple. We know what direct current will do under certain conditions to a fair degree of accuracy.

For example, we know that a tube excited on direct current gives off rays which vary in intensity in direct proportion to the milliampères passing through the tube.

We further know that the quantity of radiation *is not* related in *direct ratio* to the voltage or spark gap. If we apply double the potential or spark gap to a tube, we will much more than double the quantity of radiation which leaves the tube, and we will increase its penetrative ability as well.

As we have said, the use of direct current on a tube would greatly simplify matters. We could be perfectly sure that with the same milliampèrage and the same potential or spark gap, we would get the same results. Direct current is a simple quantity and can be measured in terms of the two dimensions of current and potential. It has no possible third variable factor which could exert an influence on the tube.

When we come to excite an *x*-ray tube from any of the ordinary *x*-ray machines, however, we get into a very different problem. The electrical pressure or potential delivered from one of these machines comes in a series of pulsations. That is to say, we are not applying a steady pressure to the tube all of the time, but, at intermittent intervals, we are applying a pressure which gradually rises from zero to a maximum and then gradually sinks again to zero.

If we were able to take a large number of very rapid successive measurements of the potential in a single such pulse, while it was rising from zero and falling again to zero, we could then plot these measurements and get a curve in which the ordinates would represent potential and the abscissae would represent time.

We can readily take a record of pulsating potentials of this nature with the oscillograph. However, with the potential and current used in exciting an *x*-ray tube in therapy, oscillograms of this nature are not made without extreme difficulty. It is certainly not a practical matter to use an oscillograph in an *x*-ray laboratory for standardizing apparatus.

Let us therefore confine ourselves to considering what probably happens when such a pulsation of potential is applied to the *x*-ray tube. Let us further consider what, if anything, we can find out about such a pulsation with a milliammeter and a "spark gap" or a milliammeter and a spark meter.

It will simplify the discussion to dispose first of the milliammeter. When a pulse of potential of the type we have mentioned is applied to an *x*-ray tube, it causes a corresponding pulse of current to flow through the *x*-ray tube. We know that the milliammeter gives us a measurement of the combined effects of all the varying values of current which go to make up such a current pulse.

We know further that the quantity of x-ray is rather closely dependent on the milliampèrage flowing through the tube. We can therefore be reasonably sure that the total milliampèrage passed through the tube represents quite accurately the total radiation delivered from the tube. This holds true, of course, if other conditions such as wave form and potential remain equal.

We can now narrow our attention to measurements of the potential applied to the tube, as this seems to be tied up in some way with the observed discrepancies between different machines, and between the results of the same machine with different settings.

Considering first the spark gap measurement, and the kilovolt meter or spark meter measurements, let us see what they really tell us about the pulsating potential we are applying to the tube.

The spark gap tells us *only one thing*, namely, the *maximum value* to which this potential rises. A measurement made with the spark gap is like measuring the pressure of steam in a boiler with a safety valve. If the safety value is set to blow at 100 lbs., the steam pressure can be 70, 80, 95, 99 lbs. or any other value less than a hundred pounds, and the safety valve will tell us nothing about it. But if the pressure ever exceeds 100 lbs. even momentarily, the safety valve will operate.

This is the function of the spark gap. All it can tell us is that at some part of each potential pulse, the potential reaches a value sufficient to break across the gap. It cannot tell us *how long* the potential stays at such a value. Further, it cannot tell us what the potential was doing during all of the rest of the pulse.

We might have had, for example, a very low potential during the entire duration of the pulse, and that potential might have shot up for a very brief instant to a value sufficient to break across the gap. The x-rays delivered from the tube when it was acted upon by this pulse would most of them have been generated when the potential was at a fairly low value. Very few x-rays might have been generated during the brief time when the potential shot up to a high value and discharged across the gap.

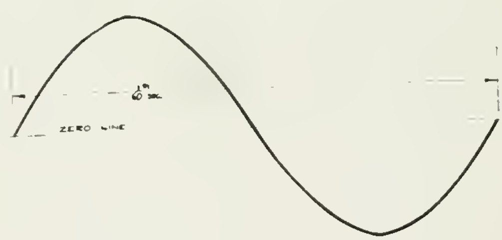
Nevertheless, if we trust the spark gap under these conditions, and assume that the value of the potential applied to the tube is fairly represented by the sparking distance of the gap, we may over-estimate the radiation from the x-ray tube by two or three times.

The kilovolt meter, or spark gap meter, on the other hand, measures an *entirely different thing*. It gives us the *mean effective value* of all of the potentials in a pulse. In this respect, it corresponds to the milliammeter.

The kilovolt meter would be a very beautiful means of determining the combined effects of all of the potentials existing in a pulse, *provided* the radiation from the tube varied directly with the potential. But unfortunately, the higher potentials have a much greater power to produce radiation than the lower potentials. And the kilovolt meter is unable to tell us anything about *what proportion* of the total pulse consists of fairly high potentials. It can merely give us the combined effects of all of them.

A simple illustration will make this matter very much clearer.

To facilitate an explanation of what wave form is, and why it effects the production of x-rays, a few illustrations are given.



COMPLETE CYCLE OF SINE-WAVE ALTERNATING POTENTIAL REPRODUCED FOR REFERENCE

1

These illustrations are *not* taken from actual oscillograms of alternating current. They are merely sketched to illustrate the effects of certain changes. In some cases the actual magnitude of these changes has been exaggerated in the drawing in order to make the explanation more obvious.

Referring to Figure 1, we have here a

sine wave of alternating potential reproduced for reference. The meaning of this curve is so generally known that it need not be dwelt upon in detail here. It merely shows a potential or electrical pressure which increases from zero to a maximum and then decreases to zero in a smooth and regular fashion, subsequently reversing its direction and increasing to a negative maximum, and then again decreasing to zero. Such a complete curve, consisting of a smooth pulsation of potential in one direction followed by a smooth potential pulsation in a reverse direction, is called a cycle of alternating potential. Sixty cycle current—the most widely used commercial frequency—employs sixty of these complete cycles of potential in each second.

Referring to Figure 2, we have a sketch showing what probably happens to such a

FOUR ARM RECTIFIER IN CLOSE ADJUSTMENT WITH AUTOTRANSFORMER CONTROL

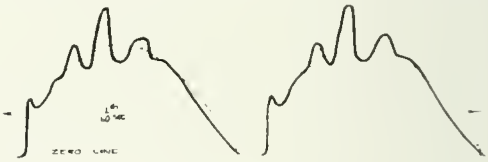
2

sine wave of potential when it is passed through a transformer and a synchronous rectifier having long arcs of contact.

It will be observed that both pulsations are in the same direction. The first function of the rectifier, therefore is seen to be a reversal of every other half cycle of potential, so that all of the pulses are passed out in the same direction. Looking at Figure 2 more closely, however, we see that these pulses of potential are *not accurate reproductions* of the sine wave form, which is dotted into the drawing for reference. The reason for this is that the rectifier does not make contact during *all of the wave.*

In other words, the potential delivered by the transformer rises somewhat above the zero value before the rectifier permits the current to flow out through the tube. After this current has started to flow, however, it continues to do so smoothly and evenly until the rectifier has rotated through the entire arc of contact, and attempts to interrupt the circuit. At this point the tube potential will be seen to drop off below the true sine values. This is due to the fact that the electricity is now transmitted over a considerable distance in the air in the form of a spark, in the rectifier, and this spark does not conduct electricity very well. Consequently the potential drops more rapidly than it would have if there had been a good conducted path.

Turning now to Figure 3, we see in somewhat exaggerated form the effect of



FOUR ARM RECTIFIER WITH TOO MUCH CLEARANCE

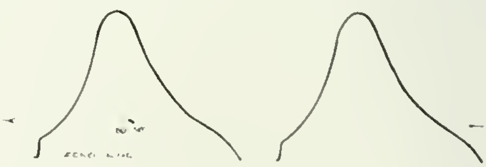
3

poor adjustment in a similar rectifier. If the rotating arms do not come very close to the stationary arcs of contact of such a rectifier, the electrical current is forced to pass across a relatively long air gap at all parts of the cycle, in the form of electric spark or arc.

Such a spark is a very unstable affair. If the tube is drawing a *large amount* of current, it will conduct it fairly well. If the tube is drawing a *small current,* on the other hand, it will conduct it with great difficulty.

As a general thing, a long sparking path of this type predisposes an electrical circuit to *surges,* or transient and rapid vibrations of electric potential above and below the smooth normal contour of the fundamental sine wave.

Turning to Figure 4, we see what happens if we employ a four arm rectifier,



FOUR ARM RECTIFIER IN CLOSE ADJUSTMENT WITH RHEOSTAT CONTROL

4

of the same type illustrated in Figure 2, but with a rheostat control instead of an auto transformer control. (It is assumed that both machines are operating Coolidge tubes.) The apparent resistance of a Coolidge to a high potential discharge cannot be expressed in simple terms. The higher the potential, the higher the resistance of such a tube to the passage of current. The result is a deformation of the smooth wave form into approximately the shape illustrated.

Let us turn now from the four arm type of rectifier (or, for that matter, any rectifier employing a long arc of contact) to the customary disc type, where the contact is made abruptly during a small portion of the highest part of the potential wave.

Figure 5 gives an idea of the performance of such a rectifier operating a Coolidge

DISC RECTIFIER WITH RHEOSTAT CONTROL

5

tube on a rheostat controlled machine. The shape of the wave form illustrated is due partly to the short arc of contact, partly to the combined effect of the Coolidge tube and the rheostat control, and partly to the surges excited by the abrupt making and breaking of the circuit when in a condition of stress.

Regarding *surges*, there is probably no better way of illustrating their presence than to refer to two commonly observed phenomena. If the operator of an *x*-ray machine closes his exposure switch, thereby passing a moderate current through his tube, and then gradually shuts down his spark gap, a spark will eventually result. The length of this spark is commonly taken as a measure of the potential applied to the tube.

If now, this gap is opened to a point where it will not spark while the tube is running, it *may be made* to pass, at will, merely by opening and closing the exposure switch. Whenever we close this switch, we throw current *abruptly* into the circuit, and create a surge, or "whip-crack" effect which temporarily increases the potential to a point where it will pass across the spark gap.

Another common observation indicating the presence of these transient potentials is the fact that when operating a rheostat controlled machine at a light load, the spark gap will, when gradually closed, flash over with a light scattering discharge. When approached more closely, this discharge becomes an arc or flame, which is generally regarded as the *true* measure of the applied potential.

This simple test is sufficient to show, that, even with a crude instrument like the spark gap, there are *two* observable values of tube potential. The question can be logically raised—*which of these values* shall we take to measure the *x*-ray, and why?

Having thus described a few of the many possible changes in wave form, let us now consider the instruments we have at our disposal for making measurements of potential, and *exactly* what each of these instruments tells us about this potential.

The spark gap is entitled to first consideration—largely on account of its age, and its long and faithful service in the cause. While it is a convenient measurement, we must not forget that an "inch of spark gap" does not really *define* an actual value of potential.

Four inches on one spark gap may mean the same potential that $4\frac{1}{2}$ *inches* mean on a slightly different spark gap.

A 4 inch spark gap measured on a machine in New York may denote an entirely different value of *potential* than 4 inches measured on the same machine after it has been transported to the mountains of Colorado.

Moreover, a 4 inch spark gap on a *dry day* may mean something quite different from four inches of spark gap when the air is saturated with fog.

In other words, our well-known and widely-used unit of potential is no more to be trusted for accuracy than a tape measure made of rubber elastic.

These vagaries are merely mentioned in passing. They cannot be avoided as long as the spark gap is used as a standard of measurement.

It is the intention of this paper, however, to deal with other factors affecting the spark gap as a means for measurement, and more closely related in the construction of the *x*-ray machine itself, rather than to external conditions.

A spark gap is presumed to measure the very *highest* value to which the potential rises during any single pulse. Below such values the air between the terminals of the spark gap is an insulator. Above this critical value, the air is "broken down" and the spark passes.

We have two forms of spark gap about which something is known, and which we can use approximately for measuring potentials. The first of these is the "point gap"—in practically universal use, but without any standard specifications for its construction.

The second of these is the "sphere gap," more recently adopted as the standard of potential in engineering work. The relative dimensions of these two gaps, and tables for their use will be given later.

There is one other commonly used method of measuring tube potential, namely, a *volt meter* connected to primary or secondary winding of the transformer, and furnished with various calibrations. Various of these were calibrated in the familiar units "inches of spark gap." Later, some of them have been furnished calibrated in *kilovolts*, in conformity with standard engineering practice for defining higher voltages.

Such a meter does not actually measure the *maximum value* to which the potential rises. It measures instead the *average value* of potentials in the entire pulse, taken as a whole.

Now, as we have seen, we are delivering from our *x*-ray machine a series of pulsating potentials. These potentials may assume almost any wave shape. There is no constant relation which can be established between the maximum value of any pulse and the average effective value of that pulse.

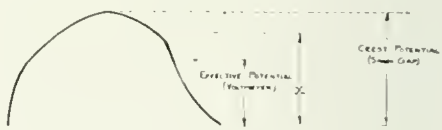
In other words, it would be very strange if there was any constant relation between readings of a spark gap and the readings of a kilovolt meter or a spark gap meter when used on different machines, or even when used on the same machine under different conditions.

The actual "*functioning potential*"—in other words, the particular potential in any pulse which is most effective in producing a quantity of *x*-rays—is unquestionably *lower* than the *maximum* value in any pulse, as determined by a spark gap. This effective "*functioning potential*" is also unquestionably higher than the *mean effective* potential as determined on a kilovolt meter or spark gap meter.

In other words, what we wish to find out with regard to the potential of a pulse is this effective "*functioning potential*" which we know to have a value somewhere between a volt meter reading and a spark gap reading.

And if we must choose between the volt meter and the spark gap as a means of measurement, it is desirable to know which of the two most closely approximate this effective potential.

To illustrate this more in detail, Figures 6, 7, 8 and 9 are given, showing the



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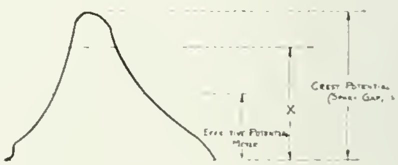

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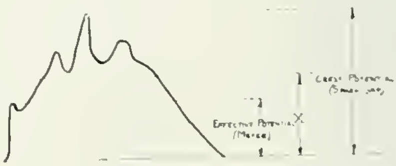


8

approximate values of volt meter and spark gap potentials in the four types of wave considered and also showing the probable value of potential which would most closely describe or define the radiation coming from the tube.

The reason this potential is always less than in the *maximum potential* and bears no definite relation to it, is that this *maximum potential* is often—especially in the case of machines with short arcs of contact or poor adjustment—very transient in its nature. And the shorter such a pulse is, the less time it has to produce *x*-rays. It is possible for such a surge to be so short that the rays produced by it are negligible in proportion to the rays from the rest of the waves.

The reason that the effective "*functioning potential*" is higher than the effective potential shown on a meter is this. The lower values of potential affect the meter, but produce practically no *x*-rays, while the *higher* values of the potential affect the meter only in proportion to their magnitude, whereas the *quantity of x-rays* produced at these values increases *very greatly*.

Referring to Figure 9 it will be seen that two values are given for crest potential,

9

one value being obtained by sphere gap and the other by point gap.

This fact deserves considerable comment. The sphere gap has been advocated at times as a possible standard for use in *x*-ray work.[1] It has even been advocated as a substitute for the point gap, on the grounds that it would give greater accuracy of results.

A sphere gap is extremely sensitive to very brief transient potentials or surges. A point gap is much less so, on account of the ability of the latter to absorb a very considerable amount of electrical energy existing in such a pulse by dissipating it as corona or brush discharge.

The sphere gap has no such safe outlet for brief high values of potential. It *must* get rid of the energy by sparking across—there is no other way.

This fact has been recognized and commented on by Coolidge and others.[2]

From the foregoing, we can conclude that if we are to define the output of an *x*-ray tube in terms of the milliampèrage passed through the tube, and the potential applied to the tube, we will have to do approximately this. We will have to devise an instrument or a measuring system which can be attached to our *x*-ray machine, and which will indicate for any applied pulsating potential, a value *less* than the *absolute maximum*, but *greater* than the *average value* indicated by a volt meter.

We can further state that for most wave forms, such a measurement would be fairly satisfactory if we could measure the *effective* or *sustained* value of the crest, at the same time *disregarding* any extremely *brief* surges or transient potentials which might be superimposed on the main wave form.

The accompanying diagram and illustrations describe an instrument which has been devised for this purpose. Briefly, its action consists in passing the pulsating primary current applied to the high tension transformer through a small rectifier and charging a condenser to the maximum potential of this current.

The condenser will then assume a value fairly accurately *proportional* to the maximum potential applied to the tube.

To prevent any brief transient surges from passing through this rectifier and reaching the condenser, a small reactance is placed in series with the leads to the condenser.

A direct current volt meter is then connected across the terminals of the condenser and used to indicate the effective current value to which the condenser has been charged.

On the assumption that this instrument would give fairly useful readings when applied to various *x*-ray machines, a number of tests were conducted. The results of

[1] W. D. Coolidge. A Summary of physical investigation work in progress on tubes and accessories. Am. J. Roentgenol., December, 1915, ii, 881.

[2] W. D. Coolidge. The radiator type of tube. Am. J. Roentgenol., April, 1919, vi, 175.

these tests are illustrated herewith in graphic form.

Figure 10 shows the calibration of the spark gap used. The source of electrical energy for this experiment was a machine making actual metallic contact during 85 electrical degrees—in other words, practically a pure pulsating sine wave form.

The A. I. E. E. specification sphere gaps were used, and the maximum spark potential which has been adopted for use with them was taken as a standard.

The point curve *must not* be confused in any way with another "standard" which is occasionally referred to in the literature, namely, the "*needle point gap*" formerly used by the A. I. E. E. as a standard of high potential. The values given in tables for this needle point gap apply only to a gap made with needles— and further they apply only for *alternating current*. They cannot be cross applied to *pulsating direct current* without errors which may reach as high as 50 per cent.

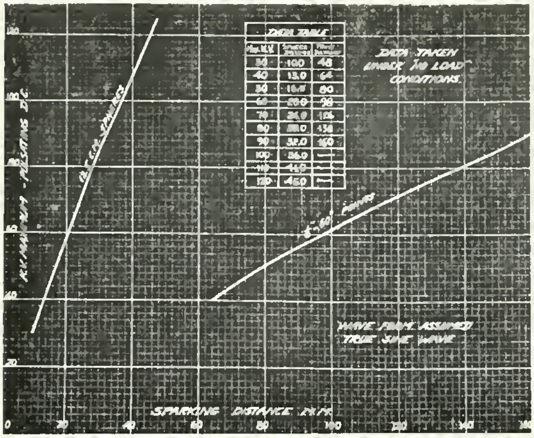


Fig. 10.

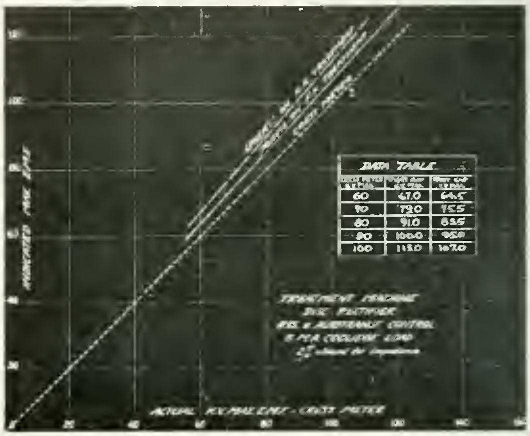


Fig. 11.

No standard specifications have ever been worked out for the so-called "point spark gap" commonly used in *x*-ray work. It was therefore assumed that ⅛ inch rod, beveled to a conical 60 degree point, and slightly blunted, would correspond to the rough average of the various spark gaps in common use.

The object in slightly blunting or rounding the point is that no user of *x*-ray apparatus takes pains to sharpen the points on his spark gap periodically, and they therefore become rounded through use. Hence it seems quite logical to start by slightly rounding such points.

Either of the curves given may be used (with appropriate reservations for inaccuracies) for translating spark gap readings on *x*-ray machine into *kilovolts* of potential. A *kilovolt* is a perfectly definite, measureable quantity. But an inch or a centimeter of spark gap is *emphatically not* a definite thing, even when measured with all possible precautions.

Proceeding with the description of the tests conducted, the crest meter was connected to the primary terminals of the high tension transformer of the *x*-ray machine under investigation, and calibrated by comparing its readings with the flash over value of a sphere gap connected to the *secondary winding* of the alternating current transformer. This sphere gap was connected on the alternating side of the rectifier, which was temporarily removed from the circuit in order to prevent any errors due to surges from sparks.

The crest meter was then adjusted by means of the variable resistance forming a part of the instrument, until the kilovolt reading of the meter corresponded to the indication on the sphere gap.

The rectifier in the *x*-ray machine under test was then connected and, with the Coolidge tube used as a load, various readings were taken.

Figure 11 shows the performance of a "treatment machine" employing a disc rectifier with relatively short arc of contact. On account of the strong surges in such a circuit, the sphere gaps employed *indicated* a *higher* potential than that effective in making *x*-rays.

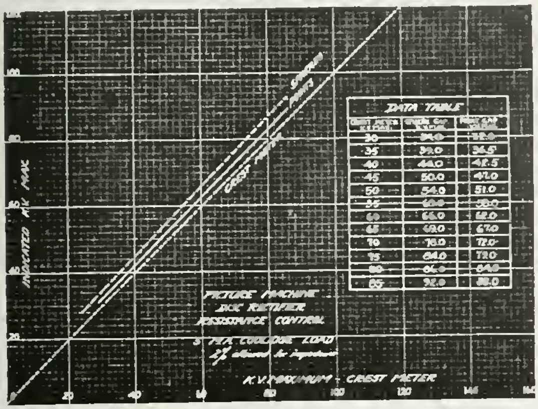


Fig. 12.

Further, the *sphere* gap, being *more sensitive* to surges than the point gap, indicated with this machine a higher potential than that from the point readings.

effect of surges in causing spark gap errors is somewhat less proportionately than that shown in Figure 11.

Figure 13 shows the performance of a "picture machine" with longer arcs of

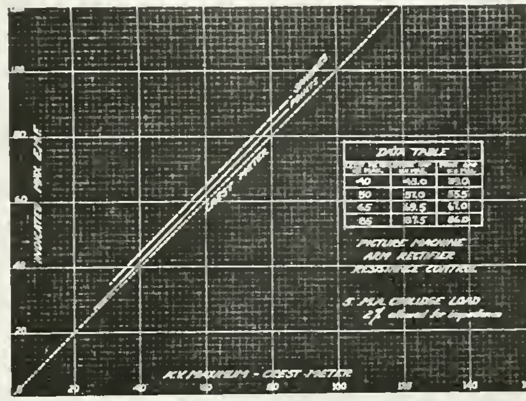


Fig. 13.

contact than those of the two preceding machines. This outfit was in fairly accurate adjustment, and it will be noted that the sphere gap, point gap, and crest meter are in far closer agreement on this account.

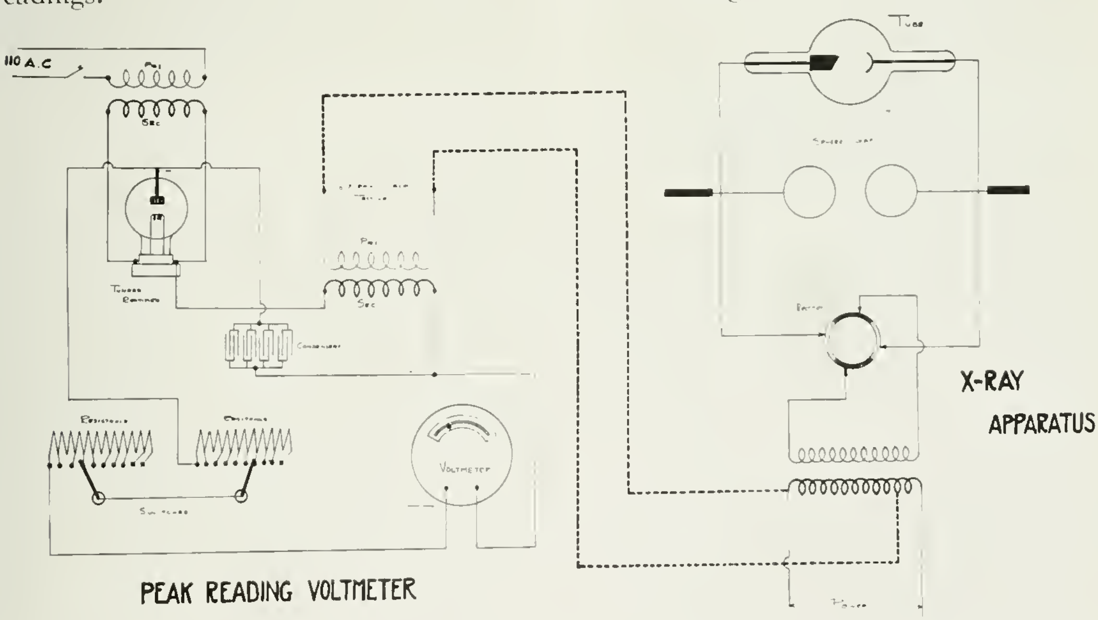


Fig. 14.

Figure 12 shows similar tests on a "picture machine" with the same type of rectifier. On account of the lower voltage, and the fact that a greater amount of resistance was used in the control, the

All these readings are *relative* only. It is possible to vary the discrepancies between sphere gap, point gap and crest meter *at will* by making slight changes in the circuit conditions.

During this investigation, the readings of the spark meter attached to these machines were also investigated, the general results being included in the following summary. It will be readily appreciated that, with the wide variety of such instruments in use, and the fact of any specifications for their standardization, no quantitative results of any value can be given here.

In closing, a *practical point* with regard to the comparative value of spark meters and spark gaps may be mentioned.

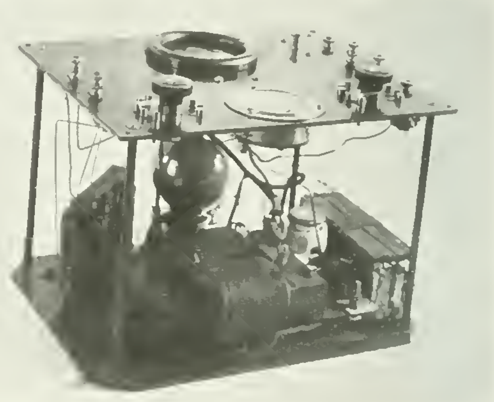
Outside view of crest meter.

A meter is a *continuous* index of what is happening, while a spark gap gives only the value of potential at a certain instant. The spark gap can, therefore, be relied on *only* if it is reasonably certain that the potential will *stay* at the value last measured. The meter, on the other hand, can be used with greater success on a highly variable supply line.

The useful results obtained from this work and applicable particularly to practical therapy may be briefly summarized as follows:

Point Gaps. Readings are often inconsistent, and must be repeated several times for workable results: With cross arm rectifier, carefully adjusted, average of all readings about 3 or 4 per cent higher than crest meter; variation between highest and lowest readings over 10 per cent; with disc rectifier, average of all readings 6 to 8 per cent higher than crest meter; variation between highest and lowest reading 15 per cent.

Sphere Gaps. Readings, almost as inconsistent as point gaps, must be repeated several times: With carefully adjusted cross arm rectifier, average of all readings about 7 per cent higher than crest meter. Difference between highest and lowest reading 8 per cent; with disc rectifier, average of all readings 12 per cent above crest meter. Difference between highest and lowest readings 20 per cent.



Inside view of crest meter.

Kilovolt Meters. Only two were tested. As the results were desired for use in therapy, all tests were at 5 ma. except for a check at 20 ma. to determine effect of increasing load. Two per cent was allowed for impedence drop at 5 ma. load.

Resistance control of the *x*-ray apparatus permits distortion of wave form. The greater the resistance the lower the kilovolt meter reading for the same crest value.

Large gaps in the rectifier make the kilovolt meter read high.

Kilovolt meter readings are *consistent*, and a return to *the same*, or nearly the same, *rheostat* setting, the same milliampérage, and the same kilovolt meter readings will give the same crest value.

RÉSUMÉ

A method of measuring significant tube potentials is presented.

The measurements taken indicate that the crest meter used responds to sustained peak potentials, but is unresponsive to surges and transients.

Spark gap readings, when investigated in comparison with this instrument, show inconsistencies, which are partially ascribed to surges.

The sphere gap seems to be more sensitive to surges than the point gap, and therefore, of less use in *x*-ray measurements. This statement applies for potentials up to 150 kv. Above this value, the spheres seem to be the best available method, in spite of their sensitiveness to surges.

Kilovolt meters cannot be relied upon unless calibrated against a number of point gap settings at the setting where used. They will then enable consistent return to that point.

Disc rectifiers give greater surges, and higher and more irregular gap readings for the same crest values than do arm rectifiers.

All rectifiers give much more consistent results when closely adjusted.

A METHOD FOR ROENTGEN-RAY DEMONSTRATION OF THE NASOLACRYMAL PASSAGEWAYS*

BY DON M. CAMPBELL, M.D., L.R.C.S. (EDINB.), JOHN M. CARTER, A.M., M.D.,

AND HOWARD P. DOUB, A.B., M.D.

DETROIT, MICHIGAN

STENOSIS, and the resulting inflammation of the nasolacrymal passageways, is a subject of paramount importance, not only to the oculist and rhynologist, but also to the unfortunate individual affected. Operations for the alleviation of this condition go back to the time of Galen, who first advocated breaking through the lacrymal bone and introducing a caustic to prevent closure of the newly-made opening. Only during the last decade, however, has any considerable degree of success been attained by the intranasal method of operation, and even during this time the operator has been seriously handicapped by his lack of precise knowledge of the size, shape and position of the nasolacrymal passageway and the point of obstruction in relation to the surrounding structures. We believe that this problem is greatly simplified by the use of the roentgen ray, following the injection of the nasolacrymal passageway with an opaque medium.

A normal nasolacrymal passageway presents the following:

1. The two lacrymal canaliculi, running from the free margin of the upper and lower lid. These run at first vertically for a short distance, and then turn at an angle to run a medial course converging toward the lacrymal sac. They then unite either in a common trunk to empty into the sac, or they empty separately.

2. The lacrymal sac is the upper dilated end of the nasolacrymal duct and is lodged in a deep groove formed by the lacrymal bone and frontal process of the maxilla. It is oval in form and measures about 12 mm. in length. Its upper end is closed and rounded, while the lower end continues as the nasolacrymal duct.

3. The nasolacrymal duct extends from the lower part of the lacrymal sac to the inferior meatus of the nose, being slightly narrowed at its lower extremity.

The methods employed in the past in the treatment of this condition may be divided into three groups:

1. The passage of large metal probes or curettes in an effort to relieve the stenosis. This method has never been entirely

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satisfactory. This has been done on several of our patients a great number of times, one patient estimating that probes had been passed on him fifty times.

2. Those attempting the removal of the sac, or its destruction by caustic, in order to get rid of an infected or abscessed lacrymal passage. This can never be a popular method, as it does not provide for the drainage of the tears into the nose as nature has intended. The excess tears must then drain over the lid margin.

3. The third group attempts to drain the tears into the nose by a short-circuiting operation into the middle meatus of the nose. This was first popularized by West, who described his operation in 1910, before the American Ophthalmological Society. He makes a large window in the lateral wall of the nose, opposite the position occupied by the middle and upper third of the nasolacrymal duct. While this is the operation of choice with many operators, the precision of the operation has been greatly reduced by the lack of knowledge of the exact position of the stricture and the size and location of the sac. We know of no way in which this knowledge may be gained accurately, except by getting a visual image of the passageway, or of the portion of it above this stricture, in its relation to the surrounding structures. This work was begun, therefore, with the object in mind of producing such a picture by means of the roentgen ray.

FIG. 1. Before operation. Shows an obstruction at the junction of the sac and duct. The sac shows a moderate degree of dilatation. Both canaliculi are well filled.

We have, in the past fourteen months, studied about sixty obstructed and normal passageways. Our method of procedure has been to undertake the usual routine of attempting to syringe solutions by way of the puncta through the sac and duct into the nose. Following this, the passageways are injected with oil and bismuth and roentgenograms are made in several positions which will be described later.

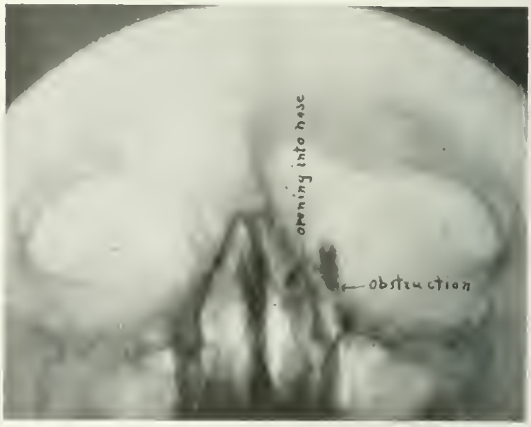

FIG. 2. Following operation in which an opening was made into the nose. Shows bismuth passing into the nose.

To give the technique of injection in detail: A few drops of a 2 per cent cocaine solution are dropped on the lower cul-de-sac and any mucus or pus which may be in the sac is expressed by pressure. If desired, the punctum to be used in the injection may be dilated slightly but under no circumstances do we slit the canaliculus. The passages are then syringed out with normal saline to which a few drops of 1–1,000 epinephrin solution have been added. Following this, the passages are injected with Beck's bismuth and oil paste. For the injection we use an ordinary 2 c.c. all-glass Luer syringe and a No. 19 lacrymal needle. In the progress of our work we have found it desirable, in certain cases, to obstruct the punctum which is not being used for the bismuth injection. For this purpose, a medium-sized common pin is put in the punctum selected. If it is found necessary to warm the bismuth paste, this should be accomplished by the use of dry heat, for if steam comes in contact with the bismuth, the oil will be precipitated out and difficulty will be experienced in getting an even flow through the small caliber needle. Less than 1 c.c. will be necessary to inject the unobstructed passageway, while about ½ c.c. will suffice in those passageways with obstruction. In trying to locate the sac, relative to the intranasal structures, we have found that the placing of a small silver rider over the anterior end of the middle turbinate, just below its attachment to the lateral nasal wall, is of considerable value. Recently we have outlined the position of the entire anterior end of the middle turbinate with a strip of bismuth, which is easily applied by using a long lacrymal needle. Our lateral plate will then show how much of the unobstructed passage lies above or below the root of the turbinate and also whether it is in front of or behind the turbinate. We have not used the marker in all our cases, but we feel it to be a procedure of value. The patient complains of little or no discomfort from the injection of the bismuth.

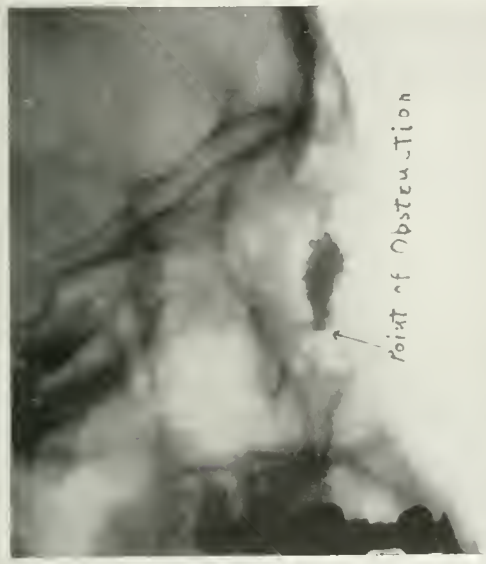

Fig. 3. Before operation. Shows an obstruction in the upper portion of the duct, with a dilatation of the sac above this.

METHOD OF ROENTGEN-RAY EXAMINATION

This has all been carried out with the duplitized-film double-screen technique. The exposures were made in a number of different positions. The positions which we have found to be the most valuable are the following:

1. The Waters-Waldron sinus position with the chin resting on the plate and the nose raised slightly from the plate. The objection to this position is that frequently the nasolacrymal duct will lie over the maxilla and thus will be partly obscured. To obviate this difficulty we have used the following position.

Fig. 4. Shows normal sac, duct and canaliculi as shown in the postero-anterior view. This also shows a metal rider over the root of the middle turbinate on the opposite side.

2. In this case we have used the same position, except that we have rotated the head toward the side which has been injected with the bismuth paste. The amount of rotation used is about 10°. This will frequently throw the injected sac over the ethmoidal cells and will show the injected sac standing out in bold relief.

3. In this position we have the patient's forehead and nose touching the plate, the plate being inclined about 15°. Here also

the sac will frequently be seen over the ethmoidal sinuses.

4. A plate made in the lateral position. It is important in this examination to see that the head is in a true lateral position. The vertical ray is directed perpendicular

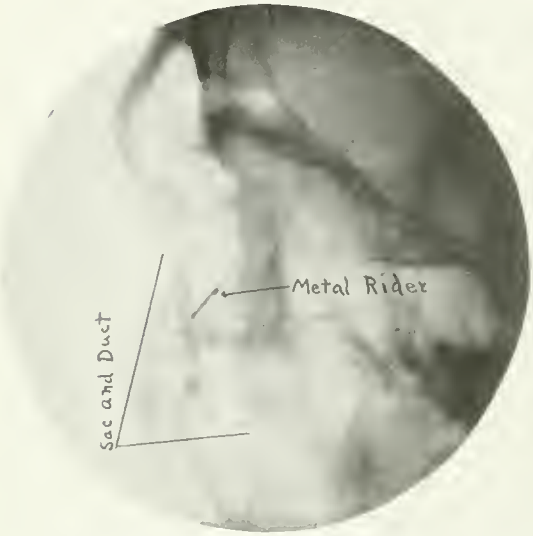

FIG. 5. Same as Fig. 4, but showing the normal structures as seen in the lateral view.

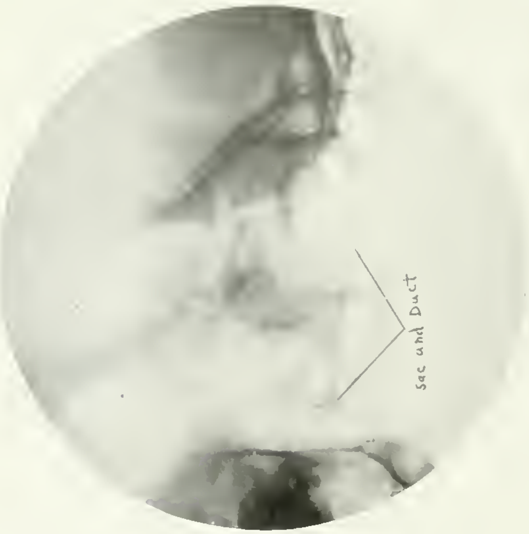

FIG. 6. Normal case showing sac and duct well outlined.

to the plate at a point about the anterior portion of the lower border of the orbit. It is often desirable to make the plates stereoscopically.

In a number of our early cases we have inserted a specially-cut film in the nose for use in the lateral position, but this has never proven as successful as with the larger film on the outside.

In the study of plates of patients complaining of no symptoms referable to this region, and therefore classed as normal

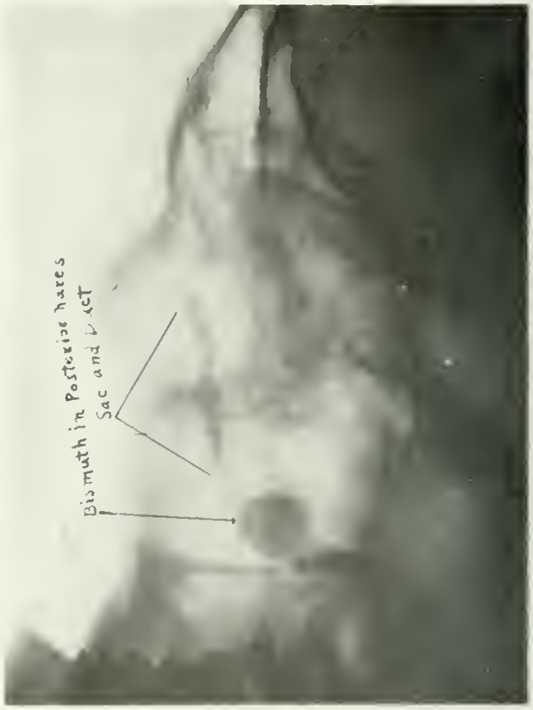

FIG. 7. Normal case showing irregular outline, which is frequently seen as a normal variation. Also, a large collection of bismuth is seen in the posterior nares.

cases, a number of abnormalities have been found. Absence of one of the puncta is occasionally found, and in one case, multiple puncta were discovered. The sac is ordinarily joined to the nasolacrymal duct with an end-to-end union, but we have found in several cases a side-to-side joining. The outline of the sac and duct, as studied from the roentgenograms of several of these cases, is seen to be extremely irregular and tortuous, and it is easy to see from the study of these plates why difficulty is often experienced in passing probes on such cases.

In this series a number of negroes have been examined, and in practically every case, the nasolacrymal passageway has been wider and straighter than in the white race. Fernandez has arrived at a similar conclusion, basing it on anatomic studies.

In the diseased or obstructed passageways, we have found two extremes: First, a very marked dilatation above the point of obstruction, very similar to the dilatation seen in the esophagus above a marked obstruction; second, the passageway may be very small or practically obliterated, due to repeated abscess formation with resulting scar tissue. Many of the intermediate forms between these two extremes have been found. One of these cases presented a fistula running from the sac into the ethmoid labyrinth, and one into the soft tissues of the face.

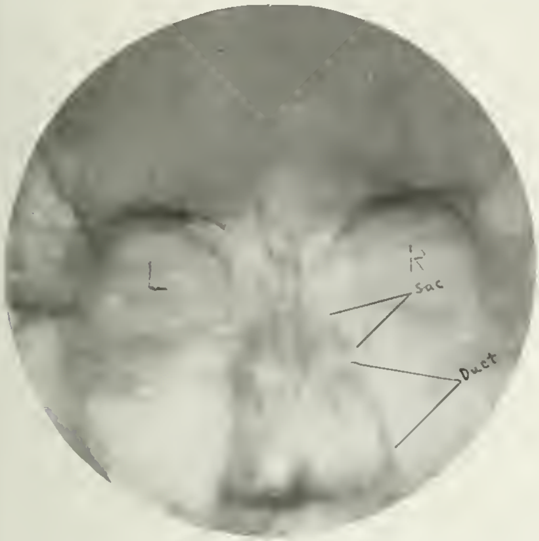

Fig. 8. Normal case shows side-to-side joining of sac and duct.

Fig. 10. Lateral view of same case as Fig. 9

Fig. 9. Shows a very narrow constricted duct, causing partial obstruction. Postero-anterior view.

Fig. 11. Shows an obstruction at the junction of the sac and duct with another constriction above this. Patient complained of repeated abscess formation in right sac and tearing on this side.

In this series there are 20 cases of complete obstruction of the nasolacrymal passageways. We have been interested to study the *x*-ray plates on these to determine the possible association of sinus disease with lacrymal obstruction. The data developed would seem to be quite significant. First, it should be emphasized that these patients have tearing as their chief complaint, and have not complained of sinus trouble, and as far as the sinuses are concerned, might at first thought, be classed as cases taken at random. To state our findings: 60 per cent of this obstructed group show on their roentgenograms definite evidence of chronic pathology in the sinuses most intimately associated with the nasolacrymal duct, namely, the maxillary sinuses; while none of them show pathology in the frontal sinuses which are further removed and not in intimate relation with the passageways. The anterior ethmoids were involved in 25 per cent of the cases showing sinus pathology. This series is too small for drawing definite conclusions, but the findings are very striking and lend weight to the theory that chronic sinus disease may often lead to lacrymal obstruction, or vice-versa.

Fig. 12. Before operation showing obstruction at junction of sac and duct with dilatation of the sac.

Table I
SINUS INVOLVEMENT IN OBSTRUCTED CASES

		Per cent
Obstructed cases	20 —	100
Pathology in sinuses	12 —	60
No pathology in sinuses	8	40

Table II
RELATIVE INVOLVEMENT OF THE SINUSES

		Per cent
Pathology in antra	12	100
Pathology in ethmoids	3	25
Pathology in frontals	0	...

Table III
COMPARATIVE PATHOLOGY ON OBSTRUCTED AND NON-OBSTRUCTED SIDES

		Per cent
Sinus pathology found	12 —	100
Sinus pathology same side as obstruction	9	75
Sinus pathology opposite side from obstruction	3	25

Very important post-operative information can be gained by the use of this method in certain types of cases. First, those cases giving a history of having had the sac removed, which later come in complaining of pus formation in this region. In one case of this series the roentgenogram demonstrated that there was

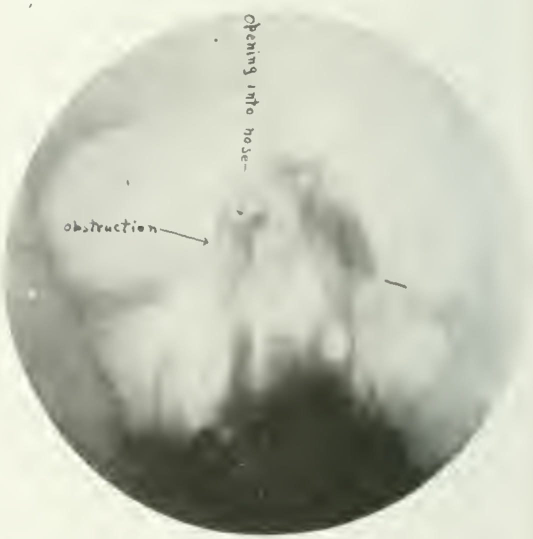

Fig. 13. After operation. Shows bismuth passing into nose through a large window made by the operation.

still enough of the sac remaining so that a short-circuiting operation into the nose was considered feasible, while in another case such a small amount of the sac was left that extirpation was the procedure of choice. Second, those cases showing unsatisfactory results following one of the short-circuiting operations. The information to be gained here is, as to whether the artificial opening is functioning, and also as to whether the opening was made near enough to the point of obstruction to obtain dependent drainage.

CASE REPORTS

Case I (No. 22,907). Female. Complained of tears falling over the cheek, on the right side. This has been inflamed at times, and the sac often contained pus, but it has been controlled by argyrol. Has never had abscesses of the sac. The nose is negative. *X*-ray of the sinuses is also negative. Operation in March, 1912, in which a new opening was made into the nose from the obstructed sac as shown in the *x*-ray examination.

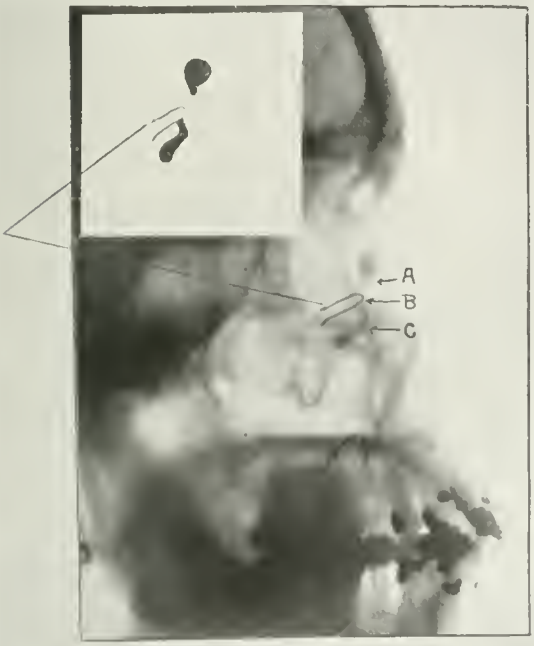

Fig. 14. Shows obstruction in sac at (A). Metal rider (B) and stripe of bismuth on anterior end of middle turbinate (C).

Figure 1 shows the opening to be very small and not placed so as to get dependent drainage. As the patient's symptoms were not entirely relieved, a second operation was done and a larger opening made, following which the patient has remained free of symptoms to date (Fig. 2).

Case II (No. 22,017). Female. Complained of tearing from the left eye over the cheek, for the last six years. Says she can press pus out of the sac. She was examined in the office and found to have an acute abscess. This was excised under gas anesthetic. Following this the acute abscess cleared up. The patient was later *x*-rayed and an obstruction rather high up in the duct was seen, with considerable dilatation of the sac above this. The operation was performed Sept. 30, 1921, with excellent results following, and the patient has had no further trouble with this eye.

CONCLUSIONS

From this preliminary report, embracing the study of sixty cases of normal and obstructed passageways, and also the study of ten of these cases following operation, certain conclusions can be noted.

1. In cases of complete obstruction this method gives valuable data in deciding what type of operation is to be performed, and if an opening into the nose is decided upon, it shows the point where dependent drainage may best be accomplished.

2. In these cases of partial obstruction it is easy to see what type of sac and duct is present and if these are suitable for probing, or if an intranasal operation is necessary.

3. Valuable post-operative information may be gained in those cases where a new opening has been made and the case is progressing poorly.

4. By the roentgenogram one can confirm or disprove that the sac has been completely removed at the time of the operation.

5. The condition of the paranasal sinuses, especially the antra and ethmoids, can be noted as the possible cause of the obstruction.

DISCUSSION

Dr. Borzell. I would like to ask Dr. Doub whether a study has been made of both sides and how favorably they compare with each other.

Dr. Doub. I did not put much data in the paper. I might say we studied both sides in a large number of instances, and found there was no regularity in the development of the two sides. We could not say that because one side might be regular, the other side would be the same. Unfortunately, we have no slides showing both sides.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922

Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

THE CALDWELL LECTURE

It is with much pleasure that the president-elect, Dr. Wm. H. Stewart, announces that Dr. Wm. Duane of the Harvard Medical School will deliver the Caldwell lecture at Los Angeles. The title of the lecture will be announced at a later date. All those who are acquainted with Dr. Duane's work are pleased that he has consented to act in this capacity, and those of us who will attend the meeting have something extraordinary to look forward to, as his contributions are of more than usual interest to the science of roentgenology.

LONDON LETTER

Dear Sir:

The idea of establishing through the medium of your Journal an "Entente Cordial" between America, France, and Britain will meet with hearty approval on this side of the Atlantic. During the war the intercourse, unfortunately only of short duration and at irregular intervals, between American and British radiologists has clearly established the fact that we have everything in common, and hardly any differences of view; if any, none so serious that they cannot be overcome in friendly discussions. Perhaps the only point on which our views seriously conflict is that of nomenclature. The time is opportune for a reconsideration of that serious question. We on this side resolutely set our faces against the attempt to "roentgenize" everything appertaining to our art, and it is in our mind that many of our colleagues on the other side of the Atlantic view the matter in the same way.

This subject alone would be worthy of the activities of a joint committee from our two Societies, and I feel sure that a happy solution to our difficulties and differences in nomenclature would be found. The committee could work in collaboration with the British Engineering Standards Association.

The matter is more urgent than it appears at first glance. We on our side are energetically working out the education question for both medical and non-medical workers in radiology, and if the students we attract are to have a clear conception of the importance of the work, then we must at once determine in what language they are to be taught the technicalities of their subject.

The proposal just put forward is that the American Society of Radiologists and the Societies on this side should each appoint a representative nomenclature committee. When opportunity offers either could send a representative to meet one or other committee in consultation, and something definite could soon be achieved. These committees could as an extension of their work, act as an information bureau, to which all radiologists visiting either country might apply for guidance and help. Another extension of the work would be for the committee to arrange for the exchange of students, and short courses of lectures from radiologists who might be visiting either country. It would give us great pleasure at any time to arrange for a course of lectures in London, by any eminent radiologist who would not be overburdened by such work while on holiday.

In Britain, educational work in radiology and electrotherapy has made decided progress. During the early years of the war, it was realized that something had to be done to put these subjects on a sound scientific basis, if, in the future, we were to hold our own in progress and technical development. The war found us collectively unprepared, though individually we were fortunately able to do enough to keep the work going.

A small committee appointed to discuss the matter quickly resolved itself into the British Association for the advancement of Radiology and Physiotherapy. The late Sir James Mackenzie Davidson was the first president, and he greatly helped the onward progress of the movement by his ready sympathy and financial support.

The University of Cambridge was approached with a view of establishing a diploma in "Radiology and Electrology." With commendable forethought and enterprise the authorities proceeded to discuss the possibilities, and after several meetings with representatives of the B.A.R.P. it was arranged that the University should grant a diploma (*a*) after examination, (*b*) by dissertation, carrying with it the right to use the letters D.M.R. and E.

Active teaching was arranged for at Cambridge and in London. The courses consist of systematic lectures, practical demonstrations, and at least six months' clinical and technical instruction at a recognized hospital.

A great deal might be written about arrangements and the scope of the instruction given. Much of that will follow in later letters, but the chief points have been dealt with very briefly in order to give our colleagues in America some idea of the activities of the radiologists, electrotherapists, and diagnosticians in this country.

The diploma at Cambridge is open to qualified men and women all over the world, who can satisfy the committee at Cambridge of their suitability. The diploma by dissertation can be obtained by candidates who have held a recognized post for a sufficient period of time. The dissertation is considered by the committee and sent out to two referees for their opinion. It is with feelings of pleasure that I can state that already several distinguished American radiologists have sent in dissertations, and have been awarded the diploma. Surely this is propaganda work of the highest order.

The University of Liverpool also grants a diploma after examination. In the able hands of Dr. Thurstan Holland the teaching is of the best, and Liverpool is certain to be a "focus spot" for American radiologists.

The non-medical assistant has not been neglected. A society—The Society of Radiographers—has been founded. It, in its turn, arranges for the training of assistants in *x*-ray and electrical departments. A certificate is given on the candidate satisfying the court of examiners. This entitles the worker to use the letters M.S.R.; i.e., member of the Society of Radiographers.

Already the stimulating influence of this society is being felt, and it is evident that the medical side of the work must be kept at a high standard if it is not to be eclipsed by the routine work of the radiographer. It is also evident that the establishment of these two societies working in complete sympathy will go a long way towards removing any antagonism that may have existed, and that to preserve the distinction between a medical side and a technical side will lead in the end to the advancement of the subjects. A highly trained medical man is unsuitable in the purely technical routine of the work, while a highly trained technical man is equally out of place as a medical radiologist. One must be complementary to the other, and both are essential; each can excel in his own branch.

Yet if real progress is to follow upon our efforts, something further requires to be done. The diploma at Cambridge should automatically become a degree in radiology. This would necessitate the provision of more extensive teaching and the endowment of a chair at the University. The teaching would require to be carried out at several recognized centers throughout the country. An extension of the system would be to provide suitable centers throughout the Empire, and the recognition of teaching schools in other countries, particularly in America. The practical value of such an extensive scheme would soon become evident, and it would be a very efficient factor in co-ordinating the teaching of the subjects in America and Britain. The endowment of research would be a logical outcome of the working of the scheme, and a central Institute of Radiology could be established.

Steps are on foot which we earnestly trust may eventuate in the formation of a nucleus of a large institution; indeed it may be said that the nucleus already exists, for the generous action of Lady Davidson has already placed in our hands the library and a number of pieces of experimental apparatus, transparencies, etc., the property of the late Sir James Mackenzie Davidson. It is the intention of a committee dealing with the matter to establish at the Institute of the future a Mackenzie Davidson Museum and Library. And later, if possible, one or more Mackenzie Davidson Chairs.

It is thus evident that we on this side of the Atlantic are alive to the needs of our specialties, and if we have not so far succeeded in raising a pile of buildings worthy of the subjects, we have at least made an effort to do so, and will eventually succeed.

In conclusion let me thank you for the honor you have done me in asking for a London letter for publication in your Journal. It will give me great pleasure to send you items of news of interest to your readers, and in order that the interest may be maintained, I have invited my colleague, Dr. Hector A. Colwell, to collaborate with me in my efforts. I feel sure that he will be able to add greatly to the value of all our communications.

Yours sincerely,
Robert Knox.

THE NEW ENGLAND ROENTGEN RAY SOCIETY

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

VOL. IX [NEW SERIES] JULY, 1922 No. 7

THE PRODUCTION OF PENETRATING X-RAYS*

BY WILLIAM DUANE

Professor of Biophysics, Harvard University

CAMBRIDGE, MASSACHUSETTS

I. INTRODUCTION

IN the treatment of certain types of malignant disease by radiation, better results can be obtained by using the penetrating γ-rays from radio-active substances than by employing x-rays. The chief difference between the two methods of treatment lies in the fact that the γ-rays are more penetrating than the x-rays, and that the γ-rays therefore project larger amounts of radiant energy into the deeper lying tissues as compared with the energy absorbed in the skin than the x-rays do. Although it will take a long time definitely to decide how much can be actually accomplished, the recent reports from Central Europe indicate that massive x-ray therapy has certain advantages; and this has greatly stimulated interest in penetrating roentgen radiation.

Several years ago, the writer began certain researches designed to determine just what to do in order to produce x-rays of great penetrating power. At its meeting in 1914, he presented to the American Roentgen Ray Society a brief statement of some of the preliminary results. The present paper contains a description of more recent experiments, and a statement of the conclusions to be drawn from them.†

Since the researches by Laue and the Braggs,[1] scientists have come to the conclusion that the x-rays consist of a series of waves travelling through space. We call the distance from one wave to the next preceding wave, or to the next following wave, a wave-length, and we usually denote this distance by the Greek letter λ. If this distance is the same for all the waves, the radiation is said to be homogeneous.

It has been found by experiments that a great many properties of x-rays depend upon their wave-lengths. For instance, the penetration of the x-rays through matter generally, *but not always*, increases as the wave-length of the x-rays decreases. Let us take as a definition of the penetration of an x-ray the distance, D, it travels through matter before half of the radiation has been absorbed or scattered. Except in certain cases described below, this distance D, is related to the wave-length approximately as represented by the following equation:

$$D = \frac{.693}{a\lambda^3 + b}, \qquad (1)$$

where a and b are constants depending upon the nature of the substances traversed by the rays. If equation 1 represents the facts, in order to *increase* the penetration (i.e. *increase* D) we must *decrease* the wave-length λ.

The object of the researches described in this paper has been (a) to determine the best means to employ in order to produce x-rays of very short wave-lengths; (b) to compare their intensity and penetration with those of the γ-rays from radio-active substances.

* A Leonard Prize Paper.

† In carrying out these researches I have had the assistance of a number of students.

II. METHOD OF MEASURING WAVE-LENGTHS

In measuring the wave-lengths of the x-rays I have used Bragg x-ray spectrometers.[1] The arrangement of the apparatus for measuring long, easily absorbed x-rays differs slightly from that used in measuring short, penetrating x-rays. Figure 1 represents the instruments employed in the first case. The x-ray tube was made in our laboratory and was exhausted by means of a set of pumps attached to the tube marked A. The pumping system consisted of a rotary oil pump, a Gaede rotary mercury pump, and a mercury diffusion pump, all three in series with each other.

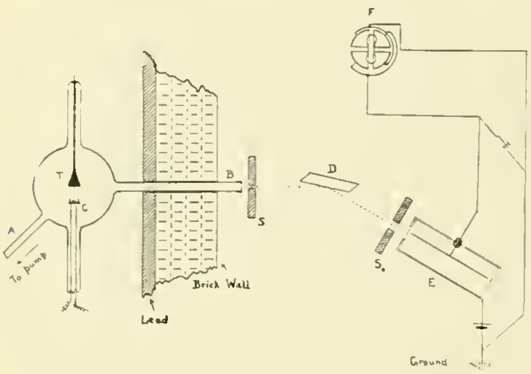

Fig. 1.

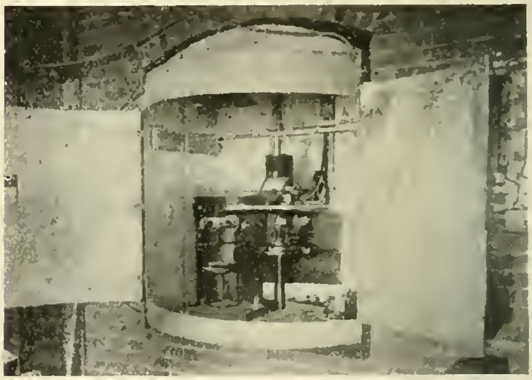

Plate 1.

A glass trap immersed in liquid air between the diffusion pump and the tube A served to condense out the mercury vapor. A Coolidge cathode, (C in the Figure) supplied the electrons which passed across and struck the target T. The x-rays there produced passed through the side tube and out through a thin mica window at B. The use of this long side tube and mica window markedly reduced the absorption of the roentgen radiation by the air, and by the walls of the x-ray tube. The target and window were so placed that the x-rays actually analyzed—on leaving the target almost grazed its surface. This gives a very narrow source of rays as seen from the window B. The side tube passed through a hole in a brick wall, which separated the room containing the x-ray tube from that in which the x-rays were examined and analyzed. The brick wall furnished excellent protection to the operator and to the measuring instruments against the effects both of the stray x-rays and of the electrical disturbances produced by the high potential currents through the x-ray tube. This protection becomes of very great importance when very high potentials are used, and in these cases a large sheet of lead 1 cm. thick was attached to the wall on the side toward the x-ray tube as an additional shield.

After emerging from the window B, the x-rays passed through a narrow slit, S_1, in a block of lead 1 cm. thick. They then impinged upon the surface of a crystal of calcite, D, supported on the table of a spectrometer, by means of which the glancing angle, θ, could be accurately measured. Under these conditions the crystal reflects some of the x-rays. It markedly reflects those only of the x-rays that have the wave-length given by the equation

$$\lambda = 2d \sin \theta \qquad (2)$$

For calcite, $2d = 6.056$, if the wave-lengths are expressed in terms of the usual unit, the ångström. One ångström equals 10^{-8} cm. The part of the x-ray beam reflected from the crystal subsequently passed through a second slit, S_2, and then entered an ionization chamber, E. A quadrant electrometer, F, measured the electrical current through this ionization chamber. Although the ionization current is not strictly proportional to the intensity of the roentgen radiation, it may be taken to represent approximately the amount of energy absorbed by the gas in it. The gases sulphur dioxide, ethylbromide, and methyliodide were used in different experiments.

In analyzing very penetrating x-rays the long side tube and mica window B make very little difference, and an ordinary Coolidge tube can be used in place of the one above described. Plate I shows a reproduction from a photograph of the spectrometer.

III. THE GENERATING PLANT

Two sources of high potential current have been used in the researches. In measurements of extreme accuracy a high potential storage battery supplied the current through the *x*-ray tube. The battery consisted of 20,000 small storage cells, furnishing, when fully charged, an electromotive force of over 40,000 volts. Only by using sections of the battery could any difference of potential below this value be obtained. Such a battery furnishes a non-fluctuating voltage. Its electromotive force, however, gradually decreases when it begins to run down, and in order to maintain the given difference of potential between the electrodes of the *x*-ray tube, the following well-known device was employed. The positive pole of the battery was joined directly to the anode of the *x*-ray tube (Fig. 3). The negative pole of the battery was connected through a variable resistance to the ground (water pipes). The small electrical circuit that heats the Coolidge cathode was joined to the same ground connection (water pipes). Under these conditions, when a current passes through the tube, a change in the variable water resistance will alter the potential of the *x*-ray tube's target, for some of the electromotive force of the battery is utilized in forcing the current through the water resistance. By observing the potential of the target as described below, and by suitably varying the water resistance, the difference of potential across the tube can be kept exceedingly constant during an experiment.

In experiments with voltages higher than 40,000 volts I have used an arrangement of apparatus first employed years ago in Europe for charging electrical condensers to very high, constant differences of potential by means of induction coils or transformers. Figure 2 represents the circuits. An alternating current (in my experiments usually 500 cycles per second) passes through the primary circuit, P, of the transformer, T. One end of the secondary coil of the transformer is connected to the ground. Under these circumstances the potential of the other terminal, S, of the secondary coil oscillates between plus and minus V volts, V being the maximum voltage delivered by the transformer. A, in Figure 2, represents an electrical valve which allows positive electricity to flow in the direction of the arrow, but not in the reverse direction. When the potential of S is positive, the current flows through this valve to the plate C of the electrical condenser, charging it up

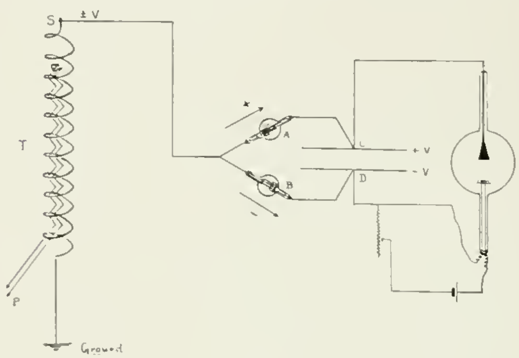

FIG. 2.

to the maximum positive potential plus V volts. The positive electricity cannot flow back through the valve A, and therefore the plate C retains its positive charge. When the potential of the terminal, S, is negative, negative electricity can flow through the valve B (which points in a direction opposite to A), and this negative electricity charges the plate D of the condenser to a negative potential minus V volts. The negative electricity cannot pass back through the valve, B, again, and therefore the plate, D, retains its negative charge. In this way we get a total difference of potential between the condenser plates, C and D, of 2 V volts, i.e., twice the maximum voltage supplied by the transformer. The target and cathode of the *x*-ray tube are joined to the two condenser plates, as represented in Figure 2. Under these conditions, if too large a current does not pass through the *x*-ray tube, the difference of potential across it remains approximately constant.

In the early experiments with this arrangement of apparatus, partially exhausted discharge tubes were used as valves. Dr. A. W. Hull, however, has designed very much better valves, utilizing the electrons from hot tungsten wires. These valves he calls kenotrons. Ordinary Coolidge *x*-rays tubes may be used as valves, however, and for very high voltages the new large-sized Coolidge *x*-ray tubes appear to give the best results.

IV. MEASUREMENT OF THE DIFFERENCE OF POTENTIAL

I have employed several methods of measuring the voltage applied to the *x*-ray tubes. Figure 3 represents the arrangement of the apparatus designed to measure the voltage with great accuracy. The high voltage battery, B, has its positive pole joined to the target of the *x*-ray tube as indicated. The circuit heating the cathode of the tube is connected to the ground (water pipes). The negative pole of the battery is also connected to the ground through the variable water resistance, W. A second circuit connects the positive pole of the battery to the ground through a set of manganin wire coils of very high resistance, R, a very much smaller resistance, r, and a milliammeter, A. A side circuit connects the terminals of the small resistance, r, through a standard cell, E, and a very sensitive galvanometer, G. A current of 10^{-11} ampere through this galvanometer produces a deflection of one millimeter on its scale. The electromotive force of the standard cell, E, opposes the flow of current from the main circuit through the galvanometer. In the particular case in which this electromotive force exactly equals the fall of potential along the resistance, r, no current passes through the galvanometer. Under these conditions the difference of potential between the target of the *x*-ray tube and the ground—that is, the total fall of potential along the circuit, Rr, bears the same ratio to the electromotive force, E, of the standard cell that the total resistance in the circuit, R+r, bears, to r. In other words, the equation

$$V = E\frac{R + r}{r} \qquad (3)$$

gives the value of V in volts. In the most accurate measurements of V, I have used two standard cells, each of which had been measured by the Bureau of Standards at Washington. The Bureau certified the values of their electromotive forces, E, to within one part in ten thousand. The ratio of the resistances, R and r, I measured by the Wheatstone's Bridge Method. In this measurement standard resistance coils, the values of which had previously been determined at the Bureau of Standards, formed the arms of the bridge. The resistances of these coils were checked up several times with a considerable number of other standard coils, so that, as a result of the whole series of measurements, I have an exceedingly accurate estimate of the ratio $\frac{R + r}{r}$. As the comparison of two resistance coils can be made with extreme accuracy, it is probable that we know the above ratio much more accurately than we know the electromotive force of the standard cell. Extreme precautions were taken with the insulation of the circuits. Further,

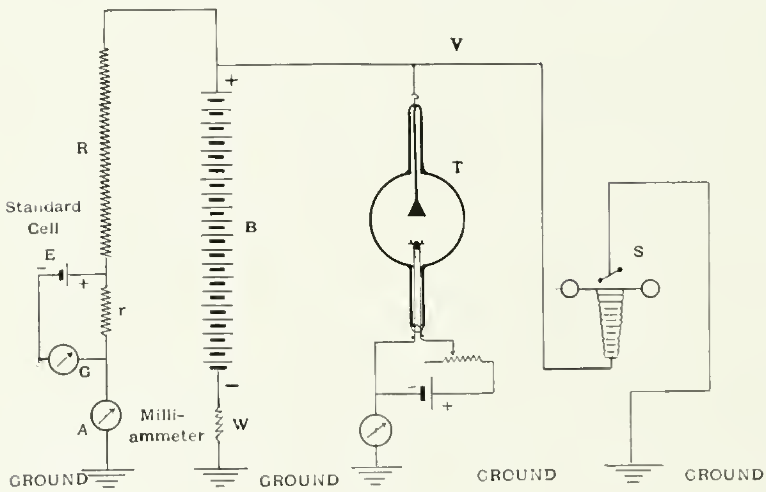

FIG. 3.

in the measurement of the ratio of the resistances, the same current passed through the circuits as passed through them in the *x*-ray measurements, so that the temperature conditions remained similar in the two cases. It seems probable, therefore, that the voltage applied to the *x*-ray tube is known with about the accuracy with which the electromotive force of the standard cell was determined at the Bureau of Standards, namely, to within about one part in ten thousand.

This extreme accuracy can be obtained only when the high potential storage battery furnishes the current through the *x*-ray tube. The variations of the voltage produced by the generating plant, described above, considerably exceed the errors of the measurement. In experiments that do not require this extreme accuracy the voltage may be estimated by measuring the current flowing to the ground through the milliameter, A. This current, multiplied by the total resistance in the circuit $(R + r)$, gives directly the voltage V.

Further, in experiments in which it is not desired to use more current than that passing through the *x*-ray tube, the voltage of the tube may be measured by means of the electrostatic voltmeter, S. This consists of two metal balls suspended so as to turn about a vertical axis. A metal wire connects these balls through their suspension to the ground. Another highly insulated wire connects the target of the *x*-ray tube to two large fixed balls. The electrical charges on the fixed balls attract the charges induced on the movable balls and turn them around through a certain angle. This angle is measured in the usual way by means of a mirror telescope and scale. The angle of deflection depends upon the voltage used, and, as the instrument is not an absolute instrument, it becomes necessary to determine by experiments just what voltage corresponds to each value of the angle of deflection. This can be done by measuring the voltage as described above, and by observing the corresponding readings of the electrostatic voltmeter.

As one often uses a spark gap parallel to the *x*-ray tube as a measure of the voltage applied to it, I have compared the values given by such a gap with those recorded on the calibrated electrostatic voltmeter. For high voltages I had to use the transformer generating plant described above. As slight fluctuations in the current coming from the power plant occur, this calibration does not appear to be as accurate as that for lower voltages, in which the storage battery supplied the current. The spark gap consisted of two polished metal balls 12.5 cm. in diameter. The Victor Electric Company kindly loaned it to me. In making the experiment, the voltage was gradually raised until a spark passed between the balls, and the reading of the voltmeter was observed at the instant the discharge took place. A graduated scale at the base of the supports for the two metal balls indicated the voltages for different settings of the gap. Column 1 of Table I contains these indicated voltages.

Table I

DIFFERENCE OF POTENTIAL IN VOLTS

Spark Between 12.5 Cm. Balls	Electrostatic Voltmeter
90,000	88,000– 90,000
100,000	100,000–101,000
110,000	109,000–111,000
120,000	120,000–122,000
130,000	128,000–131,000
140,000	138,000–140,000
150,000	148,000–149,000
160,000	156,000–158,000

A number of readings were made for each setting of the balls. The readings of the electrostatic voltmeter did not vary more than about one per cent from their mean value. The voltages as measured by the electrostatic voltmeter for the extreme readings in each case appear in column 2 of Table I. The difference of potential given by the scale on the 12.5 cm. ball spark gap agrees very well with that indicated by the calibrated electrostatic voltmeter.

V. THE *X*-RAY SPECTRA PRODUCED BY DIFFERENT VOLTAGES

If we apply a constant voltage to an *x*-ray tube we do not get *x*-rays all of which have the same wave-length.[2] The curves in

Plates II, III, IV, etc., illustrate the wave-lengths of the x-rays actually obtained under given conditions. In these curves the abscissae represent the wave-lengths, or the angles as measured on the x-ray spectrometer, and the ordinates represent the corresponding currents in the ionization chamber. All the curves have one peculiarity in common. In each case the curve shows a certain minimum wave-length, λ_m, and no x-rays come from the tube that are shorter than this minimum. The relation between the minimum wave-length and the voltage applied to the tube was discovered several years ago.[2] The relation may be expressed by the equation

$$V\lambda_m = K \qquad (4)$$

where K is a universal constant. Theoretically this relation means that a certain general law (known in physics as the quantum law) applies to x-rays. Although of great scientific importance, it does not seem necessary at present to enter into a discussion of this question.[3]

Equation 4 shows that the value of the minimum wave-length obtained in a given case may be decreased by increasing the voltage applied to the tube, and that it varies inversely as this voltage. At the time this law was discovered, many of the best physicists believed that the law did not apply, and that you could not get x-rays shorter than a certain wave-length, no matter how much you increased the voltage. During the last few years, however, the law has been tested and found correct in a number of laboratories in this country and abroad.[3]

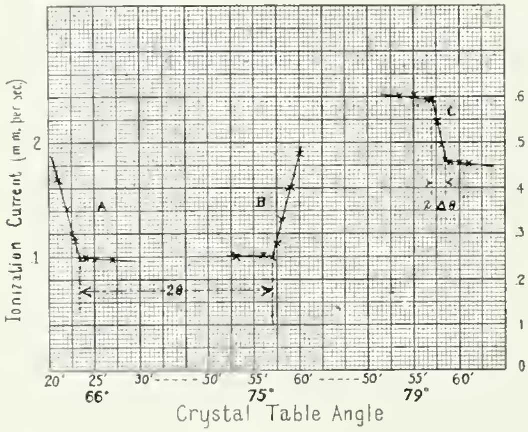

Plate II.

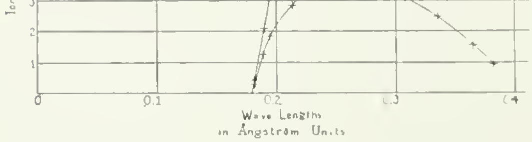

Plate III.

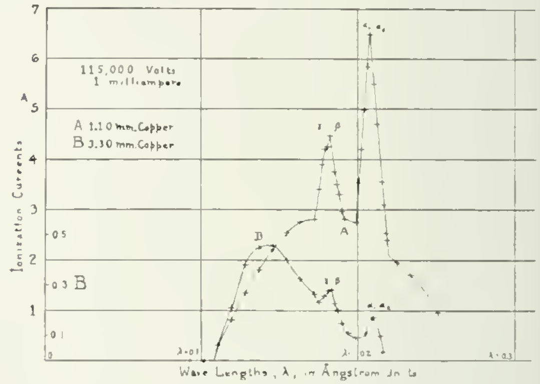

Plate IV.

VI. A REMEASUREMENT OF THE VALUE OF THE PRODUCT $V\lambda_m$

The exact value of the product $V\lambda_m$ appears to be of considerable importance in the science of x-rays as well as in general physics. In cooperation with Palmer and Yeh, I have measured it recently, therefore, using all possible precautions to obtain great accuracy. In these experiments the storage battery supplied the current through the x-ray tube and the potential of the target was measured by the standard cell method, the resistances having the values R = 6,030,500 ohms and r = 252.01 ohms. An assistant observed the galvanometer, G, in Figure 3, and regulated the variable water resistance, W, in such a way that no current passed through the galvanometer during an experiment. Under these circumstances the voltage, V, of the target remained constant during the measurement, and equaled the value given by equation 3. A second observer regulated the current that heated the Coolidge cathode coil, so as to maintain the current through the tube constant, and at the same time measured the ionization current. The curves A and B in Plate II represent the results obtained in one series of measurements. The horizontal portions of these curves give the values of the ionization currents due to stray radiation, etc. The incline portions of the curves indicate the increases in the ionization currents due to the x-rays close to the short wave-length limit of the spectrum. The curve A corresponds to measurements made on one side of the zero of the spectrometer, and curve B to measurements on the other side, after turning the crystal around so as to reflect the rays in the other direction. The abscissae represent the readings on the angular scale of the spectrometer. Since readings were taken on both sides of the zero, the whole angle between the point where the x-ray spectrum ends on one side, to the point where it ends on the other side, equals twice the angle, θ, that must be substituted in formula 2 to calculate the minimum wave-length. This value of θ, however, does not represent the exact magnitude of the angle. A small correction has to be made for the fact that the spectrometer's slit and the focal spot on the target have certain finite magnitudes. This correction we estimated in two ways,—firstly, by measuring the breadths of the slit and the focal spot, and, secondly, by measuring the breadth of an absorption line in the x-ray spectrum, as described below. Curve C in Plate 2 gives the readings of the ionization current in a determination of the correction by the second method. The breadth of the drop in this curve corresponds to the correction, $2\Delta\theta$, that must be added to the double angle, 2θ, to get its true value.

The data obtained in four complete sets of measurements of $V\lambda_m$ appears in Table II.

Column 2 contains the values of θ uncorrected for the breadth of the slit and of the focal spot. Column 3 contains the correction to be added to θ, and column 4 the corrected values of θ. Column 5 contains the values of $V\lambda_m$, the average of which is 12,354. In each of these experiments the voltage, V, applied to the tube amounted to 24,413 volts, as measured by comparison with the electromotive force of the standard cell.

TABLE II

Date	θ (uncorrected)	$\Delta\theta$	θ (corrected)	$V\lambda_m$
March 15	4° 46′ 43″	47″	4° 47′ 30″	12,350
March 21	4° 46′ 53″	43″	4° 47′ 36″	12,353
March 30	4° 46′ 53″	51″	4° 47′ 44″	12,360
April 5	4° 46′ 48″	45″	4° 47′ 33″	12,352

In the above series of measurements the x-rays came from the target of the x-ray tube in a direction at right angles to the direction of motion of the cathode particles. In order to see whether any change in the value of $V\lambda_m$ would take place if the x-rays came from the tube in a different direction,[5] we made a second series of measurements with a tube so placed as to investigate the rays coming off at an angle of 45° from the direction of motion of the cathode particles. Table III contains the results obtained in this series of measurements.*

TABLE III

Date	θ (uncorrected)	$\Delta\theta$	θ (corrected)	$V\lambda_m$
April 6	4° 46′ 35″	1′	4° 47′ 35″	12,353
April 6	4° 46′ 33″	1′	4° 47′ 33″	12,352
April 12	4° 46′ 53″	48″	4° 47′ 41″	12,358
April 27	4° 46′ 43″	47″	4° 47′ 30″	12,350

As in the previous series of measurements, the voltages amounted to 24,413 volts. It appears from the data contained in the fifth column that the value of $V\lambda_m$ is the same for rays coming off at an angle of 45° as for those coming off at right angles to the cathode rays.

VII. EFFECTS OF FILTRATION ON THE x-RAY SPECTRUM

Experiments have been performed to determine the change in the x-ray spectrum produced by interposing sheets of metal between the x-ray tube and the spec-

* This value agrees with that obtained by Blake and Duane, *Phys. Rev.*, Dec., 1917, p. 624. It has, however, greater accuracy than the 1917 measurement.

trometer (filtration). These effects may be divided into two classes, normal and abnormal filtration. In normal filtration the interposed plate reduces the intensity of the x-ray of all wave-lengths to a certain extent.[2] The reduction is much greater for the long waves than for the short, however. Hence, the x-ray beam, after it has passed through the filter, contains a larger proportion of short x-rays than before. In other words, on the average the x-rays have been shortened. The minimum wave-length, however, remains exactly the same. The curves in Plate III show the results of experiments on this question in the case of high filtration. The abscissae represent the wave-lengths, and the ordinates, the ionization currents. It appears that the shortening of the wave-lengths, due to an increase of filtration from 4.08 mm. to 10.2 mm. of aluminum, although perceptible, does not amount to very much. The reduction in the intensity of the roentgen radiation by the filter, however, appears very marked. The maximum ionization current due to the filtered rays amounts to only 37 per cent of that due to the unfiltered rays. In these curves the voltage, 68,200, was not large enough to produce the K series of characteristic x-rays.

The curves in Plate IV represent experiments at a voltage of 115,000 volts. In this case the voltage is high enough to produce the K series of x-rays, and they are represented by the peaks of curve A. Curve B represents the effect produced by increasing the filtration from 1.1 mm. of copper to 3.3 mm. of copper. It appears that the latter filtration almost suppresses the peaks on the curve corresponding to the K series of tungsten, and that almost all of the wave-lengths of the x-rays that get through the 3.3 mm. filter are shorter than those of the K series. These curves represent normal filtration.

In abnormal filtration the filter, in general, reduces the intensity of longer waves more than of shorter waves, except at a certain critical wave-length. At this wave-length there appears a very marked reduction in the intensity of the x-rays that are shorter than the critical value as compared with those that are longer. The curve in Plate V represents the results of an experiment with a filter of mercury, the marked drop in the curve indicating increased absorption for short wave-lengths at the point corresponding to $\lambda = 0.149$.

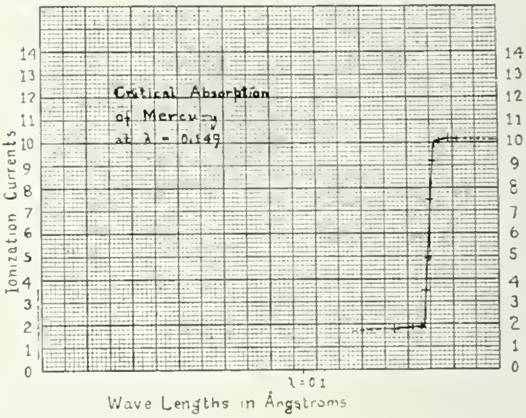

Plate V.

The exact wave-length at which this abnormal absorption occurs depends upon the chemical element, or elements, used in the filter. Each chemical element has such critical wave-lengths. Evidently if filters are used to cut down the intensity of x-rays of long wave-lengths, and thus increase the average penetration of the whole beam of rays, care must be taken to choose filters containing chemical elements that do not have characteristic wave-lengths in the region of the spectrum employed. Otherwise, the effect of the filter will be the reverse of that desired. For purposes of record, Table IV has been inserted.

It contains the values of those critical wave-lengths measured by the ionization method that lie in or near the region of x-ray spectra usually employed.[4] A list of all such critical wave-lengths may be found in a report on Data Relating to X-Ray Spectra, published by the National Research Council.[3]

As an illustration of the use to be made of this data let us suppose that we are applying a voltage of 115,000 volts to the x-ray tube, as in the experiment illustrated in Plate IV. According to the law represented by equation 4, the minimum wave-length produced under these circumstances to much has a value of $12{,}354 \div 115{,}000$,

Table IV

CRITICAL ABSORPTION WAVE-LENGTHS OF CERTAIN CHEMICAL ELEMENTS

Element	Wave-length	Element	Wave-length	Element	Wave-length
Rubidium	0.8143	Indium	0.4434	Dysprosium	0.2308
Strontium	0.7696	Tin	0.4242	Tungsten	0.1786
Yttrium	0.7255	Antimony	0.4065	Osmium	0.1683
Zirconium	0.6872	Tellurium	0.3896	Platinum	0.1582
Niobium	0.6503	Iodine	0.3737	Gold	0.1534
Molybdenum	0.6184	Caseium	0.3444	Mercury	0.1491
Ruthenium	0.5584	Barium	0.3307	Thallium	0.1448
Rhodium	0.5330	Cerium	0.3068	Bismuth	0.1373
Silver	0.4850	Neodymium	0.2861	Thorium	0.1132
Cadmium	0.4632	Terbium	0.2398	Uranium	0.1075

which equals 0.107. The spectrum contains all waves longer than this. If we examine Table IV we see that the critical absorption wave-length for such an element as tungsten is .178. If, therefore, we use tungsten as a filter it would cut down *x*-rays of wave-lengths lying between 0.107 and 0.178 to a very much greater extent than wave-lengths longer than 0.178. Tungsten, therefore, would not be a suitable substance to use as a filter. The same is true of lead, platinum, gold, and all the other chemical elements near tungsten in the table. One might use silver, however, which has a critical wave-length of 0.485: for this lies some distance beyond the part of the spectrum employed.

VIII. CONSTANT VS. VARIABLE VOLTAGE

It has been shown experimentally that the distribution of energy in the *x*-ray spectrum is about the same for a constant voltage applied to the *x*-ray tube as for an alternating voltage.[6] In these experiments no filtration was used. One might expect that for heavy filtration there would be a difference in the distribution of energy. In order to decide the question by experiment I have made measurements with 4.08 mm. of aluminum and 10.2 mm. of aluminum filtration. In order not to produce the K radiation of tungsten and to have a pure, continuous spectrum of *x*-rays, I applied first a constant voltage of 68,200 volts to the tube, and then an alternating voltage, the peak value of which amounted to 68,200 volts. The curves representing the measurements appear on Plate VI.

As in previous cases, the minimum wave-length is the same for both curves. In other words, the peak of an alternating voltage determines the minimum wave-length of the *x*-rays produced. It appears, however, from the curves, that in the case of the constant voltage there is more radiation in the short wave-length *x*-rays, as compared with the long, than in the case of the alternating voltage. An exami-

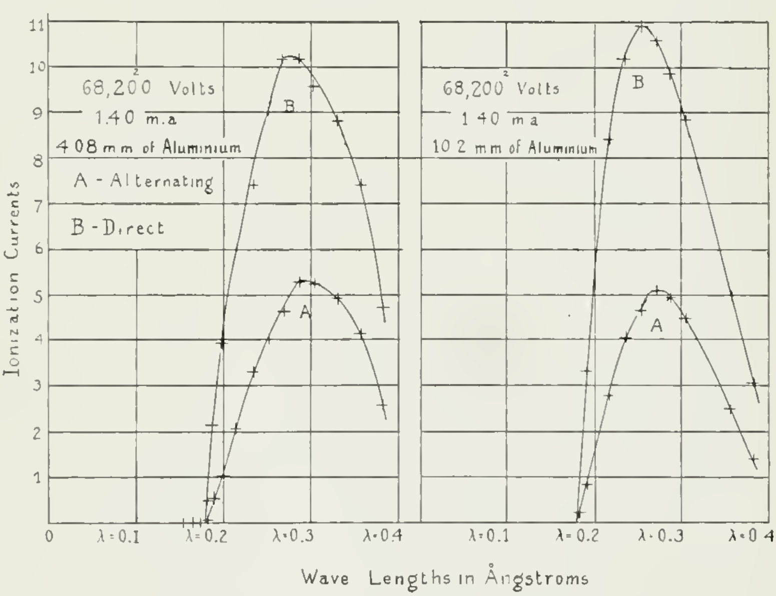

Plate VI.

nation of the curves indicates that about as much shortening of the wave-length occurs on passing from an alternating to a constant voltage as is produced by increasing the filtration from 4.08 to 10.2 mm. of aluminum. Instead of reducing the intensity of the radiation, however (as in filtration experiments), the constant voltage increases the intensity, as compared with the alternating voltage. The maximum ionization current is more than twice as large for the constant as for the alternating voltage, when the same number of milliamperes pass through the x-ray tube.

IX. EFFECT OF DIRECTION OF x-RAYS

As shown in Section VI above, the point representing the minimum wave-length at a given voltage is the same for x-rays coming from the tube in a direction normal to the cathode stream as for x-rays coming from the tube in some other direction. It has been known for a long time that the rays coming from a tube in the direction in which the cathode rays travel are, on an average, somewhat more

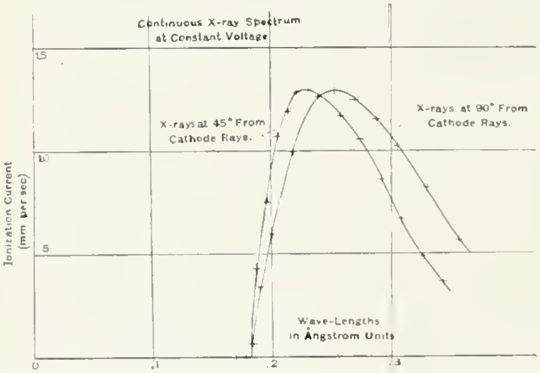

Plate VII.

penetrating than in other directions. It has been found by experiments that in the spectrum of these rays there is more energy radiated in the short wave-lengths, as compared with the long, than for rays in other directions.[5] In order to investigate this point in the case of high filtration, I made some measurements with a voltage of 68,200 volts on rays coming from the tube at right angles to the cathode stream and at an angle of 45° from it. The curves in Plate VII represent the results obtained. There appears to be quite a marked shifting of the curve toward the shorter wave-lengths for the 45° angle. The effect is larger than in the case of a change of filtration from 4.08 to 10.2 mm. of aluminum.

From these experiments it seems probable that the most penetrating beam of rays could be obtained by constructing the tube with a fairly thin target (perhaps water cooled), and by using the rays coming through the target and travelling in the direction of the cathode stream. In this case the target itself would act as a filter. Since, as explained in Section VII, tungsten should not be used as a filter on account of the fact that its critical absorption wave-length lies in the region of the spectrum used, it would be advisable to employ some other metal as a target. Probably molybdenum would be the best.

X. COMPARISON OF x-RAYS WITH γ-RAYS

It is evidently a question of considerable importance to determine the ratio of the radiation coming from a given quantity of radium (or emanation) to that due to an x-ray tube operated under given conditions. If we wish to investigate the direct radiation in these cases, great care must be taken to cut off, as far as possible, all scattered and secondary rays. Figure 4 represents the arrangement of apparatus in some experiments I have performed to investigate this question. In order to reduce the effect of scattered and secondary rays to a minimum, the source of the radiation was placed in one room and the measuring apparatus in another. The direct rays from the source (either a tube containing radium emanation or an x-ray tube) placed at A in Plate VI passed through a hole one inch in diameter in a lead plate one cm. thick, and thence through a brick wall, B, 20 cm. thick. The lead plate and brick wall cut off almost all of the stray radiation. A slight amount, however, leaked through in the case of the emanation tube, but its effects were measured and corresponding corrections made for it. After coming through the hole in the wall the rays passed through a glass vessel, C, 10 cm. long and with very thin windows in its ends. This vessel could be filled with water, and thus the amount of radiation absorbed and scattered in 10 cm. of water could be determined. After coming through the water vessel the rays passed through a hole in a lead plate, D, and thence into an ionization chamber, E. The currents in this ionization chamber could be measured by means of an electrometer, as described in Section II above. The Plate VI records the distances between the various pieces of apparatus. The data obtained in several experiments appear in Table V. Column 1 contains a description of the source of the rays, column 2, the amount of lead traversed by the rays before passing through the hole in the wall, and columns 3 and 4, the ionization currents

TABLE V

Source of Rays	Filtration Thickness of Pb, Mm.	Ionization Current		Percentage Through H_2O
		No H_2O	10 Cm. of H_2O	
50 mc. of emanation	2.0	3.36	1.44	43.0
50 mc. of emanation	3.7	2.88	1.28	44.5
X-rays, 109,000 volts	4.0	Too small to measure		
X-rays, 109,000 volts	3.0	3.85	0.591	15.4
X-rays, 109,000 volts	2.0	Too large to measure		
X-rays, 80,000 volts	2.5	2.55	0.382	14.9

expressed in arbitrary units. In column 5 appear the percentages of the radiation that get through 10 cm. of water in the various cases. In each x-ray experiment 1.0 ma. passed through the x-ray tube.

The experimental conditions in these experiments were so chosen as to produce ionization currents of the same order of of magnitude in the case of x-rays as in the case of γ-rays. It appears from column 3 that the rays from 50 mc., after they have passed through slightly more than 3 mm. of lead, produce the same ionization current as the rays from the x-ray tube produce after they have passed through the same thickness of lead, if a voltage of 109,000 volts drives a current of 1.0 ma. through the tube. Anyone who has experimented with x-rays knows that only an extremely small fraction of the total radiation gets through 3 mm. of lead. Hence, this experiment indicates how enormous must be the intensity of radiation coming from an x-ray tube, as compared with that produced by the penetrating rays from a few millicuries of emanation. Further, column 3 in the table shows that a great difference exists between the penetrating powers of the rays through lead coming from the two sources respectively. An increase in the thickness of the lead filter of 1.7 mm. reduces the ionization current due to the rays from the emanation from 3.36 to 2.88 only, whereas in the case of the x-rays a change of 1 mm. in the thickness of the lead makes the ionization current either too small to measure or too large to measure with the apparatus as it was set up.

The data of columns 4 and 5 indicate a similar difference in the penetration of the rays from the two sources through water. The increase in the thickness of the lead filter of 1.7 mm. increases the percentage of the radiation that gets through 10 cm. of water from 43 to 44½ only. In other words, such an increase in filtration does not produce much increase in the penetration through water.

In the case of the rays coming from the x-ray tube, the fraction that gets through 10 cm. of water amounts to only about 15 per cent, i.e., about one-third the percentage of γ-rays that gets through the 10 cm. of water. The change of voltage from 80,000 to 109,000 volts increases the percentage that gets through the water from 14.9 to 15.4 only. This experiment furnishes a good illustration of the abnormal absorption of the rays by the lead. The critical absorption wave-length of lead lies in the region of the spectrum of these x-rays. The lead almost completely absorbs all the waves shorter than this critical absorption wave-length, so that an increase in voltage does not increase the amount of radiation of short wave-lengths to any very great extent.

XI. PENETRATION OF HOMOGENEOUS X-RAYS THROUGH WATER

In the experiments described in Section X the rays were not analyzed by means of the spectrometer. The beam, therefore, contained rays of a great variety of wave-lengths. I have made experiments with the spectrometer and with the vessel containing the water to see whether or not homogeneous x-rays of greater penetration than that recorded in Section X could be obtained. In order to suppress, as far as possible, secondary and scattered radiation, I placed the water vessel between the *x*-ray tube and the hole in the lead plate and brick wall (Fig. 3), an *x*-ray tube without the side tube being used. It appears that for very short waves (in the neighborhood of .1 ångström) a decrease in wave-length makes very little increase in the penetration. This means that the term $a\lambda^3$ in equation 1 has become small in comparison with b. It is probable, however, that equation 1 represents only an approximation to the truth.

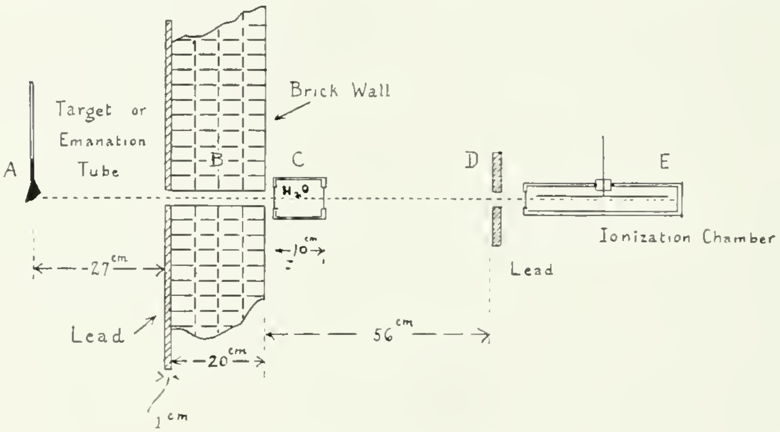

Fig. 4.

In the case of the most penetrating rays that I have been able to produce, about 20 per cent of the roentgen radiation passes through 10 cm. of water.

XII. SUMMARY

This paper has described (a) an accurate method of controlling and measuring the voltage applied to an *x*-ray tube, (b) a delicate spectrometer for analyzing the spectrum of the *x*-rays, involving very thorough protection of the instruments from disturbances due to stray roentgen radiation and to the high potentials applied to the tube.

It contains the results of experiments on the means to employ in order to reduce the value of the term $a\lambda^3$ in the equation that gives the distance to which the rays travel through matter before half the radiation has been absorbed, namely

$$D = \frac{693}{a\lambda^3 + b} \qquad (1)$$

A *decrease* in $a\lambda^3$ means an *increase* in the penetration, D, of the rays.

The product $V\lambda_m$ (V = voltage in volts, and λ_m = shortest wave-length produced in ångströms) is a constant for all voltages and all tubes. An accurate measurement of this important constant has been made (Section VI). It equals 12,354, and appears to be the same for rays coming off in different directions from the tube. From the equation

$$V\lambda_m = 12{,}354 \qquad (4)$$

we can calculate immediately the shortest wave-length in the spectrum produced by a given voltage (either constant or peak), or we can calculate the voltage required to produce waves as short as any given wave-length.

The double valve generating plant described in Sections III and IV produces voltages that are constant enough for fairly accurate measurements. The constant voltage obtained equals twice the peak voltage produced by the transformer.

It appears from the curves shown in the various plates that the *x*-rays, even at constant voltage, are never homogeneous,[2] but that they contain large amounts of radiation of longer wave-length than the minimum wave-length given by equation 4.

From the results described in Section VII we conclude that, in general, the radiation of long wave-lengths may be cut down by filtration more than the radiation of short wave-lengths, and thus, on the average, a shortening of the wave-length may be produced. Although this effect is very marked for the first few millimeters of aluminum used as a filter,[2] yet the shortening of the average wave-length due to an increase of thickness of aluminum from 4.08 to 10.2 mm. amounts to only a few per cent. The curves of Plate III indicate that the wave-length corresponding to the maximum ionization current becomes only - per cent shorter when this increase in filtration is made. A - per cent decrease in λ means, however, a 20 per cent decrease in the term $a\lambda^3$ of equation 1. The above change in filtration reduces the radiation to about 38 per cent of its original value. We conclude, further, from Section VII that great care must be taken not to choose a filter that has a critical absorption wave-length in the region of the spectrum used, for such a filter would reduce the intensity of the short x-rays much more than the intensity of the long x-rays. Table IV contains the critical absorption wave-lengths of various chemical elements that lie in the region of the x-ray spectrum usually employed.

According to the results described in Section VIII, the minimum wave-length of the rays produced by a constant voltage is the same as the minimum wave-length produced by an alternating voltage the peak value of which equals the constant voltage. On the average, however, the constant voltage produces shorter waves than the variable voltage. Although this effect is small for unfiltered rays,[6] it becomes quite appreciable in the case of high filtration. The curves in Plate VI show that the wave-length corresponding to the maximum ionization current decreases some 7 per cent, if a constant voltage is employed instead of an alternating voltage. A 7 per cent decrease in λ means a 20 per cent decrease in the value of $a\lambda^3$ of equation 1. The use of a constant voltage instead of an alternating voltage, therefore, produces about the same shortening of the waves as an increase of filtration from 4.08 to 10.2 mm. of aluminum produces. In addition to the shortening effect the constant voltage produces a radiation of much greater intensity than the alternating voltage.

Although (from Section V) the minimum wave-length appears to be the same for rays coming from the tube in different directions, the average wave-length may be shorter in some cases than in others. It has been known for a long time that the rays coming from an x-ray tube in the direction of the cathode particles are somewhat more penetrating than those coming off in other directions. The curves on Plate VII show that (in the case of high filtration) for the x-rays passing off in a direction making an angle of 45° from the direction of the cathode rays, the wave-length corresponding to the maximum ionization current is about 10 per cent shorter than for the rays coming off at right angles to the cathode stream. A 10 per cent decrease in λ means a 27 per cent decrease in the value of the term $a\lambda^3$ in equation 1.

The results obtained in comparing the ionization currents due to rays from emanation with those from an x-ray tube show that the currents due to 50 mc. of emanation are about the same as those due to 1.0 ma. through an x-ray tube at 109,000 volts, if the rays pass through a little more than 3 mm. of lead. Since very little roentgen radiation gets through 3 mm. of lead, this indicates how very much more intense the radiation from an x-ray tube is than that from emanation.

The results tabulated in Table V show that very little increase in the penetration of the γ-rays through water is produced by increasing the thickness of the lead filter from 2 to 3.7 mm. and that very little increase in the penetration of the x-rays through water is produced by increasing the voltage from 80,000 to 109,000 volts. This latter fact illustrates the effect of abnormal absorption. Further, under the experimental conditions described, the percentage of γ-radiation that passes through 10 cm. of water amounts to 43 or $44\frac{1}{2}$ per cent, while the percentage of roentgen radiation that passes through the 10 cm. of water amounts to about 15 per cent, i.e., to about one-third of the percentage of γ-radiation that gets through the water. It must be borne in mind that in these experiments scattered and secondary radiation has been, as far as possible, eliminated.

Experiments on the penetration of homogeneous x-rays through water indicate that very little change in the value of D (equation 1) occurs due to a change in the wave-length, λ, if λ lies in the neighborhood of .1 ångström. In the case of the most penetrating rays produced, about 20 per cent of the roentgen radiation passed through 10 cm. of water.

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THE SUPERNUMERARY PEDAL BONES*

BY MORRIS I. BIERMAN, B.S., M.D.

Roentgenologist and Chief of Laboratories, U. S. Veterans' Hospital No. 35

ST. LOUIS, MISSOURI

It is generally taught that the tarsus is composed of seven bones, the astragalus, calcaneus, naviculare, cuboid, and the medial, middle and lateral cuneiforms. This is but partly true. There are in reality almost three times this number of bones, but, inasmuch as they do not occur constantly, are of relatively small size, and were until comparatively recently considered to be sesamoid bones, but little attention has been given to them. Anatomies either do not mention them at all, or else mention only a few of the more important ones in small print at the end of the chapter on osteology. The student of anatomy, in the course of his prescribed studies, never hears mentioned the names of these important, so-called supernumerary bones.

In 1605, Bauhin, the anatomist, described the tibiale externum. Since that time, the same ossicle and other variable bones have been described by many anatomists, chief among whom are Vesalius, Steida, Gruber, Rosenmüller, Morel, Thilinius, Pfitzner and Dwight. Little by little, the presence of these bones has been shown to be due to the ossification of cartilaginous centers which are present in the feet of human embryos. These embryonic feet contain many such centers indicating bones which during development either entirely disappear or fuse with other centers, to represent tubercles or prominences of the well-developed constant bones. In a definite percentage of cases they persist either as independent supernumerary bones, or as well-marked processes attached to the constant bones.

In the course of this metamorphosis a great majority of the cartilaginous centers lose their identity during an early period of development, but certain centers of ossification join other centers and proceed to form a composite bone. When these centers of ossification persist as separate bones, they belong to that class of structures which, for want of a better name, are called the "supernumerary ossicles." The supernumerary ossicle may become connected with one or more of the adjacent bones by a true joint, or may have a ligamentous attachment. More frequently it is actually fused with a neighboring bone, or connected by fibro-cartilage, but yet so clearly marked off on the surface that there is no question as to its identity. Only when it is so completely fused with another bone that it loses its own characteristics is its nature in doubt.

In order to gain a better idea as to the nature of these bones, I have made composite drawings of the foot of an adult, both dorsal and plantar views, which show the supernumerary ossicles in their usual relationships to the constant elements. The variations in size, shape, and position of the individual ossicles are not of sufficient degree to cause any difficulty in their recognition when seen

* Approved for publication by the Surgeon-General.

in the macerated foot or in the roentgenogram, once their general characteristics and positions are fixed in mind (Figs. 1 and 2).

The following is a tabulation of all the supernumerary ossicles which, up to the present time, have been found on dissection and proved to be true bony variants. To this there is but one exception, and that is the secondary astragalus which was seen in a stereoscopic picture, and which the writer has described in another publication. With this one exception all the bones are firmly established as true supernumerary ossicles.

1. Astragalus
   (a) trigonum
   (b) astragalus secondarius
2. Calcaneus
   (a) os sustentaculi
   (b) calcaneum secondarium
3. Naviculare
   (a) tibiale externum
   (b) supranaviculare
4. Cuboideum
   (a) cuboideum secondarium
5. Cuneiforme primum
   (a) cuneiforme I bipartitum
6. Cuneiforme secondum
   (a) intercuneiforme
7. Cuneiforme tertium
   (a) os unci (processus uncinatus cuneiformis)
   (b) Intermetatarseum
   (c) Os vesalianum
   (d) Os peroneum

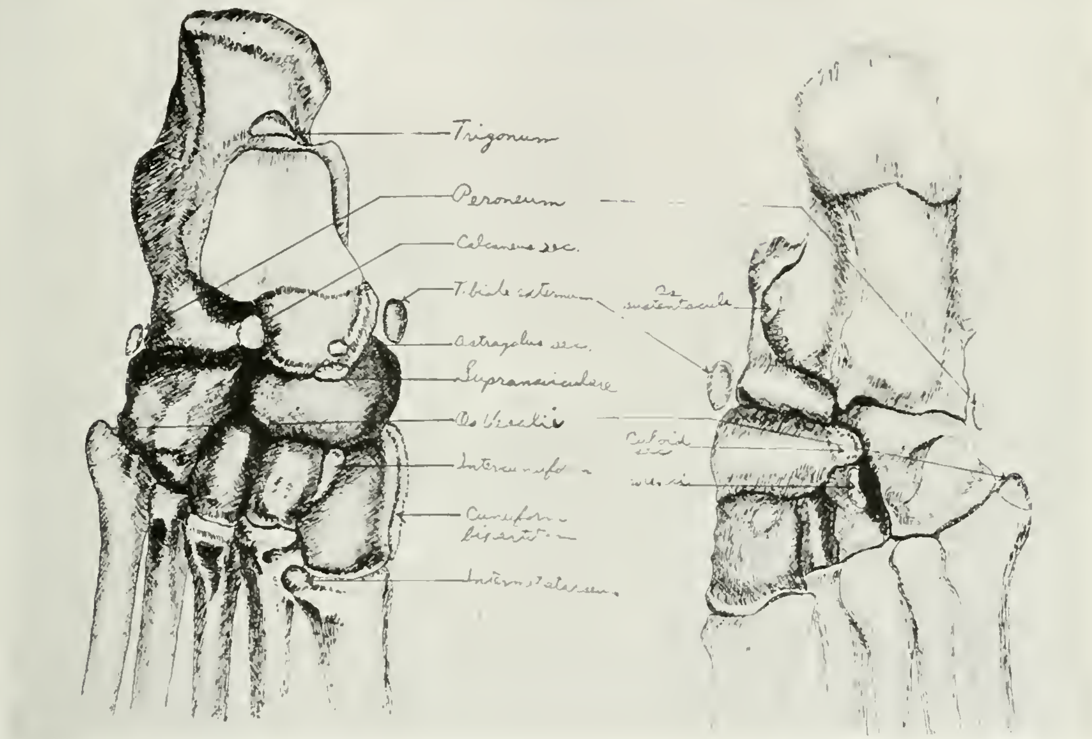

FIG. 1. Dorsal view. Composite foot showing all known supernumerary bones.

FIG. 2. Plantar view. (Same foot as Fig. 1.)

Normal bones		7
Supernumerary ossicles		13
	Total	20

Trigonum. This is the best known of the supernumerary tarsal bones, and is probably the one most intensively studied. The first accurate description was by Schwegel in 1858, although it was first recognized by Rosenmüller in 1804. The frequency of the occurrence of this ossicle varies with the opinions of the different writers. Some consider as the trigonum the ossicle in either its fused or unfused state. Others insist on the independent form. In general it would appear that it can be either found entirely independent, or distinctly marked off on the surface in about 10 per cent of all feet.

The os trigonum may be connected with the astragalus by means of fibrous tissue, or the opposed surfaces of the bones may be covered with a thin line of hyaline cartilage and separated by a joint cavity which may be continuous with the cavity of the posterior astragalo calcaneal articulation. It may be fused with the astragalus, or the only evidence of its original independence may be a groove on the under articular surface which separates the posterior articular surface of the calcaneus into pars propria and pars trigona. In size, the trigonum is usually from 15 to 22 mm. in a transverse direction, and from 10 to 15 mm. in both the sagittal and vertical directions.

Fig. 3. Trigonum.

For presentation in the roentgenogram this bone probably has the most favorable position of all the supernumerary ossicles. In a lateral view of the ankle it will be found at the posterior edge of the astragalus, bordering on the superior surface of the calcaneus (Fig. 3).

Astragalus Secondarius. This is a small, oval ossicle lying above and behind the head of the astragalus, near the anterior portion of the neck, apparently posterior to the dorsal talonavicular ligament. There is no record in the literature of this ossicle having been described, other than that reported by the writer, and since it has never been found at dissection, it must be classed with those supernumerary structures which are still considered doubtful. Figure 4 is a reproduction of the writer's case.

Os Sustentaculi. This is a small, wedge-shaped bone which comprises the upper posterior end of the sustentaculum tali. Its size is about 10 mm. in a transverse direction, 7 mm. in a sagittal direction, and its greatest thickness about 4 mm. So far as could be found in the literature, there were no cases reported other than the two reported by Pfitzner, who first saw the bone in 1896. It is, therefore, quite rare, and represents an originally independent skeletal piece that has not yet been entirely assimilated by the calcaneus. The upper surface of the os sustentaculi completes the joint surface of the sustentaculum, and articulates with the collum tali. Its under surface coalesces with the sustentaculum.

Fig. 4. Secondary astragalus.

Up to the present time it has not been shown in a roentgen-ray film, and it is doubtful whether it ever will be. Its anatomical position is such that it cannot be shown on standard anteroposterior views of either the ankle or foot. It would seem possible, however, that it might be shown when the foot is in a position about midway between these two standard positions, but probably not otherwise.

Calcaneum Secondarium. This was first described by Steida in 1867. Though very few cases have been reported, it probably is not as rare as is commonly supposed. Pfitzner found it 17 times in 840 cases, about 2 per cent. The bone is generally small and of irregular shape. It forms the anterior upper edge of the anterior part of the calcaneus (the so-called processus anterior calcanei). Its greatest diameter is the transverse. In the well-developed form it is approximately 12 to 15 mm. long, 8 mm. wide, and 5 mm. thick, and stretches as a bridge between the calcaneus and os naviculare. At other times it lies dorsally in the intervening space which is bordered by the calcaneus, astragalus, naviculare and cuboid. Dwight considers the secondary calcaneus to be an entirely different structure, which is not here discussed.

Fig. 5. Calcaneum secondarium (after Lillienfeld).

The bone is fairly well shown in a lateral view in a roentgenogram. Most commonly it is found fused with the calcaneus, as its independent condition is quite rare. Due to its irregular form, confusion with a bony fragment following injury can not always be excluded (Fig. 5).

Tibiale Externum. The tibiale externum has been known for many hundred years. It was first described by Bauhin in 1605, and was for many years known as the "sesamoid bone in the tendon of the musculus tibialis posticus." It is a pyramidal-shaped bone, and lies in the medial angle between the naviculare and astragalus, therefore behind the former and medial to the latter. Its base borders directly on the tuberosity of the naviculare; the longest measurement being about 12 mm. and its transverse measurement about 9 mm. The rudimentary forms are somewhat roundish and lie free in the soft tissues. Usually some fibers of the medial end of the end tendon of the m. tibialis posterior, as well as the l. calcaneonaviculare, insert into it.

Its favorable position permits it to be well shown on the film when roentgenographed in the dorsoplantar direction (Fig. 6).

Fig. 6. Tibiale externum.

Supranaviculare. This is an extremely rare supernumerary bone which may have been described by Pfitzner, but certainly was by Pirie and Paccini. The writer has examined a patient who showed this bone developed bilaterally. The ossicle is situated on the upper posterior border of the naviculare, and articulates both with the naviculare and the head of the astragalus. It is best shown on the roentgenogram in a lateral view (Fig. 7).

Cuboideum Secondarium. The secondary cuboid, first described by Schwalbe, is rarely found as an independent bone. It is usually fused with either the cuboid or naviculare; more frequently with the latter. In fact, the expectation is to find it fused with the naviculare, though its fusion with the cuboid must be kept in mind. When it is united to the naviculare it is situated at its lower, outer edge, and astragalo-cuboid articulation. At times it is so placed with reference to the naviculare as to be directed proximally into the sole of the foot. More frequently, however, it is attached to the lower part of the naviculare, giving the latter a four-sided characteristic outline. At other times it is so directed as to border on the cuboid. the latter becomes quadrate in form. When fused with the cuboid there results the When this condition occurs, the cuboid and naviculare are in contact, and may be connected by fibro-cartilage.

Fig. 7. Supranaviculare.

In connection with the alcaneum secondarium, Pfitzner describes the os cuboideum secondarium as an abnormal process of the cuboid which presents an abnormal articulation between this and the head of the astragalus, but which has not yet been found separate in the adult. In differentiation from the os calcaneum secondarium, he believes that it is situated more plantar and tibialwards, while the latter lies more dorsally and fibular. Probably both of these forms are identical.

Its independent condition is very rare, and is evidenced by the fact that Pfitzner never saw it entirely separated. In the accompanying reproductions it is unusually well shown (Fig. 8 and 9).

Os Cuneiformis I Bipartitum. This anomaly was first described by Morel in 1757, and occurs in about 0.3 per cent of all feet. The plane of division is always parallel to the plantar surface of the medial cuneiform, and appears so smooth that any confusion whatsoever with a fracture is out of the question. On the distal surface the line of division is seen to be midway between the dorsal and plantar borders, while on the proximal

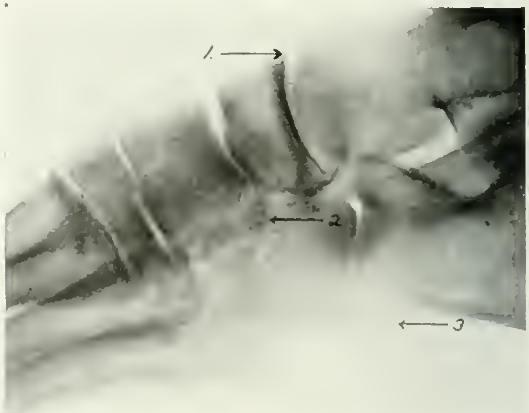

Fig. 8. Lateral view. (1) Supranaviculare; (2) cuboidium secondium; (3) peroneum.

surface the division is usually into small dorsal and large plantar halves.

The literature has no record of any one having identified it on a roentgenogram, but it should be best seen with the inner side of the foot on the plate, and should not be very difficult to show.

Intercuneiforme. The intercuneiform has so far been observed only by Dwight, and so his description must suffice: "This is a small wedge-shaped bone with a dorsal triangular surface situated on the dorsum of the foot close in front of the scaphoid, separating the proximal parts of the internal and middle cuneiform bones, but apparently cut off from the latter rather than from the former . . . The interpretation of roentgenograms of this region of the foot strikes me as difficult. I think I have seen this bone thus shown at least once, but I do not dare to feel sure of the observation."

Os Unci. To quote Pfitzner: "In the human family I found only one individual case of a process on the plantar surface of the lateral cuneiform which exactly corresponds to the processus uncinatus of the cat." Lillienfeld has described a case in which he found a small bone corresponding to the size and position of the processes uncinatus, an os unci. The ossicle is crescentric in shape, so that the concave surface turns toward the cuneiform, while the convex part somewhat covers the naviculare shadow.

it is unfavorably situated for presentation, since in this region the shadows of the neighboring bones are superimposed, and the lines are quite confusing. Perhaps its rarest condition is that shown in Figure 10, where it is seen to be fused with the first metatarsal (Fig. 10).

Os Vesalii. The vesalianum is extremely rare. In over 2,000 cases Pfitzner did not see it at all. Gruber saw it 3 times

Fig. 9. Anteroposterior view. (Same foot as Fig. 8.) (2) Cuboidium secondarium; (3) os peroneum; (4) os unci; (5) tibiale externum.

Fig. 10. Intermetatarseum (fused).

In addition to its great rarity, this bone is extremely difficult to show on the roentgenogram on account of the numerous confusing lines in the region of the cuneiform bones. It is unusually well shown in Fig. 9.

Intermetatarseum. It must be remembered that when Pfitzner calculated a frequency of about 10 per cent of this ossicle he did not, in his classification, consider only the entirely independent ossicles, but included all the three neighboring abnormal processes of bone, which he held to be fused intermetatarsei.

When the bone is entirely independent

in about 5,000 cases dissected. It lies on the lateral edge of the foot in the angle be een the cuboid and the 5th metatarsal, and articulates with both. The bone is pyramidal in shape with the apex directed posteriorly. The base is about 8 mm. in a lateral direction and 12 mm. in the dorsoplantar direction. From base to apex it is about 10 mm. The base, which is at a right angle to the long axis of the 5th metatarsal, usually coalesces with a corresponding surface on the posterior end of that bone. Postero-medially it articulates with the cuboid.

It is easily seen in the roentgenogram.

Geist reported seeing it once in 100 cases, and Kleinberg, 3 times in about 300 feet examined by means of the roentgen ray. Either these writers were extremely fortunate, or else their cases were instances of unfused proximal epiphyses. The writer has never seen what could be with certainty called an os vesali pedis in the adult (Fig. 11).

Os Peroneum. The peroneum was first described by Vesalius, but more accurately and completely by Pfitzner, who showed that it is a supernumerary ossicle, and not a sesamoid bone in the tendon of the peroneus longus. In the well-developed form, the tendon of the m. peroneus longus passes over it and is united to it by only a few fibers, while the migrated rudimentary form is entirely enclosed by the tendon. It does not appear to articulate with the cuboid, near whose lower lateral border it is placed. Form and size vary, so that it is difficult to assume a normal. It is frequently subdivided. According to Pfitzner it is seen in about 8 per cent of all feet. It frequently escapes observation, with the plantar surface of the foot on the film, but is best seen in the lateral views with the lateral side of the foot on the film (Figs. 9 and 12).

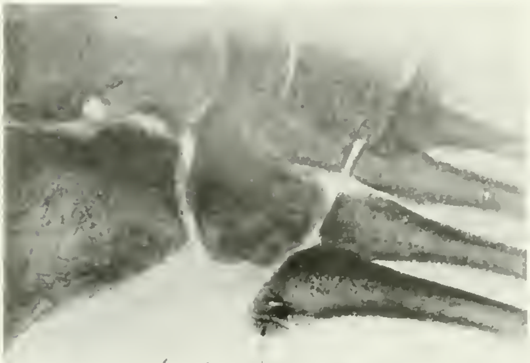

Fig. 11. Os vesalii (after Dwight).

Fig. 12. Os peroneum (divided).

From the foregoing descriptions of the individual supernumerary bones it is quite evident that most of them appear relatively frequently in the normal foot. It is usually not difficult to determine that an additional structure belongs to this variable class of bones. Where there is a variant present, it is the rule to find other evidence of developmental variations. For instance, if an os vesalianum is present, search for other evidences of developmental variations will usually result in finding other variations, probably not so pronounced, but definitely present, such as an os tibiale externum or os peroneum. Or, less easily recognized supernumerary bones may be present, such as a fused os trigonum or fused secondary os calcis. Such variations are at times very difficult to recognize, but the more we look for them the more often we recognize them. There is hardly a hand or a foot which has not some slight variation from the so-called normal; and when a distinct supernumerary bone appears, the other evidences of developmental variations are more numerous.

It is evident that the term "supernumerary ossicle" is a misnomer. The bones are not supernumerary; rather, they are lacking from the original plan in the average foot of today. It is probably true that they are reappearing less and less often, but it will undoubtedly be many thousands of years before they disappear entirely. They appear in the feet of mummies found in Egypt. Incidentally, Pfitzner found one of the largest tibiales externum he ever saw in a mummy about 5,000 years old. The other bones were about the same as are found in the foot today. If these supernumerary ossicles are elements which were once constant structures, and there is no doubt that this is true, and they are now appearing only infrequently in the human foot, our attention is struck by the fact that very little morphological change has taken place in the foot during the last 5,000 years. It may be that the morphological changes were accelerated by the change in posture to the standing position, but all in all, we can but marvel at the antiquity of the human race.

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THE RECTOSIGMOID APPARATUS*

BY HORACE W. SOPER, M.D.

ST. LOUIS, MISSOURI

ANATOMICAL CONSIDERATIONS

The iliac colon extends from the crest of the ilium to the inner border of the left psoas muscle. It is the only portion of the lower colon that is always accessible to palpation. The pelvic colon forms a freely movable loop, varying in length from 5 to 33 inches, the average length being about 17 inches. It has no constant position, but in its most typical arrangement passes from the termination of the iliac colon at the inner border of the left psoas muscle, loops to the right, and ends in front of the third sacral vertebra, where its junction with the rectum forms the pelvirectal flexure. The rectum is between 4 and 5 inches in length and lies in contact with the sacrum and coccyx. At its termination the rectum bends slightly backwards and merges into the anal canal. The anal canal, about 1 to 1¼ inches in length, is directed downwards and backwards, forming almost a right angle with the rectum. It forms a narrow canal with longitudinal folds of mucous membrane, surrounded by the muscle fibers that form the external and internal sphincter apparatus.

It is impossible to enter into a description of the diseases that involve the lower intestinal tract without some consideration of the topography of the entire colon. The usual description above applies very well to the average normal subject as the organs appear at autopsy. In the living individual, the anatomical relationships are not constant, but vary with the structure or bodily habitus of the individual.

Mills, in his work on habitus, has demonstrated that the visceral contents of the abdominal cavity conform to certain definitely recognizable anatomic types. The most striking variation is shown in the differences in the position and form of the stomach. Mention may be made here of the long narrow fishhook-formed stomach of the asthenic, extending to the pelvis, in contradistinction to the almost transverse high stomach of the hypersthenic.

The colon also shows very marked variations corresponding to the bodily habitus of the individual. In the hypersthenic, the sigmoid loop or pelvic colon is high above the pelvic cavity, and really presents but one curve almost circular in character. In the sthenic, the loop is more markedly S-shaped and is contained partly in the pelvis. In the asthenic, a portion of the transverse colon and the pelvic colon are massed together in the pelvic cavity (Figs. 1, 2 and 3). In each instance, the position assumed by the colon corresponds to its particular anatomic type and is not to be considered as pathological. Therefore, from a clinical standpoint, the consideration of the form and position of the lower colon presents, a priori, a very pertinent question, namely, does the colon conform to the bodily habitus, or is there a variation from the individual's anatomic type? For example: the pelvic colon of the asthenic may be pushed out of the pelvis by a tumor mass, or the hypersthenic colon may be tied down in the pelvic cavity by inflammatory processes.

The rectum, also while immovably fixed, shows certain variations corresponding to habitus. In the asthenic type, the anal canal is short, located near the coccyx, and the proctoscope enters at once into a large capacious ampulla. In the hypersthenic individual, the anal canal is much longer, situated further from the lower spine, and proctoscopy reveals a relatively much smaller ampulla. In many hypersthenic individuals I found, by actual proctoscopic measurement (the patient in the knee-shoulder position), that the anal canal was from 2 to 2½ inches in length, while that of the asthenics varied from 1 to 1½ inches in length.

The variation in form, observable in the different anatomic types, is not more striking than the differences exhibited in function. In this connection, one may mention the evident tonicity of the colon in the hypersthenic as compared with the extreme atony of the asthenic colon. The rate of

* Read at a Meeting of the Gastroenterological Society, Boston, June 9, 1921.

motility is high in the hypersthenic, low in the asthenic, intermediate in the sthenic. It may be physiological for the hypersthenic to defecate two or three times daily, while in the asthenic, the rate may be normally so slow as to permit an evacuation but once in two days. The intestinal tube of the sthenic and hypersthenic is well adapted to the high energy requirements of individuals exhibiting this structural type. On the contrary, the intestinal tube of the asthenic with its atonic character, low position and slow rate of motility, places the asthenic individual at a disadvantage in the machinery required for the production of bodily energy.

A predilection for the development of certain pathological conditions may be associated with habitus, e.g., the asthenic is notably predisposed to colonic stasis and more frequently presents the syndrome which is usually termed "autointoxication." Moreover, the pelvic colon, from its low position, is more likely to become involved in pelvic inflammatory processes. On the other hand, the condition known as diverticulosis occurs more frequently in hypersthenics and sthenics.

William J. Mayo[2] has made a very careful study of the rectosigmoid apparatus. He has shown that it consists "of $3\frac{1}{2}$ inches of the intestinal tract, which includes the terminal 2 inches of the sigmoid and the proximal $1\frac{1}{2}$ inches of the rectum." It is the narrowest part of the large intestine and is more often the location of pathological processes than any part of the gastrointestinal tract excepting the stomach and duodenum. Mayo's study is based upon dissections in 46 cadavers. The terminal sigmoid contracture was found in 80 per cent of cases examined. Mayo has shown that the rectosigmoid apparatus is controlled by the pelvic plexus of nerves which is made up of a variable number of sympathetic ganglia joined from above by spinal nerves from the lumbar region and from below by the spinal nerves from the sacral region (Fig. 4).

Fig. 1. Colon in individual of asthenic habitus. This colon is to be regarded as normal for this type. Note that the transverse colon descends well into the pelvis.

Fig. 2. Colon in individual of sthenic habitus. This is the position occupied by the transverse colon in individuals of this type. Note the pelvic colon is well within the pelvis.

Langley[3] and others have shown that nerves derived through the hypogastric plexus are inhibitory in character, while those from the spinal and sacral nerves produce contracture of the muscle-fibers of the intestine upon stimulation.

Fig. 3. Normal colon in individual of hypersthenic habitus. Note that the pelvic colon is really well above the pelvis representing the characteristic position for this type.

Keith[4] has shown that the smooth muscle-fibers in this region have the power of originating contraction and that impulses are collected in certain neuromuscular nodes and correlated.

Mayo and Hurst both are of the opinion that the failure of coordination in early life results in the so-called idiopathic dilatation of the colon, or Hirschsprung's disease. This disease is, therefore, according to Mayo, similar in origin to cardiospasm at the cardiac orifice and ileocecal valve stasis. Hurst[5] has suggested the name of *pelvirectal achalasia* instead of Hirschsprung's disease (Fig. 5). According to Hurst, the active relaxation of the circular muscle-fibers at the pelvirectal juncture fails to occur, and a spasm is originated, which leads to partial obstruction with consequent dilatation and hypertrophy of the pelvic colon. The colon, when once dilated, produces a kink by overhanging the undilated portion below, thus producing increased difficulty in defecation, progressive accumulation of fecal matter and progressive dilatation and hypertrophy of the muscle-fibers of the colon, finally

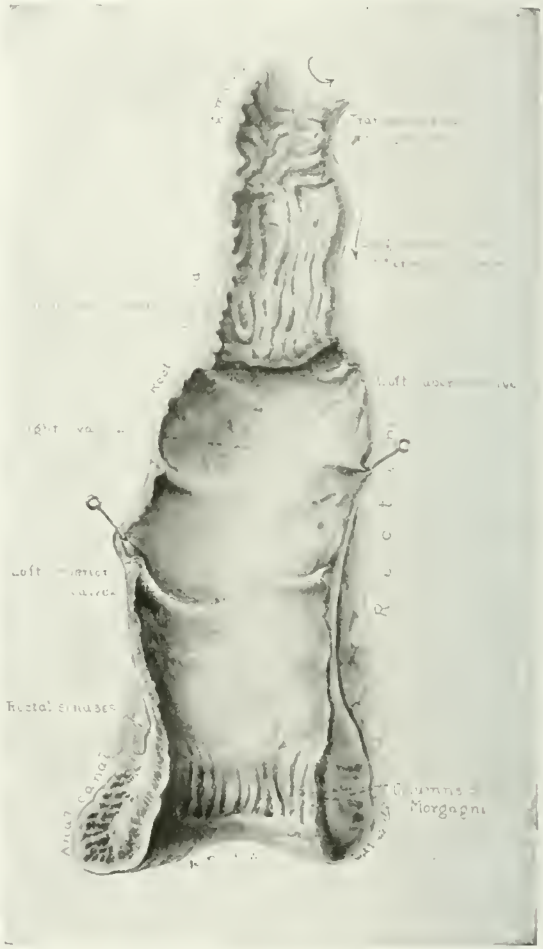

Fig. 4. Terminal sigmoid, rectum and anal canal from inside. W. J. Mayo. Courtesy of *Surgery, Gynecology and Obstetrics*.

resulting in broken compensation with the loss of peristaltic power.

PHYSIOLOGY

Mayo's anatomical studies have led him to the conclusion that the rectosigmoid apparatus is a definite mechanism, which retards the fecal current and prevents continuous progress of the intestinal contents into the rectum. Hurst, who examined a large number of young adults, comes to the same conclusion; he further states that normally the rectum does not contain fecal matter, except during the act of defecation. At other times the fecal column is prevented from entering the rectum by the tonicity of the rectosigmoid apparatus.

The studies of Hurst,[5] Holzknecht,[6] Barclay,[7] Case,[8] and others disclose that

Hurst has demonstrated that about thirty-three hours' time is required for a meal to be entirely evacuated from the gastrointestinal tract. Food taken nine hours before the act of defecation should reach the splenic flexure and part of it appear in the feces. These figures represent the time required for the average healthy individual at active muscular work. Modifications must of course be made for

Fig. 5. Hirschsprung's disease in a child aged ten. Note small rectum and huge over-hanging pelvic colon.

Fig. 6. An enema of 5 ounces of magnesia sulphate solution carrying 35 grams of bismuth subcarbonate. Plate taken two minutes after injection.

the colon is emptied by a series of mass movements. When the fecal column which has been held up at the rectopelvic juncture enters the rectum the desire to defecate is provoked. As Hurst[9] has shown, this desire is not due to stimulation of sensory nerves, inasmuch as they are absent in the rectum except in the mucosa of the anal canal. The reflex is established by means of the "muscle sense" of the distended rectum. The first mass movement empties the rectum and part of the pelvic colon. Secondary mass movements occur and continue until, under normal conditions, the entire large intestine below the splenic flexure is completely emptied.

the asthenic type who habitually have a slower rate of colonic motility, as well as the hypersthenic whose motility is higher than the average individual, as pointed out by Mills in his work on habitus.

While roentgen-ray examination is the best means to determine colonic motility, simpler tests are available, e.g., a 5 gr. carmine capsule or 2 charcoal tablets given with the evening meal should appear (trace at least) in the feces evacuated the following morning. The second morning the entire stool should be colored by the carmine or charcoal. On the third morning there should be no trace of the coloring matter in the feces.

In corroboration and amplification of the work of Mayo and Hurst, the writer has examined a large number of patients, both normal and abnormal, by means of the sigmoidoscope, and has made the following observations:

1. After normal defecation in the morning the rectum contains either no fecal matter or only slight traces adhering to the mucosa.

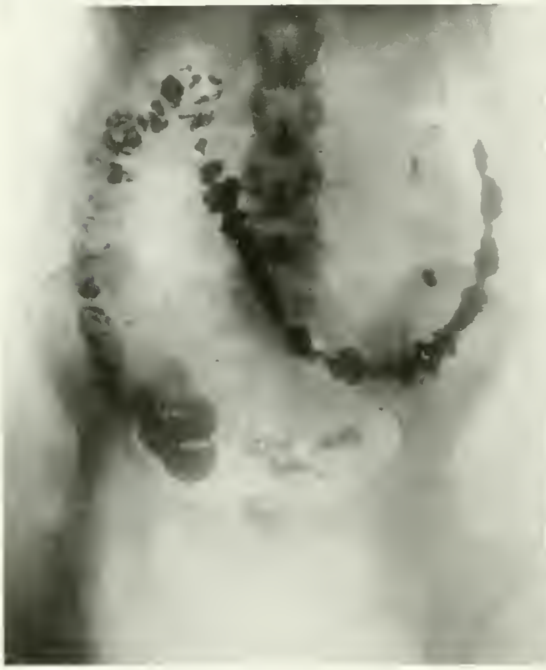

Fig. 7. Barium meal twenty-four hours after ingestion.

Fig. 8. Same case as Fig. 7. Plate taken one-half hour after injection of magnesia sulphate solution and ten minutes after defecation.

2. The normal rectosigmoid apparatus as viewed through the sigmoidoscope includes from 2 to 3 inches of the bowel and it can be seen to alternately contract and dilate synchronous with respiration.

3. Normal cases present considerable variation in the tonicity of the contracture. It is always possible to pass a 5/8 inch caliber tube through it.

4. Normal cases examined in the morning prior to the act of defecation reveal the fact that the fecal column is above or just engaging the rectosigmoid area.

5. The formation of the feces probably occurs in the iliac colon. This is particularly true of the fragmentary form of constipation in which small, hard, round masses appear in the feces.

PATHOLOGY

Mayo has pointed out that in an investigation of the last 100 specimens of cancer of the rectum and rectosigmoid removed consecutively at St. Mary's Hospital, it was found that 63 per cent of the growths involved the rectosigmoid, 30 per cent the rectum only, and 7 per cent the anal canal.

As the writer[10] has shown in previous communications, polypi are frequently found at the rectopelvic angle, also various forms of pus infections often occur; furthermore spasms or hypertonic contractures of the apparatus are a frequent cause of obstinate constipation, a condition which I have described as sigmoidospasm. The writer[11] has further demonstrated that a solution of magnesium sulphate applied directly to the contracted area will bring about relaxation of the contracture; if this treatment be continued for a period of weeks or months it will result ultimately in the correction of the spasm and restoration of colonic function. The majority of the cases of sigmoidospasm are associated with a contracture of the iliac colon; however, they may exist independently of each other. The iliac colon is of extreme interest; it is always palpable; under normal conditions it can be made to contract under the palpating fingers as a rather firm finger-like cord. The contracture will, however, not be persistent, but will relax from time to time. In atony of the iliac colon no such contracture can be elicited by palpation. In spasm of the iliac colon we find the presence of a finger-like cord which cannot be made to relax and which is often tender to pressure. The iliac colon can be reached by injecting the magnesium sulphate solution by means of the sigmoidoscope and a soft rubber tube, with the patient in the knee-chest posture.

Recently we have been working with atonic conditions of the rectosigmoid apparatus and iliac colon. When magnesium sulphate is taken into the stomach it is partly converted into sodium sulphate and magnesium carbonate, substances which increase the contractile phase of peristalsis, according to Meltzer.[12] The remaining unconverted portion of magnesium sulphate stimulates the inhibitory or relaxing phase of peristalsis, thus producing the well-known rush movement of a dose of epsom salts. Meltzer's definition of tonus is as follows: "The resultant effect of the antagonistic action may be manifest at the same place and at the same time. This is tonus. The degree of character of the tonus depends on the preponderance of one or the other factor."

Fig. 9. Insufflation of bismuth subcarbonate. Showing normal rectosigmoid apparatus in stage of relaxation.

Fig. 10. Showing normal rectosigmoid apparatus in stage of contraction after insufflation of bismuth subcarbonate. Note the outline of the collapsed rectum.

Goldschmidt and Dayton[13] have shown that the colonic wall is impervious to the passage of magnesium sulphate or sodium sulphate; therefore, there can be no possible danger in using these salts in the bowel. They have demonstrated that hypertonic solutions of these salts increase in volume and decrease in concentration approaching the blood level. Solutions of concentration nearly iso-osmotic with the blood show little change in volume. Hence there is free

FIG. 11. Insufflation of bismuth subcarbonate outlining a definitely contracted rectosigmoid apparatus. Note the outline of the rectum which is partially gas filled.

FIG. 12. Barium enema showing outline of the rectum and a portion of the pelvic colon. The narrow connecting part is the rectosigmoid apparatus. Patient had pelvic abscess many years ago: resulting exudate fixed the rectum and colon in this position.

FIG. 13. Normal rectosigmoid apparatus in stage of partial contracture. Verified by sigmoidoscopy.

FIG. 14. Colon after barium meal fortunately depicting a contracted rectosigmoid apparatus, verified by sigmoidoscopy.

passage of water with no diffusion of the sulphates. Sodium chloride solutions, on the other hand, diffuse freely from gut to blood and vice versa. In cases of extreme atony, I used sodium sulphate and found it produced painful contractures without much result in producing defecation. Equal parts of a 25 per cent solution of magnesium sulphate and sodium sulphate have, on the other hand, given us very remarkable results in producing defecation in many cases of atony of the rectosigmoid apparatus, pelvic and iliac colon (Figs. 6, 7 and 8).

During the past year we have been using this method as a routine treatment in atonic cases of long standing, and we find that, in many cases, restoration of the contractile power of the rectosigmoid apparatus and pelvic colon occurs. The most severe forms of atony of the rectum with complete absence of the rectosigmoid apparatus are greatly benefited by a daily enema of the combined salts. This enema is also of great value in post-operative atonic conditions of the lower colon. In cases of post-operative *contractures* the solution of magnesium sulphate alone should be employed.

Visualization of the rectosigmoid apparatus by means of the roentgen ray presents extreme difficulties. The anatomic relationships are such that one rarely secures a view fluoroscopically. The plate method is equally disappointing: we have attempted to secure views by having the patient assume different postures, with but little success. We must recall the fact that we are dealing with an elastic tube that is frequently changing its position, that is overhung and obscured by loops of iliac colon and that is alternately contracting and dilating in a rhythmic fashion. The inconstant and ever-changing anatomic relationships make it impossible to establish normal standards.

The opaque meal (feed test) is absolutely unreliable, inasmuch as it will frequently give the impression of contracture or atony of the bowel when, as a matter of fact, the roentgenogram merely portrays the temporary physiological phase of relaxation or contracture.

By means of the opaque enema roentgenologists have established quite definite standards, and are able to distinguish various fixed types of colon. The enema, however, canalizes the rectosigmoid region even in cases of spasm; the colon gradually fills, and finally the enema fluid distends the rectum as well as the rectosigmoid. Even in the rare instances in which this region will be visualized on the plate, no narrowing or contracture will be in evidence.

Fig. 15. Barium enema showing absence of rectosigmoid apparatus. This appears to be a definite type of colon in which there is no line of demarkation between the rectum and pelvic colon. We consider it a characteristic type. The resulting constipation is exceedingly obstinate in character.

It is, therefore, obvious that sigmoidoscopy is the only reliable method by which the condition of the rectosigmoid apparatus can be ascertained. We have, however, been able to secure quite good views of the rectosigmoid region by the following method: The patient is placed in the knee-chest posture and insufflations of bismuth subcarbonate made by means of a powder blower through the sigmoidoscopic tube. He is then placed in the dorsal position and immediately plated (Figs. 9, 10 and 11). Very excellent views of the rectosigmoid may at times be secured in patients who have had severe pelvic inflammatory processes. The resulting exudate involves the wall of the bowel, impairs its elasticity, fixes its position and thus renders it a very good subject for the roentgen ray (Fig. 12). Other illustrations are shown depicting the rectosigmoid region, and are to be regarded as fortunate accidents occurring in the course of a large number of observations* (Figs. 13, 14 and 15).

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* I wish here to express my indebtedness to Dr. R. Walter Mills, without whose aid and valuable suggestions this work would not have been possible. My thanks are due to Dr. L. E. Printy and Dr. Frank R. Finnigan for much of the sigmoidoscopic work.

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ROENTGENOLOGICAL FINDINGS IN MONGOLISM*

BY M. WILLIAM CLIFT, M.D., F.A.C.P.

Consulting Roentgenologist, Michigan Home and Training School

FLINT, MICHIGAN

THE study, which forms the basis of this report, was inspired by an article which appeared in "The Archives of Neurology and Psychiatry" by Dr. W. Timme, entitled "The Mongolian Idiot." In this article, he described changes in the outline of the sella turcica, in 23 cases of Mongolism which he believes to be characteristic of this condition. The findings in our own cases have been so at variance with this author's conclusions, that we feel justified in making a brief preliminary report at this time, notwithstanding that the work is as yet incomplete.

Mongolism or Mongoloid Idiocy is characterized by the facial configuration of these patients, which is very like that of the Mongolian races. At the present time the condition is generally held to be a distinct disease entity, although there are still some endocrinologists who consider it but a type of infantile myxedema. However, there are marked points of difference between Mongolism and myxedema, one of the most striking being the difference in skull conformation. The Mongoloid is a round head and the skull is small. The myxedematous case is characterized by a large skull which is usually brachycephalic. The peculiar expression of the face giving the condition its name, is due to the oblique, slit-like palpebral fissures, the small button-like nose and the high zygomatic arches. The tongue is not usually increased in size as in myxedema, but is furrowed. The ears are small and set well back on the head. The body is usually well proportioned and the neck is not shortened as in myxedema. The skin is smooth and moist. One of the most striking features noted in this condition is the shortening of thumb and little finger. These patients may be somewhat stunted in height, but this feature is perhaps less constant and less in degree than in myxedema. While there is a general retardation in bone development, the bone nuclei appear at about the normal time, according to Falta. Closure of the fontanelles and sutures is abnormally delayed. Dentition also occurs

* Read at the Midwinter Meeting, Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 26-28, 1922.

late and irregularities of the teeth are common. These children are all mentally deficient, but are cheerful, lively and mischievous.

According to Timme, in 23 out of 24 cases of Mongolian Idiocy, the roentgenograms of the skull showed an excavation under the anterior clinoid processes in the anterior part of the pituitary faucae. He attributes this finding to changes in the anterior lobe of the hypophysis. The extension of the excavation to the optic groove, he believes the basis of certain eye-findings which were present in his cases, namely, an unequal graying of the optic discs on the temporal sides; also, in certain cases, the disc was apparently edematous. On the basis of this hypothesis, that is, anterior lobe disturbance, he suggests the use of anterior lobe extract, combined with whole gland feeding and thyroid in small doses in the treatment of Mongoloid idiocy.

It is not our purpose at this time to deal with the clinical aspects of this condition nor question the validity of the etiology suggested, as this phase of the subject will be reported at a later date by my associate, Dr. T. A. McGraw, Jr. The roentgenological signs in Mongolism, however, we have attempted to review carefully in a series of of typical cases. The material at our disposal consisted of about 50 cases at the Michigan Home and Training School, Lapeer, and 5 private cases of Dr. McGraw's. It must be stated that the study is not entirely complete, but sufficient material has been examined to justify the conclusions which are reported herewith.

The roentgenological findings in Mongolism can be considered under two heads, namely, those which relate to the general skeletal formation and those which are concerned with the sella turcica itself. Under the first head, our findings may be summarized as follows: The cranium of the Mongoloid is small; in many cases it might be classified as microcephalic. It is dolichocephalic in shape and the cranial bones are uniformly thin. The suture lines were frequently separated, and in many cases irregular rarified areas occurred along the edges. The acral parts, particularly the nose and maxilla are poorly developed. As will be noted, these findings are characteristic of general retardation of bone development. The only condition which may be considered as in any way characterizing the roentgenological picture of the disease under this head, is the disproportionate developmental deficiency on the part of nose and maxilla. Schuller emphasizes this point and suggests the term "acromicria" in apposition to acromegaly in which we find the most extreme development of these parts.

As regards the sella turcica, our findings were far from uniform. The sella differed in shape, in about the same ratio as in normal individuals. It was quite uniformly small, as might be anticipated, when one considers the size of the Mongoloid head. In this regard it may be stated, that we are convinced after a study of a fairly large number of heads during a period of four or five years, that the size of the sella is of relatively little diagnostic importance in the absence of definite erosion; and furthermore, that both the size and shape are influenced by the size and shape of the skull, and particularly of the cranial base. In this series of Mongoloids, not a few of our cases showed the appearance described by Timme. On the other hand, many of the most characteristic cases clinically were negative. Following this work we reviewed many of our routine plates in our office covering a variety of different conditions, the majority of which were normal. In these cases we found this condition appearing quite as consistently as in our Mongoloid series. It should be obvious, therefore, that whatever the cause of this appearance, it is neither constant in Mongolism nor confined to that condition alone. That it is not due to erosion is quite evident, I believe. On every plate I have seen, the cortical bone of the sellar floor, planum sphenoidale and anterior clinoids are intact. Observation on the normal dried skull has shown that it is possible to reproduce this appearance on the roentgen-ray plate by a slight variation of the angle in the central ray. This produces a slight notch-like recess, which runs forward beneath the shadow of the anterior clinoid process and is outlined by the lower border of the anterior clinoid process above and the lateral margin of the planum sphenoidale below. Not infrequently one or both clinoid processes rise considerably above the roof of the sphenoid and in these instances even the most accurate lateral projection will produce this same appearance. So far in our study we have been unable to find any consistent change in the sella turcica in cases of Mongolism which can be considered definitely pathological. We are thoroughly convinced from this investigation as well as from former studies with the feeble-minded, that fairly extensive changes in the way of enlargement of the pituitary body may occur without involving the sella. The constant study of lateral plates has, we fear, caused us to lose sight of the fact that the sella turcica possesses a transverse as well as an antero-posterior diameter. It takes only a casual study of the floor of the skull and the pituitary fauca to realize that the anterior clinoid processes are quite widely separated and can only be involved by extraordinary enlargement of the pituitary body which is found in tumors of that gland. It is also quite evident that involvement of the anterior clinoid from pressure can hardly occur without eye-symptoms, the result of pressure on the optic nerve. To sum up our observations on Mongolism we may state that in our opinion there is no single characteristic roentgenological sign in this disease, and the only departure from normal is a generalized delay of bone development. This feature, except for a slight selective character on the part of the nose and maxilla, is common to a number of other diseases, some of endocrine origin and others due to obscure causes.

STANDARDIZATION OF ROENTGEN-RAY REPORTS*

BY P. M. HICKEY, M.D.

DETROIT, MICHIGAN

AT a recent surgical congress where a symposium was held on the diagnosis and prognosis of sarcomata, there were read several reports on the roentgen-ray examinations of bone tumors occurring in a well-known hospital during a period of ten years. From these reports, it was difficult to determine, in the majority of cases, the actual bone condition encountered. Practically none presented definite ideas of the bone pathology. The diagnoses advanced were given in a nomenclature which evidently varied with the nomenclature used by the different physicians who had written the reports. One could not help feeling that they had been written in a very haphazard fashion, without much regard to scientific accuracy. The audience natura ly came to the conclusion that in the particular hospital referred to, the statistics in regard to sarcoma, when viewed from the roengten-ray standpoint, possessed very little value. Furthermore, the surgeon who quoted these reports made the statement that he thought this particular institution was no more deserving of criticism in this regard than many other large hospitals.

The writer of this paper after listening to these reports and to the surgeon's criticism, felt that an investigation of this question was warranted. Accordingly, a circular letter was sent out to the members of the American Roentgen Ray Society asking that sample reports of roentgen-ray examinations of different parts of the body be sent in for study. A generous response was rece ved and a large number of reports are on file, which cover examinations of the skull, the mastoids and sinuses, the chest, and the bones for fracture and bone tumor.

While no attempt, as yet, has been made throughly to classify these reports, the writer wou d state that after going over them superficially, he is convinced that many could justly be criticized.

On comparing reports covering roentgen-

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ray examinations with reports made by pathologists on pathological tissues, we have been impressed with the general inferiority of the roentgen-ray report. In making this statement, I do not wish to be understood as criticising the conclusions or the diagnoses made in these reports, their accuracy comparing well with that of the pathological reports.

The superiority of the pathological reports, when viewed from the standpoint of form and accurate description, is due to the better training of the pathologist. The average pathologist receives a long course of training under competent professors, which teaches him to describe the appearance of the material submitted for examination, and requires him to make drawings of specimens and label the various types of tissues described.

The inadequacy in roentgen-ray reports is due to the present inferior methods of instruction, and to the fact that few colleges demand of their students in roentgenology, accurate descriptions or drawings.

A study of present non-standardized methods of instruction in roentgenology in our American medical colleges reveals the fact that many of the institutions still give a short course of lectures only, without familiarizing the student with the routine of plate examinations and plate descriptions.

One of the functions of the American Roentgen Ray Society is to present to the medical colleges the shortcomings in their methods of study in roentgenology, and to make suggestions as to how these shortcomings can be remedied.

To return to the reports which were sent in, I would like to state that in only a few cases were they so worded that the reader could form from the descriptions a diagnosis of the conditions present. It then follows that in order to make our reports more valuable they should be written in a manner and with a nomenclature which would convey distinct ideas as to the conditions present. Such a system of reports is, of course, of the utmost importance in hospital work; that is, in hospitals which conform to the present high standard.

Judging from some of the letters received, I would conclude that not all the members of the American Roentgen Ray Society recognize the necessity of having reports conform to a certain standard of excellence. Some evidently prefer to inject into their reports their own individual style. Nevertheless, reports filed in hospitals should be scientifically accurate and should follow an accepted nomenclature, so as to have value in a statistical sense. Individual style in reports usually means eccentricity. Such reports may be sufficiently valuable as to diagnosis; but they do not carry the importance that a simple concise statement does.

In going over the reports of fractures, we were unable always to visualize the type of fracture from the report. For example; from one hospital, we received a report which read as follows: "Comminuted fracture of the tibia and fibula, in good position." Another roentgen-ray report read: "There was a fracture of the tibia, and the cast should be removed in ten days." A simple statement that there is a fracture of the lower end of the radius is usually confirmatory evidence of what the patient has known since the accident, and does not give the surgeon any scientific information about the type of fracture. The shorthand type of reports often assumes to advise as to whether further manipulation is necessary. We scarcely think there is any ground for argument that the roentgen-ray report in a question of fracture should give a clear-cut description, so that anyone reading it would have a definite idea of the traumatic pathology present.

If one wished to make a statistical study as to the comparative value of different lines of surgical procedure in the treatment of fractures of the lower end of the radius, the handicap would be formidable if one based his study on many of the reports which are found in our hospitals.

In the reports upon bone tumors, we found a considerable variation in the types. Most of them gave fragmentary descriptions of changes from normal, and conclusions, which, while probably correct, left the impression that they were reached by a process of intuition rather than by a line of scientific reasoning, the result of deductions from the pathological data observed.

Reports upon the chest varied from one, which described and diagnosed the condition n two words, to lengthy reports, which, after describing the conditions, took up the question of prognosis and finally gave advice as to the method of treatment. It is only fair to assume that advice as to the treatment of a patient with a pulmonary condition should be based on the data obtained from complete observation and examination, and not upon a roentgenogram, which procedure might cast discredit upon the art of roentgenology.

From reading these reports we can draw one important conclusion, namely, that whether the report is brief or lengthy, a standardized nomenclature should be adopted. In practically none of the reports were the descriptions based upon the relative densities observed; none following the method first brought out by Crane in 1899, or the more recent one brought to the attention of the profession by Aberu of France.

In reading over the reports giving the results of the examinations of the mastoid, we were impressed by their greater uniformity, the majority of them following the type of reports in Law's work. In this particular instance, the greatest value has resulted from an authoritative and comprehensive study of a single subject.

Reports which were presented upon the work of paranasal sinuses showed great variation. Most of them were characterized by extreme brevity as to conclusions, which we might call the intuitional type. It seems to the writer that, as regards the important topic of standardization of reports, discussions and difficulties are always encountered. Very probably the solution of the problems is not to be found in reports of committees, but can be reached only by improving the methods of education along roentgenological lines, presenting to the Association of American Colleges the necessity of high standards of laboratory courses.

If we grant, then, that an attempt should be made to standardize roentgen-ray reports in standardized hospitals, the first procedure is to adopt or recommend a standardized nomenclature. As an example of this standardized nomenclature in the description of fractures, I would submit the following scheme which was sent in by Dr. Harold J. Pierce of Terre Haute, Ind.:

FORM OF REPORT ON FRACTURES

- *X*-ray examination reveals
  - Simple
    - *a* Complete
    - *b* Incomplete
    - *c* Comminuted
    - *d* Fissure
  - Multiple
    - *e* Depressed
    - *f* Perforated
    - *g* Diastatic
    - *h* Impacted
- Fracture of the
  - Side
  - Part
- Line of fracture is
  - *a* Irregular
  - *b* Transverse
  - *c* Longitudinal
  - *d* Oblique
  - *e* Spiral
  - *f* T-shaped
  - *g* Stellate
- From a point cm. from a bony landmark
  - *a* Downward
  - *b* Outward (to about cm. from bony landmark)
  - *c* Upward
- The fragments are
  - *a* In good alinement (to the extent of cm.; to the extent of degrees)
  - *b* Overlapping
  - *c* Angulated
- The upper fragment is displaced
  - *a* Upward
  - *b* Downward
  - *c* Inward
  - *d* Outward
- The lower fragment is displaced
  - *a* Upward
  - *b* Downward
  - *c* Inward
  - *d* Outward

One of the functions of the American Roentgen Ray Society is to study the question of standardized nomenclature, and to make recommendations which can be used in standardized hospitals. We feel that the Society, after recommending such a standardized nomenclature, should take steps further and recommend certain requirements which should be followed in writing roentgen-ray reports in standardized hospitals. Such a standardized procedure has been laid down for the systematizing of diagnoses, and certain standardized methods of history-taking have been adopted in many hospitals. These recommendations should suggest the form to be followed in describing lesions both fluoroscopically and roentgenographically. Recommendations along this line should not err on the side of verbosity but should outline proper guidance, and encourage conciseness and clearness.

Another way in which the American Roentgen Ray Society could further the movement toward improvement of our roentgen-ray reports would be to require of the applicants for membership that each submit a certain number of reports which should follow a prescribed form. This is not an Utopian idea, but simply follows the example of the American College of Surgeons in the examination of their candidates.

CONCLUSIONS

1. The American Roentgen Ray Society should make an effort to secure more uniform and better roentgenological courses in the medical colleges of the United States.

2. The American Roentgen Ray Society should recommend a standardized nomenclature to be used in writing roentgenological reports.

3. The American Roentgen Ray Society should foster a standardized type of roentgen-ray reports in the examination of different parts of the body for definite conditions.

4. The American Roentgen Ray Society should require of its candidates the submitting of one hundred roentgenological reports of actual cases written in conformity with the standardized nomenclature and recommended standardized form.

ROENTGENOLOGY AND INTERNAL MEDICINE*

BY LEWELLYS F. BARKER, M.D.

BALTIMORE, MARYLAND

INTERNAL medicine and roentgenology are closely akin. The internist specializes in the diagnosis and therapy of the so-called internal diseases, making use of every method and every principle that can aid him in this task. The roentgenologist is the master of the technique of a particular method of examination, which has become as indispensable to the physician as it is to the surgeon and to every medical and surgical specialist. In addition to command of a special technique, the true roentgenologist, in contrast with the mere roentgenological technician, is a consultant who interprets what he sees at roentgenoscopic examinations and on inspection of roentgenograms. He supplies a group of facts obtainable by the application of his methods and in no other way, facts that are often of very great importance among the totality of data upon which modern, comprehensive and exact diagnoses are based; and in the execution of the therapy based upon these comprehensive diagnoses the roentgenologist may also be called upon in turn, to play an important part.

Just as the internist must possess a knowledge of the anatomy, the physiology and the pathology of every part of the human organism and be acquainted with the practical technical methods of special workers who study each of these parts, so the roentgenologist who makes himself responsible for the interpretation of the shadow pictures obtainable from all parts of the body by *x*-ray methods, must be similarly informed with regard to the normal structure and normal functions of these parts, and with the alterations that the structures and functions undergo in disease.

A skilful technician without medical education may, it is true, after long practice under instruction, be able to make very good *x*-ray plates or *x*-ray films of the various parts of the body, but only an educated physician who has a wide and deep acquaintance with the methods and principles of both the preclinical and clinical sciences can make roentgenoscopic examinations that will be of value, or can interpret adequately the meanings of the variations in density that are visible in

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roentgenograms. No wonder, then, that the internist and the roentgenologist are reciprocally interested in one another's work, for each can receive help from, and give help to, the other. Each is a draught-horse in the modern diagnostic team. Though a large set of persons, medical, surgical and special, may be harnessed together in the work of present-day diagnosis, it will be generally acknowledged that in this set the internist and the roentgenologist must always draw the heavier parts of the load.

As a working internist who has a keen appreciation of the burden that the modern roentgenologist must bear, I desire, on behalf of my colleagues in internal medicine, to express to the members of this society our deep feeling of gratitude for the hearty support and the close cooperation of roentgenologists in our work. I, personally, owe a debt that I can never repay to my colleagues, Dr. F. H. Baetjer, Dr. C. A. Waters and Dr. Pierson, in the *x*-ray department of the Johns Hopkins Hospital. Their help in the hospital work during my incumbency and also in private practice has been incalculable. I know, too, that the internists of different parts of this country who enjoy similar relationships with roentgenologists feel just as I do. Let us who are internists reciprocate in any way that we can. It is a duty we owe you and one that we perform with pleasure, though despite our best efforts there will always be, I fear, a debit balance in your favor.

In the brief time allotted to this address I cannot do better, perhaps, than to refer to some of the ways in which the roentgenologist today is helpful to the internist and to some of the limitations to which his efforts seem to me to be subject. The field of application of roentgenology to internal medicine is so very large that I must content myself with a mere sketch, rather than try to depict any detailed picture. A talk is always more interesting, too, if it has its origin in personal experience. What I shall have to say, therefore, will be based in large part, if not wholly, upon the ways in which roentgenoscopy and roentgenography have helped me in my own diagnostic work, upon some of the instances in which I have found it misleading, and upon my own studies of the bibliography of the subject.

In making general diagnostic surveys, the consulting internist accumulates data through the anamnesis, the general physical examination, variou slaboratory tests, various *x*-ray tests and examinations made in many special domains. He secures information in these various ways regarding the respiratory apparatus, the circulatory apparatus, the blood, the digestive apparatus, the urogenital apparatus, the locomotor system, the nervous system, the endocrine glands and the metabolic processes. He then arranges the facts he has collected in groups and broods over them in order that suggestions of solution of his diagnostic problems may occur to his mind.

He reasons out the bearing of each possible suggestion of solution, compares the implications deduced with the data actually accumulated in the given case, and finally establishes identity between the facts of the case and the facts that should be demonstrable if one of the suggested solutions were correct, thus arriving at his diagnosis. He is careful not to make a diagnosis upon the anamnesis alone, upon the general physical examination alone, upon laboratory tests alone, upon *x*-ray reports alone, or upon the reports of specialists by themselves. On the contrary, he keeps his mind open, suspending judgment until he has at his disposal facts of different kinds in sufficient number clearly to define and to localize his dianostic problem.

He makes his study complete enough to prevent anything of importance being overlooked; and he tries to synthesize his total findings into satisfactory conclusions adequate to the requirements of the case. The anamnesis is exceedingly valuable to him, the physical examination is indispensable, the laboratory and *x*-ray tests may be most helpful, and the reports of experts in special domains may throw light upon obscure parts of the problem, but he depends, as I have said, upon the results of no one of these alone.

He makes use of them all in as far as is necessary for the satisfactory completion of his diagnostic task. The internist feels that in this way, and in this way only, can patients be given the full advantages of the application of the scientific medicine of to-day.

In his work of analysis, then, the internist is greatly helped by the roentgenologist, and in his work of synthesis, or integration, the results of the roentgenological findings are given their due place and proportion. You will readily understand that an internist, working in the way I have described, will be most helped by a roentgenologist who reports both his objective findings and his opinions regarding the meaning of those findings; these two things—(1) objective description of findings and (2) interpretation of findings—should, however, be kept sharply separated from one another.

Some roentgenologists give only objective findings without interpretations; others give only interpretations without reports of objective findings. Neither of these methods of reporting is wholly satisfactory to the higher type of internist, who desires both. Moreover, the roentgenologist who reports both and the internist who receives and studies both and who under the guidance of the expert inspects the roentgenograms himself will grow in knowledge and in diagnostic ability more rapidly than when the roentgenologist restricts his reports to one or the other content.

Much is to be gained, too, from roentgenological reports that are made first without knowledge on the part of the roentgenologist of the symptomatology and secondly, later, with knowledge of that symptomatology and of the other facts collected by the internist. It is helpful both to the roentgenologist and to the internist to see how far the former may go from the application of his own method and technique alone. Subsequent to this, much is to be gained from a conference of the internist with the roentgenologist at which all the clinical and laboratory findings are considered in association with the *x*-ray findings. This plan, though time-consuming, makes for the progress of both roentgenology and internal medicine, especially if both roentgenologist and internist later on control their conclusions (1) by the subsequent clinical course, (2) by any surgical operations that are performed, and (3) by autopsy findings in fatal cases.

RESPIRATORY APPARATUS

No better example of the successes of *x*-ray examinations on the one hand and of the limits of their performance on the other could be given, perhaps, than the results obtainable in the study of diseases of the respiratory apparatus.

No internist to-day would be willing to try to get along without the information that the *x*-ray can give concerning the lungs, the pleura, the air passages, and the lymph structures and the blood vessels of the respiratory organs.

X-rays of the paranasal sinuses and of the chest have become almost routine in the study of clinical cases. The specialist on diseases of the nose and throat would scarcely venture an opinion in his domain before ascertaining the condition of the antra, the frontal sinuses, the ethmoid cells and the sphenoidal sinus as revealed in roentgenograms. For roentgenography gives information that is more reliable than transillumination of the sinuses can yield.

The internist desires to compare the physical findings of the lungs and pleura with the findings in the *x*-ray plates, especially if he suspect a dilatation or a stenosis of the air passages, a foreign body in the bronchi, or an inflammatory or neoplastic process in the lungs or pleura. If gangrene of the lungs, abscess of the lungs, or empyema be suspected, he desires to confirm his physical findings by *x*-ray examinations and, especially if operation be indicated, to determine the exact position, the form and the extent of an inflammatory focus or of a cavity. He wants to be sure, too, whether a process is single or multiple and, if multiple, whether operation offers chances of success. In lung abscesses, the demonstration of a 'fluid level' with a clear space above due to air in the abscess cavity, and a comparison of the appearances in roentgenograms taken in the upright with those taken in the recumbent position are important aids to clinical diagnosis.

In pulmonary tuberculosis, the *x*-ray is less helpful in deciding that tuberculosis exists than in giving definite ideas as to the exact location and extent of a process known to exist. The *x*-ray demonstrates the precise anatomical relations of tuberculous foci, but it will not always determine how much of a process is tuberculous and how much is due to a complicating bronchopneumonia, due, say, to streptococci. Moreover, reports regarding activity or inactivity of a tuberculous process based upon *x*-ray findings alone are peculiarly dangerous and inaccurate. Much more, in my opinion, can be decided regarding activity and prognosis by methods other than the *x*-ray. Roentgenologists have been responsible too often for sending persons to sanitaria when they did not need to go; many people have been compelled to give up their work and go to the Adirondacks, to Asheville, or to Arizona, at great expense and on insufficient grounds. On the other hand, the roentgenologist will sometimes make a negative report on the lungs of a patient who has incipient tuberculosis and whose sputum contains tubercle bacilli. His report may be entirely correct in such a case from the *x*-ray standpoint. We must not expect roentgenograms to tell us more than they are capable of. But neither can we afford in pulmonary tuberculosis to do without the information that the roentgenogram can yield. I have been more than once genuinely astonished to find how wide-spread the anatomical changes demonstrable by the *x*-ray were in tuberculous lungs in which from the history and the physical examination I had supposed a much more circumscribed process to exist.

There are certain special circumstances in which roentgenograms contribute valuable information in the tuberculous. Thus the *x*-ray is often helpful in revealing the enlarged paratracheal glands in the tuberculosis of childhood, the areas of consolidation in tuberculosis of the senile, and the distribution of peribronchitic tuberculosis and of miliary tubercles at any age. It must not be forgotten, however, that not everything that looks like a miliary tubercle in the lungs is really due to tuberculosis. Great conservatism should be observed in drawing etiological conclusions from roentgenographic shadows. More than once roentgenologists have made the diagnosis of acute, or subacute, disseminated miliary tuberculosis, when in reality they were dealing with non-tuberculous lesions. Dr. George Dock of St. Louis has dwelt upon some of the fallacies to which the roentgenologist of the chest is liable, in an admirable address that he delivered last June, and which was published in The American Journal of Roentgenology.

In the diagnosis of tumors of the lung, internists have been greatly helped by the *x*-ray, especially when recurring small hemorrhages of the lung otherwise unexplained have occurred in men or women past middle life. Such tumors may be primary, originating either within the bronchus of a lung lobe or at the hilus, or secondary metastatic growths often visible in both lungs. But here, too, roentgenograms are not always decisive, for it may be difficult to distinguish the shadow of a primary tumor of a lobe from that, for example, of a pneumonic consolidation; and it is especially hazardous to be dogmatic regarding the existence of a carcinoma of the hilus, which can so easily be confused with tuberculous or luetic changes there. Miliary carcinosis has been mistaken for miliary tuberculosis, for pneumonoconiosis, and for other minute disseminated lesions. When there is thickening of the pleura or a pleural exudate over a lung tumor it may be difficult to recognize the latter. Even the differential diagnosis between tumor and aneurism is not always easy.

Roentgenograms are very helpful in the exact delimitation of pleural thickening, in the determination of the extent of a pleural exudate, in the recognition of interlobar exudates and thickenings, and in the discovery of pneumothorax.

In mediastinal disease, roentgenograms are very useful in determining the size of, position of, and presence or absence of pulsation in space-occupying masses there, and often clues as to their nature can thus be obtained. The enlarged lymph-glands of Hodgkin's disease and other masses in the mediastinum often show rather characteristic shadows, but one usually has to depend upon methods of examination other than the *x*-ray for a decision as to the real nature of such masses. Dermoid cysts are rare, but are often recognizable in the *x*-ray when they are present. A substernal struma can sometimes be recognized by its triangular shadow with the base upwards, especially if a connection with a goiter in the neck can be established; care must be taken, however, not to confuse such a substernal struma with an aneurism of the arch of the aorta.

A word as to enlarged thymus. Where an enlarged thymus has been suspected, my experience with *x*-ray reports has been rather disappointing; either no shadow has been found at all, or a thymus shadow has been confused with shadows due to other masses (substernal struma, enlarged lymph-glands, mediastinal tumor, or the vena cava). Reports in the literature indicate that shadows diagnosed enlarged thymus have often failed of confirmation at autopsy.

CIRCULATORY APPARATUS

One of the triumphs of the *x*-ray consists in the easy diagnosis of aortic aneurism when it is present, by means of roentgenoscopic examination and of roentgenograms. Indeed, the ease of diagnosis by means of *x*-ray examinations is so marked in contrast with the difficulty sometimes experienced by the older methods of physical examination that there is some danger that students and even physicians will neglect the time-honored methods of inspection, palpation, percussion and auscultation to their great disadvantage. Aneurisms of the ascending aorta, of the arch, and of the descending aorta rarely escape detection on roentgenoscopy if use be made of oblique as well as of sagittal and frontal transillumination. Moreover, on roentgenoscopy the examiner can see the exact size, position and extent of the pulsating mass, whereas by ordinary physical methods of examination only a very vague idea of these may be obtainable.

When a roentgenoscopic examination is made as a part of the routine diagnostic procedure, it is by no means uncommon to discover an aneurism that has given rise to no clinical symptoms and has been wholly unsuspected. Imagine the chagrin of a consultant who has failed to discover such an aneurism through neglect to apply roentgenoscopy! I have had my lesson, and have, therefore, for several years past made it a practice to include careful roentgenoscopic study of the cardiovascular stripe as a part of the routine study in every patient applying for a general diagnostic survey.

I have said that it is easy in the majority of cases to make the diagnosis of aortic aneurism on careful *x*-ray examination. But, now and then, a case is met with in which the greatest difficulty is experienced and in which the most expert roentgenologist may go astray. Other processes in the mediastinum (mediastinal tumors, lymph gland masses, dermoid cysts, substernal struma, esophageal diverticula, cold abscesses, etc.) may sometimes closely resemble aneurism. I remember very well a patient I once saw with Dr. H. C. Buswell of Buffalo as a fellow consultant. Physical examination indicated the presence of a large space-occupying mass in the mediastinum, but the physical signs did not favor the view that this mass was an aneurism. I inclined to the diagnosis of a non-aneurismal mass, probably a lymphosarcoma. One of our best roentgenologists, very reliable and conservative, examined the patient roentgenoscopically and roentgenographically and, despite the clinical signs, felt sure that he was dealing with aneurism, indeed with a large aneurism of the aorta. He even went so far as to say that he would, in the case mentioned, almost stake his reputation upon the diagnosis of aneurism. Shaken by his feeling of certainty, I revised my diagnosis and reported to Dr. Buswell that I had reluctantly concluded that the patient had an aneurism. Dr. Buswell was braver than I; he had the courage of his clinical convictions and maintained that in his opinion the mass could not be aneurism. He referred the patient to Dr. Burnam for radium treatment and, to his joy and our surprise, the mass entirely disappeared!

The study of the cardiovascular stripe in general by roentgenoscopy, orthodiagraphy and the teleroentgenogram I regard as most valuable in clinical diagnosis. Notwithstanding all the objections made, I feel that we get information regarding the size of the heart as a whole and of the great vessels, and particularly regarding the form and size of the left ventricle, the left auricle, the pulmonary artery, the aortic knuckle, and the right auricle, that can be obtained in no other way. Especially in the obese, ordinary percussion, as everyone knows, is most fallacious, and even in persons of normal weight I have seen great discrepancies among the percussion results of supposedly accurate clinical observers. The methods of percussion in common use for the demonstration of the outlines of the heart and great vessels certainly demand revision in the light of *x*-ray findings. Time will not permit me to dwell upon the details, but the information that can be gained by a careful study of the configuration of the heart silhouette obtained by the *x*-ray is now much relied upon by internists for confirmation and extension of the findings on physical examination in valvular diseases of the heart, in hypertrophy and dilatation of the several chambers, in myocardial diseases, in congenital malformations, and in diseases of the pericardium.

DIGESTIVE APPARATUS

The amount of time, energy and equipment expended in *x*-ray studies of the digestive apparatus exceeds, I suppose, that in any other domain. If you will recall the number of dental *x*-rays, of esophageal examinations, of roentgenoscopic examinations of the gastrointestinal tract, of plate series after contrast meals, of gall-stone plates and of barium enemata made every day, you will agree with me in this statement, I feel sure.

Dental roentgenograms have revolutionized both medical and dental practice in recent years. Internists, in their search for focal infections, have discovered the importance of oral sepsis for the origin of lesions at a distance (antritis, endocarditis, arthritis, myositis, nephritis, etc.); and dentists have begun to realize that the frivolous devitalization of teeth formerly resorted to in connection with their beautiful crown and bridge work led often to disastrous results later on. You are all familiar with the remarkable conditions that have prevailed in this country during the past few years. I need not recount them. Nor need I dwell upon the many tragedies of unnecessary wholesale tooth extraction that we have all witnessed. Dentists, physicians, and even the laity, however, are becoming better informed regarding the situation, and dentists and physicians are now happily tending ever more to desirable collaboration in the study and treatment of patients. From now on, a tooth, let us hope, will never be unnecessarily devitalized, nor should a tooth be extracted unless it is really a menace to the person who carries it. The *x*-ray, here, can be a blessing or a curse, according to the way in which its findings are interpreted and acted upon.

The diagnosis of esophageal diseases has been rendered infinitely more satisfactory through the use of *x*-ray methods of examination. Through their application, diverticula, stenoses, tumors, idiopathic dilatations and the presence and situation of foreign bodies are, as you know, now easily recognizable.

It is, however, in the study of the stomach, the duodenum and the large intestine that the greatest advances, perhaps, in the domain of the digestive apparatus have been scored. Our knowledge of the form relations of these structures in the living, of the tonus, and of the peristalsis, in health and disease, has been greatly forwarded through the application of the *x*-ray. When one thinks of our ignorance of gastrointestinal function at the end of the last century and compares it with our present knowledge he cannot but be most grateful to roentgenology.

I could spend the whole evening in discussing the information that the *x*-ray can give us regarding the structure and functions of the digestive tract, and another evening in a critical examination of the deficiencies of the method. I shall, however, refer only to gastric and duodenal ulcer, to cancer of the stomach and of the colon, to diverticulitis, to the gall-bladder and to the appendix, and shall make only brief mention of these.

That through the *x*-ray extraordinary advances have been made in the more precise diagnosis of ulcer of the stomach and of the duodenum everyone knows; but that, even here, *x*-ray reports often fail us, every internist who sees many gastric cases also knows. American roentgenologists have made important contributions to the technique of the demonstration of ulcer signs. When an ulcer has been chronic and has led to cavity formation with thickened walls, the *x*-ray often reveals a typical ulcer crater or niche; but the *x*-ray diagnosis of ulcer depends in many cases not upon the discovery of direct ulcer signs but upon the discovery and interpretation of certain indirect signs in the form of functional disturbances. For gastric ulcer these include local spasms, incisures on the greater curvature, changes in peristalsis and in emptying time, signs of hypersecretion, localizable pain points on roentgenoscopic examination, and for duodenal ulcer they include spasm of the bulb, permanent filling of the pars superior, displacement of pylorus to the right, shortened emptying time of the stomach, reflex gastrospasm, and other signs of disturbed function. Sometimes the *x*-ray may give information regarding certain sequels of an ulcer (hour-glass stomach, perigastric adhesions, gastrectasia from pyloric stenosis, etc.). When there are no direct ulcer signs present, roentgenologists should, I think, be very conservative in making a positive diagnosis from the functional symptoms alone or from the supposed anatomical sequels alone; for similar functional symptoms may appear in association with nervous gastropathies, or reflexly from gall-bladder disease, or from a chronic appendix, and similar anatomical sequels may follow upon pathological peritoneal processes not secondary to ulcer.

Again, the differential diagnosis between ulcer of the stomach and ulcer of the duodenum or a decision as to the presence or absence of ulcer in either stomach or duodenum may, in some cases, be particularly difficult, especially in the absence of an exact anamnesis and of carefully conducted laboratory tests. On the functional side it is true that marked hypermotility visible on *x*-ray examination and spasm of the stomach without niche suggest ulcer if the rest of the gastrointestinal tract be negative and if there be no tuberculosis of the lungs and no marked neurotic state. When *x*-ray functional signs of ulcer are present, a slow emptying time speaks in favor of pyloric ulcer, a rapid emptying time in favor of duodenal ulcer. Surgeons, of course, went too far a few years ago in declaring that marked hyperacidity always means ulcer. Roentgenologists have sometimes gone too far in ruling out ulcer from their own findings when the clinical findings (typical pains, marked hyperacidity, hematemesis, occult blood in stool, etc.) have been positive. When all diagnostic methods are used, it seems clear that there are a certain number of cases in which the internist is justified in deciding that ulcer is certainly present, or at least highly probable, even though the *x*-ray findings are negative, or are very uncertain.

In cancer of the stomach we can count upon the *x*-ray to give us important information. It frequently reveals tumor masses, or evidence therefor, before they are palpable and even at a stage when the chemistry and microscopy of the gastric contents may not be decisive. It distinguishes extra-gastric from intra-gastric masses; it permits of a determination of the exact location and size of the tumor; it often demonstrates the presence or absence of metastases in the lungs or in the bones; and it may give clues to operability and to the best surgical technique to employ. In cancer, there may be demonstrable certain characteristic filling defects (constant, not removable by palpation or change of position); the gastric peristaltic waves may be seen to be interrupted at a definite point; and if the pylorus be not obstructed, emptying time may be shortened owing to the accompanying achylia. In cases of pyloric obstruction, marked dilatation favors the diagnosis of cancer, moderate dilatation that of ulcer. In some cases it may be impossible from the *x*-ray findings alone to decide between benign ulcer and cancer.

Now and then a patient who has not complained of gastric symptoms at all will be found to exhibit, on roentgenoscopic examination, signs of a huge gastric cancer. For this reason, I ask for a roentgenoscopic examination of the gastrointestinal tract as a routine measure in general diagnostic surveys, for the consultant cannot afford to overlook a symptomless gastric cancer any more than he can afford to overlook a symptomless aortic aneurism.

On the other hand, I have at times received negative *x*-ray reports when gastric cancer existed. I remember last autumn a physician from the south who consulted me on account of a severe anemia, which proved to be of the secondary type. There was also achylia gastrica and he had occult blood in the stool. No tumor mass was palpable anywhere. We suspected, of course, carcinoma of the stomach, or possibly an old ulcer with recurring small hemorrhages. Repeated *x*-ray examinations, however, revealed no signs either of ulcer or of cancer. Blood transfusions gave only temporary help, and the stools continued to contain small amounts of blood. Dr. John Dorsey, the resident physician in charge of the private ward, urged the importance of the persistence of the blood in the stool and I advised the patient to submit to exploratory laparotomy. He consented to this and Dr. Finney exploring found a carcinoma of considerable size on the lesser curvature of the stomach. The *x*-ray plates were reviewed after the operation but the roentgenologist, an expert, reported that, even knowing that a cancer was present, there was nothing to be seen in the *x*-ray plates to indicate it, nor had anything been observed on roentgenoscopic examination pointing to it.

In the study of gall-bladder disease we have been helped much less by the *x*-ray than in the study of ulcer or cancer of the stomach. Though it is true that, in 10 or 15 per cent of the cases, gall-stones if present will appear in the plates with ordinary technique and that, in a much larger percentage of cases, their presence can be demonstrated if rays of low penetrating power, duplitized films and special screens be employed, still we know that gall-stones are present in many cases in which the *x*-ray findings are entirely negative. Similarly, the *x*-ray is powerless to demonstrate the presence or absence of a cholecystitis, unless there be pericholecystitic adhesions or marked dilatation of the gall-bladder and, even then, the findings are often equivocal. Again, many of the shadows in *x*-ray plates reported as gall-stones have been shown not to be gall-stones at all, but other shadows in the neighborhood (e.g., calcified costal cartilages), though the roentgenologist can, as a rule, by making examinations at different phases of respiration and in different positions distinguish gall-stone shadows from simulants. In my experience, for the diagnosis of cholelithiasis, cholecystitis, biliary stasis, etc., the general clinical study (anamnesis, physical examination, laboratory tests) has been much more helpful (except in the few cases in which stones are actually visible) than the roentgenological findings. The help that the *x*-ray can give regarding these right upper quadrant lesions is of course not to be despised, but it should not be overestimated.

The same remark holds for the right lower quadrant—the region of the appendix and the ileo-cecal valve. An appendix should not, in my opinion, be removed simply as the result of abnormal *x*-ray findings, if the clinical study be otherwise negative. Moreover, clinical studies may not infrequently indicate the necessity for the removal of an appendix when the *x*-ray findings are negative. In doubtful cases, the *x*-ray report may be decisive if it include a curled appendix, a persistent filling of the appendix, or signs of adhesions in the right lower quadrant, such as displacement of the stomach downward and to the right and ileal stasis.

In the diagnosis of annular carcinoma of the colon and of diverticulitis, the barium enema is a great boon. Many cases of these two diseases are now recognized that formerly would have gone overlooked for a long time.

In the analysis of cases of chronic constipation, *x*-ray studies are also very helpful. The separability of the ascendens type with its marked cecal stasis, the determinability of the markedly spastic type with mucous colitis, and the recognizability of the *x*-ray appearances in dyschezia are some of the interesting achievements.

The peculiar filling defects met with in ileo-caecal tuberculosis and in carcinoma of the caecum are exceedingly helpful diagnostic signs. That, also, an unsuspected Hirschprung's disease will occasionally be revealed by a routine *x*-ray study is matter of common knowledge.

In how far the recently introduced method of artificial pneumoperitoneum will prove to be justifiable and helpful, it is as yet too early to say. Certainly, masses in the abdomen that cannot be shown in any other way can be revealed by this method. Still, one would like to feel sure, in a given case, that the results to the patient would compensate him for the discomfort he has to undergo and for the risks of air embolism and of infection that he runs, though these risks seem to be slight.

UROGENITAL SYSTEM

The internist, as well as the urogenital specialist, owes much to roentgenology for the help that it yields in diagnosis in urogenital domains. Its successes are most clearly seen perhaps in the demonstration of the presence (and the determination of their size and exact location)of stones in the kidney, in the renal pelvis, in the ureter, in the bladder and even in the prostate, especially in the lateral regions of the prostate where they may be inaccessible to palpation.

Pyelography, with the aid of collargol or of thorium nitrate, is now indispensable in cases in which it is necessary to determine the shape and position of the kidneys, of the renal pelvis or of the ureters. Plosis of a kidney, and dilatations, stenoses and kinks of the ureters, can be very clearly shown. A diverticulum of the bladder, or a bladder tumor, can sometimes be discovered by cystoro entgenography after injection of a 10 per cent solution of potassium iodide in cases in which cystoscopy, for one reason or another, cannot be applied.

Though roentgenography, as I have said, is a most reliable method for the demonstration of the presence or absence of stones in the urogenital organs, it does fail in a certain percentage of the cases. Thus stones have been shown to exist when the *x*-ray plates were negative and, on the other hand, shadows have been interpreted as renal stones or ureteral stones when they were due to gall-stone shadows, to calcified costal cartilages, to calcified glands, to scybalae, to phleboliths or to bones or teeth in dermoid cysts. The roentgenologist who tries to interpret plates of the urogenital domain should be familiar with all these possibilities and should give them due consideration when making a differential diagnosis.

Even the ejaculatory duct and several inches of the vas deferens can now be injected with a shadow-yielding fluid, a method that may prove to be of practical use to urogenital specialists.

In carcinoma of the prostate, operation should not be undertaken until after *x*-ray examinations of the bones and of the lungs have been made for metastases. The same is true in carcinoma of the kidney and in hypernephroma.

LOCOMOTOR SYSTEM

In the study of the locomotor system, *x*-ray help is precious, though the surgeon and the orthopedist are more intimately concerned, perhaps, than the internist. Still, the internist also has to study diseases of the bones, joints and muscles, and, in his study, he desires the aid of the *x*-ray findings. They throw much light upon the nature and the extent of the arthropathies, the osteopathies and the myopathies. In arthritis, the *x*-ray will determine in how far the process has involved the solid parts and the soft parts of the joint structures and gives clues to the stage of the process, the kind of the process, and prognosis. *X*-rays of the spine often reveal the cause of lumbago, sciatica and of girdle pains in the trunk (arthritis, tumors, sacralized fifth lumbar vertebra, osteomalacia, etc.). The demonstration of the presence of cervical ribs will often clear up the etiology of severe radiating pains in the arms. Osteomyelitis, tuberculosis of bones, luetic periostitis, and neoplastic changes in the bones, are, as a rule, easily recognizable in the *x*-ray.

The changes in osteogenesis imperfecta and in osteomalacia are characteristic. Only last week a patient consulted me complaining of vague pains throughout the body, especially on movement. She stated that she thought she was growing a little shorter in stature. On *x*-ray examination of the spine, osteomalacic softening of four of her vertebrae was discovered, the roentgenologist solving at a stroke the diagnostic puzzle.

Finally, the internist remembers gratefully the significance of symmetrical bone defects at the edges of joints for the diagnosis of gout, and of smaller and larger circumscribed spherical bone defects for the diagnosis of multiple myeloma, even when Bence-Jones body is not present in the urine.

NERVOUS SYSTEM

Abnormal masses within the nerve substance are rarely demonstrable directly except when calcification has occurred (in tumors, solitary tubercles, gummata, cysticercal cysts, old inflammatory foci, etc.). Calcifications of the pineal body, of the choroid plexus and of pacchionian granulations are easily recognizable.

Recently, through Dandy's brilliant studies with the help of roentgenologists, it has become possible, in many cases, to localize non-calcified tumors of the brain by means of ventriculo-roentgenography (air injection of the cerebral ventricles). The technique is not difficult, and though there is some danger incurred, it is minimal, and the successes achieved in the localization of non-focal tumors of the brain before operation thoroughly justify the procedure in selected cases.

Local and general pressure effects within the skull revealed by the *x*-ray are often helpful in differential diagnosis. Changes in the sella turcica have been much studied with relation to intra-sellar tumors and extra-sellar tumors, in acromegaly and in dystrophia adiposo genitalis; but it should be remembered that the form of the sella is often changed from a general increase in intracranial pressure due to causes far removed from the hypophysis, and that it may be changed, also, by alterations in the sphenoidal sinus underlying the sella.

Diffuse pressure effects within the skull are evidenced by a marked increase in the digital depressions visible in the *x* ray and in the sharpening of the ridges between them. Premature closing of the cranial sutures in the craniostenosis of the tower skull is a characteristic roentgenological finding.

Much to the disappointment of the laity and of many physicians, the changes in the brain and skull in epilepsy demonstrable by the *x*-ray are rarely of much help to the diagnostician. The finding of a small, closed-in sella in epilepsy is, in my opinion, of no practical importance. Sometimes we see irregular deformations of the skull, sometimes a foreign body, sometimes signs of increased intracranial pressure, or occasionally calcified residues of old inflammatory foci; but, in the majority of instances, *x*-ray findings in epilepsy have been practically negative.

Roentgenology is also applicable to a certain extent in the study of diseases of the spinal cord and of the peripheral nerves. In organic diseases of the spinal cord, the *x*-ray may be helpful in diagnosis (Charcot's joint in tabes, bone changes in syringomyelia, vertebral caries in compression myelitis). Spina bifida is easily revealed by the *x*-ray and may account for obscure organic nerve lesions. Cervical ribs as causes of neuralgias in the domain of the brachial plexus have already been referred to. Paralysis of the nervus recurrens in aneurysm, root pains in hypertrophic osteoarthritis of the spine, paralysis of the diaphragm due to lesions of the N. phrenicus, intermittent claudication in arteriosclerosis, and paralysis of the cervical sympathetic in retrosternal struma are among the objective and subjective clinical findings that are often explicable by a study of roentgenograms or by roentgenoscopy.

ENDOCRINE SYSTEM

In certain endocrine disorders, finally, the *x*-ray findings are helpful for diagnosis. I may mention, without describing them, the bone changes in acromegaly and in dystrophia adiposo genitalis where the pituitary gland is diseased, the finding of a substernal thyroid in some cases of

Graves' disease, the occasional demonstrability of an enlarged thymus in status thymicolymphaticus, especially in children, the premature union of the epiphyses with the diaphyses in dwarfism due to hypergenitalism, the delayed union of the epiphyses in hypogenitalism, and the delayed ossification and the anomalies of dentition in the hypothyroidism of myxedema and cretinism.

CONCLUSION

In this address I have been able only to touch upon the most salient features of the advantages of roentgenology for internal medicine and to refer to a few of its difficulties and dangers; but I have said enough, I trust, to convince you that those of us who work in internal medicine appreciate highly the gifts of which the roentgenologist can be donor, and that we observe with sympathy and gratitude the efforts of the members of this association to make roentgenology ever more useful to us.

It is especially pleasing to internists to note that the tendency among roentgenologists to make more intensive and specialized studies than formerly is growing. There is great need for original research in roentgenology, research directed not only toward the improvement of technique but toward the more accurate interpretation of findings through control by clinical studies, through observation of the findings at the operating table and through checks upon intra vitam interpretations made after exact anatomical examinations at autopsy.

In our larger cities it would be advantageous if roentgenologists would unite into groups, so that specialization within the groups would become possible, each specialist being responsible, not only for routine studies in his particular domain, but also for the prosecution of original research in that domain. It would be especially helpful if our large hospitals and our universities would provide the funds for such amplification and intensification of roentgenological work. Too often the most meagre budget is appropriated for the *x*-ray departments in these institutions, the niggardly amount placed at the disposal of *x*-ray workers being really insufficient for the carrying on even of careful routine examinations. Nothing is left over for research work and we have to thank the roentgenologists themselves for defraying the expense of their productive studies. I am told that in some hospitals and medical schools, the *x*-ray departments are not only required to make enough money to pay the expenses of the *x*-ray work, but are expected also to provide a surplus for the use of other departments! I have the hope that hospital superintendents and medical faculties may, before long, become wise enough to recognize the crying needs of roentgenology, and energetic enough to secure the funds adequately to provide for them.

Let me, in closing, assure you that you will among the internists in this country find enthusiastic allies in your struggle to attain your ideals. Everything that contributes to your advance and to the advance of the subject you represent will also help internists in their work of diagnosis and treatment.

DISCUSSION

Dr. Hickey. I would like to say we have experienced much pleasure in hearing this masterly résumé of the work which has been done in roentgenology. Those of us engaged in teaching will, I am sure, use this résumé and try to outline the topics which can be covered in the subjects discussed. It is very gratifying to help the spirit of cooperation which we think can be established between the roentgenologist and those interested in medicine. It was delightful also to hear Professor Barker speak of the passing of the tendency of the internist to rely on other methods of diagnosis than those he has been accustomed to. It is deplorable that some of the younger men, as we see them in the hospitals, will not place more dependence upon the methods of diagnosis which have been given them in the older methods of examination. The best interests of the patients are not observed by such a procedure. I think the society is to be congratulated in having heard this very instructive talk. Another thing which occurs to me before closing is that some of the mistakes the roentgenologists have made have been due to their being too much crowded. The telephone rings for the diagnosis before they have really finished the last part of the routine. The internist does not content himself with one examination. He examines the patient several times and re-examines; and I think one way to guard against some inexcusable errors is to repeat our examinations. We do not give ourselves a chance to study the cases thoroughly.

Dr. Moore. I wish to thank Dr. Barker for the manner in which he has brought out this subject. It seems that if we are fortunate enough to be so located, that after drawing our opinions from our signs we can submit them to some consultant who will help us, we can finally place our specialty at the top—where we wish it to be. I could not help but be impressed by what he said. If we will be positive in so far as opinion justifies us in presenting the evidence we collect from direct signs, and then present the evidence collected by indirect signs with realization of the limitations, we will be in some degree such a help to the internist as he is to us.

Dr. Christie. It has been very pleasing indeed to hear Dr. Barker's appreciation of the roentgenologist and to hear his criticisms. I suppose perhaps each of us is struck with a different thought in regard to it. One of the things impressing me is that not only must the roentgenologist realize his limitations, but it is important for the internist to realize the limitations of roentgenology. It is very frequent that the roentgenologist of not too great experience is pushed off his feet by himself—he is so anxious to arrive at the positive diagnosis that he goes too far. He has come to realize the limitations as Dr. Barker has presented them. Another thing is this, that roentgenology has come to be such a broad field. We cannot be specialists along these lines, but it is necessary for the roentgenologist to meet a man on his own ground. The specialist in diseases of the chest must know his problems with sufficient assurance to talk in his own language. It seems the field is so very broad that the solution of it must come by groups of roentgenologists getting together. We have tried to divide our subjects so that each has a particular branch to follow, and I think this is the only way we can have a knowledge of such an immense field as roentgenology must cover. Another thing is this. If we are to take our places at all as consultants, and I think it is gratifying to have this word used, we want to be considered consultants—if we are to reach that ideal at all, there must be a great change in all branches of medicine toward roentgenology. We must have some method of roentgenology, and the time is ripe when we must discuss these things. I believe all of us should give it a great deal of thought from now on. We owe much to Dr. Barker for coming here and speaking in this way.

Dr. Holmes. The situation, I feel, after hearing this presentation, has been expressed very readily. There are one or two things, apparent, probably because they have entered into our own work so much. One is the necessity, as Dr. Hickey pointed out, of a careful description of things as we see them before we draw conclusions. The internists are appreciative of that fact, but they want to know on what we base our conclusions; and I think if we take more pains we will gradually get a better vocabulary than at present, so that we can express ourselves more clearly. Another thing is the tendency of medical men to obtain medical information as a fact. In some hospitals the roentgenological department comes under the laboratories. I have found that there is danger in this arrangement. We have to be very careful in making our statements; and I think if we have more instruction and if they see our work more, they will realize to a greater extent, our difficulty. Our examination of a heavy person with a high stomach is not as valuable as in cases where the stomach can be easily felt. More and better instruction will help along these lines. We are very appreciative of the help of the internists and the attitude they are taking.

Dr. Barker (closing discussion). First let me say how gratifying it is to me that my paper has called forth so much discussion—as I said when I started out, I think the discussion is really more interesting than the paper itself.

Answering the last question first: possibly I did not quite make myself clear. The speaker gathered from what I said that I referred only to the distant relations of the teeth. My intention was to mention the teeth as the first portion of the digestive tract. As a matter of fact, I believe the teeth are much more closely connected with the other organs than with the digestive tract.

Dr. Hickey spoke of the hurry of the work. This is almost a disease. We are all too hurried. You roentgenologists are too hurried. I do not know why we cannot get the leisure they have in Europe. I think those of you who have studied in Europe will appreciate all the more the fact that they lead much wider lives in certain respects, but less deep lives in other respects. Perhaps we will learn how to live over here later on.

This brings up a little incident which happened some few years ago when I was in Chicago. One of my colleagues rose at five o'clock in the morning to play golf. He had to be at the laboratory at eight, and so in order to get in his game of golf he had to rise at five o'clock.

Dr. Hickey referred to the repetition of examinations and spoke about the internist repeating the examination of the heart. I imagine the reason the roentgenologist does not do it so often is two-fold. It is the internist's feeling that the examination is made but once; and then the expense again has something to do with each. It does not cost much to listen twice with the stethoscope.

Dr. Moore referred to the lack of interest on the part of some of the students and the internists, and I believe Dr. Bowen also referred to the fact that they are not interested. They are not of course interested in descriptions. They want to know what is what. Also the internists do not have much time and their work is heavy. How can you expect the student to be interested if he is taking courses in roentgenology and the rest of the time is under doctors who do not know the value of leisure, who do not know how to appreciate it or to make use of it where it ought to be supplied? Can you expect them to be interested?

Dr. Christie has said that the internist must realize the limitations of roentgenology. That is true. We internists are gradually learning what the *x*-ray can do. We thought it could do impossibilities. We have to learn not to make these unfair demands. The laity does not know what it can do, but the family doctor is apt to expect that the roentgenologist can do everything. We have to have general men. We also have to have the intensive specialist in each branch. I believe it is valuable for some men to be very wide and for other men to limit their work. We need both kinds of men in roentgenology just as we do in medicine. The laboratory report should be a fact and the truth, but the internist should remember it is part of the truth. I think the internists are more and more realizing the difference between the consulting roentgenologist and a picture-taker. The layman thinks the roentgenologist is a picture-taker. He wants a plate, and I hope you do not give it to him—that is not what he should have. He thinks that if he brings a plate to you and you glance at it, that is not worth anything. For the internist not to understand the difference between a photographer and a roentgenologist is inexcusable

APPENDICITIS DUE TO THE PRESENCE OF FOREIGN BODIES IN THE LUMEN OF THE APPENDIX*

BY JOHN T. MURPHY, M.D., F.A.C.P.

TOLEDO, OHIO

ALTHOUGH appendicitis is now recognized as a lesion of microbic origin, it is necessary to consider that in the occasional case foreign bodies may be a predisposing factor. The literature to the present time reports relatively few foreign bodies, but I think a more extensive canvass of the surgical work done and not reported would lead to the discovery of a far greater number. There are, however, several facts found in searching the literature which would lead one to believe that it still is a comparatively rare phenomenon. Kelly,[1] in 460 cases, found only one; Bell,[2] in 1,000 cases, found 5; Kelly and Hurdon,[4] in 1,000 cases in the Johns Hopkins Hospital, found only 5; Fowler[3] found foreign bodies in 5 per cent of 100 cases; Grondahl[6] found foreign bodies in 10 of 400 operated cases; Heineck[7] states that foreign bodies were found twice in 3,750 autopsies. The types of foreign bodies are many, including pins, bird shot, fish bones, seeds, calculi, hairs, etc. Of these foreign bodies the pin is the most frequently reported. Mitchell[8] in 1894 collected 33 such cases from the literature. Kelly and Hurdon[4] added 13; Fowler[3] added four which these authors omitted from their statistics, and collected 13 additional cases from the literature down to 1912, making a total of 63 cases of appendicitis due to a pin in the appendix. In the literature since then I find similar cases reported by Rivarola,[9] Reichelderfer,[10] Mahoney,[11] and Fowler[3]; a total of 67 to which I will add the following 2 cases.

CASE 1. Baby, aged seventeen months. March 29, 1919.

* Read at the Midwinter Meeting of the Central Section of the AMERICAN ROENTGEN RAY SOCIETY, Chicago, Ill., Feb. 22, 1922.

Diagnosis. Mass in right side. X-ray showed pin in region of ileocecal valve.

Operative Diagnosis. Abscess in ileocecal region.

Treatment. Incision and drainage.

Family History. Parents living. Negative.

Personal History. No previous illness.

Present Illness. Last June, nine months previously, baby swallowed pin. Two weeks ago began to show indications of stomach trouble. Refused food. March 27, 1919, mother noticed mass in right side of abdomen. X-ray showed pin in region of ileocecal valve.

Shadow of Pin, Case 1.

Physical Examination. General condition fair. Mass in right side.

At operation. Abscess.

Description of Operation. Incision and drainage. Patient returned for second operation on April 12, 1919.

Diagnosis. Pin in intestinal tract.

At Operation. Pin in appendix. Perforated, small pocket of pus.

Description of Operation. Incision along line of old incision. Appendectomy: Iodine catgut for ligation; purse-string suture of linen; amputation. Stump treated with carbolic and alcohol; inverted. *Closure:* Iodine catgut No. 3; fascia, chromic catgut No. 2 (double). Skin, silkworm gut. Iodoform gauze drainage.

Case II. Female, aged fifty-eight. Operation, April 25, 1919.

Diagnosis. Abdominal exploratory.

Operative Diagnosis. Inflammatory mass adherent between uterus and bladder containing appendix.

Family History. Mother living at seventy-five years, and well. Father died at seventy-eight. Two sisters not living: one died in childbirth; the other from an unknown cause. No record of tuberculosis or carcinoma.

Personal History. Record of healthy childhood and girlhood. Menstruation eighteen years, duration four days, regular. Married at nineteen. Seven children living, three dead; one died of pneumonia, one in infancy, one following childbirth. No other pregnancies. No constipation. No leukorrhea. Menopause at forty-two years.

Present Illness. Pain in right abdomen for eight or nine weeks. Gives record of sensation of "breaking" in abdomen seven weeks ago. Some nausea recently. No flowing or discharge. No marked loss of weight.

Physical Examination. Tenderness over whole lower abdomen. Bimanual examination shows thickening of broad ligament.

Condition Found at Operation. Inflammatory mass adherent between uterus and bladder, bound up with omentum, glands along ileum and cecum, immobilizing the cecum. Appendix in abdominal mass. Pin found which had perforated appendix and was surrounded by hard fecal matter. Different portions of mass resembled carcinoma. Mass sent to laboratory for examination.

Description of Operation. Median line incision. Freed mass and brought out of abdomen. In examining it found a pin which had perforated the appendix. Surrounding pin was hard fecal matter. Appendectomy. Iodine catgut No. 3 used throughout. *Closure:* Peritoneum, iodine catgut No. 3; fascia, chromic catgut No. 3. Drainage of tube and iodoform gauze.

Pathological Report. Section from specimen shows chronic inflammation involving a mass of fibrous tissue and fat; possibly might be called a fibrolipoma.

Mitchell states that the appendix seems to act especially as a trap for pointed bodies and for small heavy bodies such as shot. The explanation given is that such bodies by reason of their shape and weight become more easily engaged in the appendicular orifice and fall into the canal. On the other hand, it is extremely difficult for such objects as fruit seeds to pass through the appendix lumen except when the appendix is of the fetal type. The point of a long, narrow, pointed body, such as a pin, can enter the lumen of the appendix without difficulty and the intestinal peristaltic movements push it in. Bird shot are found comparatively frequently among such appendicular foreign bodies. Kelly and Hurdon[4] collected 8 cases and in the recent literature I find such cases reported by Vander Veer,[12] Ainger,[13] Hall,[14] Spence,[15] Waller,[17] and Grondahl.[6] Waller's case was curious. A bird shot in the appendix acted as a ball-valve and prevented deflation of an enormously inflated but otherwise normal appendix. Bouvoisin and de Courmont[33] found 13 glass beads and a nail in an appendix, contained in a strangulated inguinal hernia sac. Lossen[18] and Tixier[19] report hair bristles. Foreign bodies in the appendix act in several different ways depending on their shape and size; small sharp objects by direct erosion and pressure on the mucous membrane open a means of infection into the submucosa and muscular coats; larger objects, by interfering with emptying, cause stasis in the appendix. At other times the sharp foreign bodies may cause a direct perforation with abscess formation or a general peritonitis.

Intestinal worms are frequently found in the appendix but it is doubtful whether such should come under the designation of true foreign bodies. According to von Becker[20] the oxyuris vermicularis is found in 50 per cent of all normal vermiform appendices surgically removed and in a similarly high proportion at post-mortem examinations. He thinks an etiological connection between the oxyuris and appendicitis can be excluded. Kelly and Hurdon[4] also remark that the oxyuris is sometimes found in large numbers in the normal appendix and may cause attacks of severe spasmodic pain simulating appendicitis. These parasites have been studied by Arbore-Rally[21] and by Metchnikoff[22] who find that they may also be demonstrated in acutely inflamed appendices and may have provoked the attack. Erdmann[23] in 29 cases of acute appendicitis in children found from six to thirty pin-worms in four cases. Kelly and Hurdon[4] collected nine cases of lumbricoids, eight of oxyuris and four of other parasites. Langley[24] has reported oxyuris, Marulanda[25] found the trichocephalus in sixteen of twenty operated cases of chronic appendicitis, and Russell and Bulkley[26] found it in 15 per cent of 129 appendices removed from children. The anchoring extremity of the trichocephalus causes abrasion of the mucosa which may result in infection. Although 89 of these removed appendices were gangrenous and contained pus, this condition was observed in only 4 per cent of those with the parasites.

Hogan[27] recently reported an unique case of appendicitis caused by the endamoeba hystolytica. This patient was operated upon for appendicitis, and pathological examination showed a true inflammatory condition involving the mucous and submucous coats and the presence of the endamoeba.

Appendicular calculi are but rarely reported. Rigollot-Simonnot and Saissi[29] reported a very large calculus (3 cm. × 18 mm. in size) in 1913. The patient did not show any acute crises and the chronic manifestations were not extreme. Although the case came to operation the operator doubted whether he would find an appendicitis. Blanchod[30] reported his own personal case of appendicular calculus. This case was diagnosed as appendicitis, but the symptoms were not all clear. A roentgenogram showed calculi which were thought to be ureteral, but verifying clinical ureteral symptoms were absent. The original diagnosis was therefore adhered to.

At operation two large calculi were removed from behind the cecum and a mass of adhesions. The appendix was completely gangrenous up to its cecal insertion. Roux in 1913 collected 7 cases in which a calculus was demonstrated in the appendix by roentgen-ray examination prior to operation. Most of the appendicular calculi are, however, more probably fecal concretions and probably not to be considered as true foreign bodies. Klemm,[31] who reported on 7 cases of appendicular fecal concretions, does not think that the presence of such stones causes any specific phenomena, but the course of an inflammation is much more rapid with them than in the non-calculus appendix.

Kleebat[32] thinks that with an appendicular concretion the indication for operation is given by the danger of stasis in the contracted portion of the appendix with resulting inflammation and gangrené. Kleebat also dwells upon the differential diagnosis in roentgenograms of such concretions from calculi in the ureters and calcareous deposits in the mesenteric glands, this diagnosis being dependent more particularly upon the clinical phenomena.

Concretions are also usually found existing around certain foreign bodies which have long remained in the appendix. This is especially true of pins. Of the total of 63 cases of pins in the appendix collected by Fowler, 22 were encrusted. In such cases it is often the concretion and not the pin which causes perforation of the appendix. But inflammatory changes in the appendix are the cause of the formation of the concretions, and not the result of their presence.

On the whole, it may be said that when appendicitis occurs from the presence of a foreign body in the appendix it runs a rather mild course except when the body is a sharp scrap of metal or some similar substance. In Fowler's collection of 63 cases due to pins, peritonitis was observed in only 13 and an appendicular abscess in 30.

In only a few instances has the incidence of a foreign body in the appendix been suspected before operation, especially in the case of calculi.

From this résumé of the literature, especially in connection with the success in the diagnosis of calculi in the appendix by the aid of roentgen rays, it is evident that the more general use of this means of diagnosis in abdominal work will soon increase the number of cases so diagnosed, both in the calcareous conditions and in other types of dense foreign bodies.

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DISCUSSION

Dr. Kessler. I desire to report one case which occurred in the practice of one of our St. Louis surgeons, in which the symptoms were those of appendicitis. At operation a stone was found in the appendix.

Dr. Lewald. I have a case of pin necrosis that has been present for fifteen years. The interesting point about it is that there was a sinus which finally healed and then broke down again. This sinus was in the right inguinal region. It was only after the second sinus appeared that a roentgen-ray examination was made and the presence of the pin demonstrated in the right side. The case was operated on and the pin removed. There was a little stump of an appendix in a more or less inflammatory exudate. I have a similar case which I shall investigate. I regard it as a concretion case.

Another case was of considerable interest because we were asked to *x*-ray the lung only because it was thought there was a pneumonia which was simulating appendicitis. Due to our habit of using large plates, we were able to see the condition in the appendix with a negative lung. The appendix was removed and was found to contain a pebble. Further inquiry by the attending physician led to the discovery that a week previously the youngster had swallowed a pebble.

We have 2 cases of shot similar to those Dr. Murphy has mentioned. One was found in a hernial sac; the appendix was found in the hernial sac and probably the patient was suffering more from the shot in the appendix than from the hernia. Amputating the appendix cured him. Another case occurred in a man from the south who was in the habit of eating pheasant every Sunday morning. Six shot were found in his appendix. He still has them and without discomfort.

We had 3 cases of concretions such as Dr. Murphy mentioned. One of them was almost operated on as a ureteral calculus. We catheterized the patient, made a roentgenogram and found that the shadow was outside the ureter. At operation the calculus was found in the appendix. We had 2 other cases in which large concretions had formed in the region of the appendix because they were larger than the lumen of the appendix would hold.

It seems to me that once these concretions are discovered, and if the patient is suffering from abdominal distress, we are justified in the opinion that the appendix should be removed. I am cautious in this matter, unless the clinical evidence is sufficient to warrant a diagnosis.

Dr. Murphy (closing discussion). I have nothing to add except that I think we should keep looking for these things, for in that way we may be able to clear up a case that we would not otherwise discover.

SOME PRACTICAL RESULTS WITH A POTTER-BUCKY DIAPHRAGM*

BY R. B. WILSEY

Research Laboratory, Eastman Kodak Company
ROCHESTER, NEW YORK

At the recent meeting of this society in Washington, a report was presented of an investigation of the efficiency of the Bucky diaphragm principle, in which a study was made of the effects of various factors in the design of the diaphragm grid. Using a container of water as the scattering material, it was found that the intensity of scattered radiation falling upon the film was determined by the ratio of the width to the depth of the diaphragm slits, and did not depend upon the absolute size of the slit or the distance between the scattering material and the film. It was found easily possible by this method to remove 80 per cent or more of the scattered radiation. The wood filler holding the lead strips in place appeared to have very little effect upon the efficiency of the diaphragm. The effect of the Bucky diaphragm upon contrast is governed by its efficiency in removing scattered radiation: its effect upon definition depends also upon the distance between the scattering material and the film; and the investigation showed that this distance had a very marked effect upon the definition. In roentgenographing through a 6 inch depth of water, with a distance of one inch between scattering material and the film, a slit ratio as small as .044 ($^1/_{23}$) failed to produce any improvement in definition; in

*Read at the Midwinter Meeting, Eastern Section of the American Roentgen Ray Society, Atlantic City, January 26-28, 1922.

fact the definition was poorer than without the diaphragm. However, by reducing the distance between scattering material and film to $3/8$ of an inch or less, with a suitable ratio of slit width to slit depth, improvement in definition was obtained in roentgenographing through 4 inches of water. In order to secure this advantage over the whole area of the film, the cassette should fit the curvature of the grid, and thus maintain the same distance between scattering material and film over all parts of the film.

These results agreed in the main with the experiments of Dr. Potter on the Bucky diaphragm, and their quantitative character made it possible to proceed with more certainty to the refinement of this most valuable apparatus. It was quite evident from this investigation that the most promising improvement of the Potter-Bucky diaphragm consisted in shortening the distance between the scattering material and the film.

For the sake of convenience, the experiments just described were performed with a single element of the Potter-Bucky grid, a single slit, whose dimensions could be varied as desired. A complete Bucky grid, whose design is based on the results of these experiments, has just been completed and it is desired to report upon the preliminary results obtained with it. The slit depth is 0.16 of an inch, the slit width 0.05 of an inch, making the slit ratio practically $1/3$. The lead strips are 0.010 of an inch thick; the filling material consists of strips of celluloid. The whole grid is supported in a substantial frame with a curved aluminum floor 0.02 of an inch thick. The top cover of the diaphragm is of aluminum $1/32$ of an inch thick, and the top of the curved cassette is of the same thickness. The free space that must be allowed between the grid and the cassette and between the grid and the diaphragm cover depends on how accurately the curved surfaces approximate true cylindrical surfaces, and how accurately adjacent surfaces fit each other. It was found that when the diaphragm cover was supporting a weight or was under compression, the distance between it and the film was about $5/16$ of an inch. Probably this distance can be diminished slightly by suitable adjustments. These figures are not claimed to be the best dimensions for a Bucky grid; no doubt they will be improved upon. Preliminary tests with the diaphragm indicate that thicknesses as small as 4 inches can be roentgenographed with advantage. Roentgenographs of the human knee made with this diaphragm show, in addition to the enhanced contrast, better definition and more detail in the bone structure than roentgenographs made without the diaphragm. There are here exhibited roentgenographs of various parts of the body made both with and without the Bucky diaphragm; a close inspection of these roentgenographs will show the advantage of the thin grid in improving roentgenographic definition and detail.

LOS ANGELES

LOS ANGELES and Southern California are well known throughout the world as the playground of America. You who are coming here, perhaps only for a short time during the convention, will find Los Angeles and its surrounding country a real vacation center in the truest sense of the word. For the benefit of those members of the American Roentgen Ray Society who are planning to spend their vacations this summer in Southern California and attend the convention in Los Angeles, from September 12th to 16th, we shall tell a few things about Los Angeles and list some of the attractions which Southern California has to offer its visitors.

A little over thirty years ago Los Angeles had less than 50,000 people. Ten years later its population had doubled; and by the year 1910 it could boast of an official population of over 300,000. The 1920 census figures showed an increase to 576,673, which figures were revised in July of the same year to a grand total of 611,636 or a gain of in excess of 90 per cent for the ten-year period. This gain was approximately five times the average gain for the United States during the same period. Conservative estimates place the present population at 750,000. Today Los Angeles is the ninth city in population and wealth and the tenth in industry in the United States. During the same period from 1910 to 1920, Los Angeles County's population increased practically at the same rate, from 504,131 in 1910 to 936,455 in 1920, or a gain approximately of 85.8 per cent, which shows very clearly that the growth and development of the country district immediately surrounding the city of Los Angeles has kept pace with the growth of the city itself.

Los Angeles is a city of homes of unsurpassing beauty of every type, from the smallest cottages to the largest mansions. Her lawns are green the year round; and the trees, flowers, shrubbery, and palms are to be seen everywhere. The rare beauty of the grounds surrounding the attractive homes of this city is the constant theme of admiration on the part of eastern visitors. Los Angeles is a city of schools, which are among the best built and the best equipped in the whole country. It has two great universities as well as several large business colleges and colleges of music and art. This city pays a larger tax per capita for schools than any other city in the United States. It is situated

Ocean front at Santa Monica, near Los Angeles.

in the center of a land of almost perpetual sunshine, between the mountains and the sea. Los Angeles is both a winter and a summer resort. From 200,000 to 300,000 tourists come here annually to spend their vacations. One of the many reasons for this is the fact that it is a sportsman's paradise.

It boasts the most highly improved system of highways in the United States, stretching in every direction from the heart of Los Angeles through the great valleys to the mountains and to the ocean. From a spin on any of these fine boulevards one may stop to fish or hunt, for a splash in the surf, or for a tramp in the hills or beautiful mountain canyons. From the ocean to the foothills, through orange groves and rose hedges, these splendid asphalt and concrete lanes invite business and pleasure travel alike.

Within easy motoring distance of the city are scores of pretty little suburban cities, each having its own distinctive charm. Visitors in Los Angeles have little difficulty in selecting a different motor trip for each day of the month, and every one of them is over smoothly surfaced highways lined with roses and orange, lemon, and walnut groves.

Perhaps the most convincing tribute to the highway system of this locality is the enormous number of automobiles in the one county of Los Angeles. Exactly 211,-679 automobiles were registered in this one county on January 31, 1922, which is more than the total registration for any one of thirty-two different states of the Union.

Westlake Park, Los Angeles.

The Los Angeles County coast line contains a varied succession of scenery. In addition it has this great advantage, that the beauties of the beach and the ocean may be enjoyed to perfection every month of the year. Even at midwinter, when the beaches on the Atlantic Coast are deserted, numerous visitors may be seen at the beach resorts on a Sunday or holiday, enjoying a dip in the surf or gathering ocean treasures. Not only is the winter climate beyond all comparison with that of the eastern coast at the same time of the year, but the summer is also far more pleasant. On the coast there is never an oppressively warm day.

The leading seaside resorts of Los Angeles are Santa Monica, Ocean Park, Venice, Redondo Beach, Long Beach, and Catalina Island. Santa Monica, which is within less than an hour's ride from Los Angeles, is an improved, progressive, seaside city with beautiful homes, a fine beach, and many attractions for the summer visitors. It is famed as the place "Where the mountains meet the ocean." Here one may enjoy superb mountain climbing; and in less than an hour descend for a swim in the surf.

Ocean Park, which joins Santa Monica on the south, is built up with neat cottages for a couple of miles along the beach, with a cement walk 4 miles long and 30 feet wide.

Still further south, Venice, which can be reached from Los Angeles in about thirty minutes, is a most unique and attractive resort. With its canals, fine piers, great surf, and bath-house, it is one of Southern California's most popular beaches.

Long Beach, situated almost due south of Los Angeles, is a thriving city of over 55,000 people, with one of the finest stretches of hard level beach on the coast, and a pleasure wharf 1,800 feet in length. During the past few years the growth of Long Beach has been unusually rapid. Here is located the Virginia Hotel, the scene of many brilliant social events of Southern California.

No one can afford to miss Santa Catalina Island, whose rugged peaks may be seen rising out of the haze 20 miles out from Los Angeles harbor. The island is widely known as the greatest big game fishing resort in the world. Santa Catalina is an exceedingly picturesque mountainous island, 23 miles long and about 4 miles wide. It is reached by steamers from either Long Beach or San Pedro. The waters here are so clear that, through the glass bottoms of specially fitted boats making regular trips, wonderful submarine scenes may be admired. With the fish, large and small, swimming about in the forests of kelp, and darting here and there at great

Linda Vista Bridge.

Skyline from Pershing Square.

depths, and with star-fish, sea anemones and other forms of sea life in a bewildering wealth of color and action, one gets a picture never to be forgotten. Here, too, are to be caught the huge sea bass, the great fighting tuna, and the sword fish, for which the ambitious sportsman angles with rod and tackle of such light weight as to make the successful landing of a large fish appear absolutely impossible. The bathing at Catalina is unexcelled anywhere in the world; and there are the night trips to sea with the search lights revealing myriads of flying fish in midair. The hotel accommodations are of the best; and a week will be found all too short to stay on this wonderful island.

The Sierra Madre, or Mother Range, the foothills of which are about 10 miles from Los Angeles, is a romantic and interesting range of mountains. Along this range are numbers of interesting canyons. The two most popular peaks in the Sierra Madre are Mount Wilson and Mount Lowe. The former is reached by a comfortable trail, either by horseback or on foot. Near the summit is an excellent camp where good accommodations are furnished to visitors. The crest of the mountain is a park-like tract shaded by giant pines, from which the visitor looks across a tremendous gorge into the heart of the range. Here is a world-renowned astronomical observatory containing the largest telescope in the world. Mount Lowe is reached by electric cars and cable, the whole forming an interesting and ingenious system of mountain railway which extends to Alpine Tavern, at a height of about 5,000 feet.

So far we have mentioned only a few of the beauty spots of Southern California. If space permitted, we would tell you of Pasadena, famous throughout the world as a city of millionaires, with its magnificent castles, beautiful residences, and luxurious hotels; of Riverside, which is the home of the orange and of the Mission Inn, perhaps the most unique hotel in all the world; of Redlands, with its Smiley Heights; of San Diego, our neighboring city on the south, where among many attractions perhaps the most unusual is the chance to get a glimpse of Old Mexico at Tia Juana; and of numerous other places including our many mountain resorts, of which Big Bear Lake is considered the best known and liked.

And do not forget that Los Angeles is the movie capital of the world. Approximately 80 per cent of the moving pictures of the world are manufactured here, at Hollywood, Culver City, and Universal City, the climatic conditions being unexcelled for photography. This has led to the development of an industry of large proportions employing thousands of people. Here is where your favorite movie star lives and works, almost without a doubt.

So varied is the topography of Los Angeles city and county that the picture makers find corners of any part of any country in the world in the county, if not in the city. The deserts of Arabia are behind El Segundo, in the sand dunes. The mountains of Switzerland are anywhere in our hills. The Canadian woods are only four hours away, up by Big Bear Lake, with the pines and snow and the mountains. The green sloping hills of Britanny are anywhere along the coast; and the palm-fringed isles of the South Seas are at the mouth of Topango Canyon. The rocky cliffs of Monte Carlo have been located between Long Beach and Redondo. In fact, all the world is here for the convenience of the picture folk.

Some of the studios admit visitors on certain days; and all of them admit visitors with special passes. Visiting members of this convention will have little trouble meeting their favorite movie actor or actress face to face.

However, attractions for the tourist and the visitor, admirable as they may be, do not represent the only attractions to which Los Angeles is proud to lay claim.

Los Angeles' industrial growth has kept up with its growth in population, which is saying a good deal. Figures recently issued by the Chamber of Commerce show that the city now has 3,800 manufacturing establishments of various kinds, of which number 450 were established in 1921. These concerns employ over 125,000 workmen, whose monthly pay-roll runs over $16,000,000. The value of manufactured products from these industries in 1920 was in excess of $788,000,000, as compared with $103,357,000 in 1914, $68,586,000 in 1909, and $15,134,000 in 1900.

Los Angeles has practically the only 365 working-day climate in the United States; and the saving made possible by the climate, both to industrial establishments and to the workers themselves through the medium of better health, lower fuel, cost of clothing, and enjoyment of real outdoor life, is an advantage which will, in time, outweigh the reputation of this locality as a national playground.

Los Angeles, through her wonderful aqueduct system which is the longest in the world, has a supply of pure mountain water sufficient to take care of over 3,500,000 people; and can increase the supply through additions whenever it becomes necessary. In the last ten years it has actually been increased from 14,600,000 gallons

Wilshire Boulevard near the Ambassador Hotel, Los Angeles.

to 30,000,000 gallons in the city alone; and from 91,000 water service in operation in 1910 to over 230,000 in operation at the present time. The water flows through 52 miles of tunnel, 12 miles of siphon, 100 miles of lined and covered conduit; 40 miles of open lined canal, 21 miles of open unlined canal and 8 1/2 miles of reservoirs. It is to the abundance and cheapness of her water supply that Los Angeles owes much of her prosperity and her ability to grow.

Los Angeles is the geographic center of the Pacific Coast of the United States for trade with the west coast of Mexico and South America, and for trade with the eastern ports of the United States through the Panama Canal. And, what is even more important, Los Angeles considers itself the natural port of the Pacific to receive the bulk of the commerce that in the near future will be exchanged between the United States and the great countries of the Orient—China, Japan, Australia, the Philippines, and Russia. It is determined to hold every advantage it has in being situated at the entrance to all these enlarging markets. Consequently $20,000,000 has been spent or appropriated for the development of its harbor, the object being to provide adequate facilities for warehousing and docking at the lowest possible rates.

Over sixty steamship companies, having vessels in international service, operate through Los Angeles harbor. Its commerce has increased from approximately 2,100,000 tons in 1918 to almost 5,000,000 in 1921.

That Los Angeles has been building on a firm foundation is evidenced by the way her growth has continued during the period of recent depression. The value of her building permits has been the wonder of the whole country since the early months of 1920. During that year the value of building permits amounted to $60,023,600. 1921 went over with a vengeance and rang up a total of $82,761,286. But the present year promises to set an even greater record with a total of over $39,000,000 for the first four months of the year.

Los Angeles bank clearings have been very conspicuous during the last two years because of their increase at a time when practically every other city of the country was registering losses. From $1,048,090,667 in 1910, bank clearings have increased to $3,994,401,000 in 1920, and $4,211,196,797 in 1921. What better testimonial could be written on the continued growth and prosperity of a great city?

Looking North on Broadway from 7th Street.

We could tell you much more about this wonderful city and its surrounding back country; but what we have said is sufficient, we believe, to impress upon your minds the fact that, while Los Angeles and Southern California continue to be the playground of the nation, they are rapidly becoming the industrial, financial, and population center of the west as well. And we are sure that you will want to come and see for yourselves.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922

Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

AMERICAN ROENTGEN RAY SOCIETY

TWENTY-THIRD ANNUAL MEETING

Preliminary Program

For many years our far western members have been making every effort to persuade us to meet on the Pacific Coast; at last they have succeeded. The twenty-third annual meeting of the American Roentgen Ray Society is to be held in Los Angeles, California, September 12th to the 16th, 1922.

The members of the various local committees have been unusually active in their efforts to make our visit both comfortable and attractive.

The Hotel Ambassador has been selected as the meeting place; it is one of the best hotels in the west. Special attention is to be given to members and guests. The hotel management has provided a comfortable, well-ventilated meeting room, where our scientific sessions are to held; spacious quarters are assigned to accommodate our scientific and commercial exhibits.

The scientific program will have as much, if not more than its usual attractiveness. The following accepted papers will give some idea as to the scientific treat to be expected:

MISCELLANEOUS

Hickey, Dr. P. M., Detroit, Mich. "The Effects of the War on the Development of Roentgenology."

Pahlerr, Dr. G. E., Philadelphia, Pa. "A Study of the Blood of the American Roentgenologist."

Watkins, Dr. W. W., Phoenix, Ariz. "The Commercial Laboratory in a Small City."

NEUROLOGY

Crouse, Dr. H. W., El Paso, Tex. "The X-Ray in Neurological Diagnosis—Its Shortcomings and Possibilities." (By invitation.)

HEAD

Ruggles, Dr. H. E. and Schulze, Dr. Elizabeth; San Francisco, Cal. "The Importance of Proper Technique in the Determination of the Sphenoidal Angle." (Dr. Schulze, by invitation.)

Law, Dr. F. M., New York City. "Errors in the Interpretation in Lesions of the Sinuses."

Evans, Dr. Wm. A., Detroit, Mich. "Roentgen Study of Mastoid Pathology in Children under Five."

BONE

Bloodgood, Dr. Joseph C.; Baltimore, Md. Title unannounced.

Cotton, Dr. Albertus, Baltimore, Md. "The Roentgenologist in the Diagnosis and Interpretations of Fractures."

Keith, Dr. D. Y., Louisville, Ky. "The Value of Grant's Pins as seen Roentgenographically in the Treatment of Fractures."

Brown, Dr. W. L., El Paso, Tex. Title unannounced. (By invitation.)

George, Dr. A. W., Boston, Mass. Title unannounced.

JOINT

Chamberlain, Dr. W. E., San Francisco, Cal. "Lower Back." (By invitation.)

Blaine, Dr. E. S., Chicago, Ill. "Bilateral Sacroiliac Arthrosis Obliterans and Its Probable Etiology."

Taylor, Dr. R. G., Los Angeles, Cal. "Roentgen Gastrointestinal Studies in Over One Hundred Cases of Chronic Deforming Arthritis." (By invitation.)

URINARY TRACT

Nichols, Dr. B. H., Cleveland, Ohio. "The Importance of Technique in Roentgen Examination of the Urinary Tract."

Bowman, Dr. W. B., Los Angeles, Cal. Title unannounced.

CHEST

Sante, Dr. L. R., St. Louis, Mo. "Roentgenographic Examination of Lobar Pneumonia and Its Complications."

Jaches, Dr. Leopold, New York City. "Pulmonary Tuberculosis."

Dunham, Dr. Kennon, Cincinnati, Ohio. "X-Ray Evidence of Absorption of Tuberculous Exudate."

Pirie, Dr. A. Howard, Montreal, Canada. "Prognosis in Tuberculosis of Lungs from Examination by X-Rays."

Christie, A. C., Washington, D. C. "Intrathoracic Changes Following Roentgen Treatment of Breast Carcinoma."

Allison, Dr. R. G., Minneapolis, Minn. Title unannounced.

Brown, Dr. Philip King, San Francisco, Cal. "Annular Pneumothoraces." (By invitation.)

Childs, Dr. S. B. and Hall, Dr. J. N., Denver, Colo. "New Growths Within the Chest." (Dr. Hall, by invitation.)

Matson, Dr. R. W., Portland, Oregon. (By invitation.)

Holmes, Dr. G. W., Boston, Mass. "Cardiac Pneumofibrosis."

Waters, Dr. C. A., Baltimore, Md. "Bronchiolitis Fibrosa Obliterans."

Moore, Dr. A. B., Rochester, Minn. "Bronchiectasis."

Bowen, Dr. D. R., Philadelphia, Pa. "Thoracic Empyema with Especial Reference to Interlobar Types and to the Study of Chronic Empyema."

Manges, Dr. W. F., Philadelphia, Pa. "Our Technique in Aiding with the Fluoroscope in the Removal of Foreign Bodies from the Air Passages."

GASTROINTESTINAL TRACT

ESOPHAGUS

Manges, Dr. W. F., Philadelphia, Pa. Title unannounced.

STOMACH AND DUODENUM

Alvarez, Dr. W. C., San Francisco, Cal. "Peculiar Types of Gastric Peristalsis."

Forssell, Dr. Gösta, Stockholm, Sweden. "Roentgenographic Studies of the Mechanism of Movement of the Mucous Membranes in the Digestive Tract."

Carman, Dr. R. D., Rochester, Minn. Title unannounced.

Imboden, Dr. H. M., New York City. "A Further Consideration of the Intermittent Obstruction of the Duodenum."

GALL-BLADDER

Burnham, Dr. M. P., San Francisco, Cal. "Importance of Indirect Roentgen Findings in Chronic Infection of the Biliary Ducts and Gall-bladder."

SMALL INTESTINES

Portis, Dr. Milton M., and Portis, Dr. Sidney A., Chicago, Ill. "Carcinoma of the Small Bowel."

COLON

Payne, Dr. R. A., Portland, Oregon. "Retrocecal Appendix."

LeWald, Dr. L. T., New York City. "Report of Twenty-five Cases of Transposition of Viscera. Differential Diagnosis Especially from Non-rotation of Colon and from Dextrocardia."

Boardman, Dr. W. W., San Francisco, Cal. "Enteroliths."

Jenkinson, Dr. E. L., Chicago, Ill. "Report of Three Cases of Primary Carcinoma of the Gastro-intestinal Tract with Bony Metastasis."

THERAPY

Osmond, Dr. J. D., Cleveland, Ohio. "X-Ray Treatment of Acute Infections of the Antrum and Frontal Sinus."

Kinney, Dr. L. C., San Diego, Cal. "Roentgen Therapy of Tinnitus Aurium."

Waters, Dr. C. A., Baltimore, Md. "Further Report on Roentgen-ray Treatment of Hypertrophied Tonsils."

Ullmann, Dr. Henry J., Santa Barbara, Cal. "The Bacteriology of Irradiated Tonsils."

Ledoux-Lébard, Dr. René, Paris, France. Title unannounced.

Gaylord, Dr. Harvey R., Buffalo, N. Y. Title unannounced. (By invitation.)

Case, Dr. James T., Battle Creek, Mich., and Warthin, Dr. A. S., Ann Arbor, Mich. Title unannounced. (Dr. Warthin by invitation.)

Schmitz, Dr. Henry, Chicago, Ill. "The Technique of Radiation Treatment of Cancer of the Uterus." (By invitation.)

Soiland, Dr. Albert, Los Angeles, Cal. "Conservation—the Keynote of Superradiation."

Erskine, Dr. A. W., Cedar Rapids, Iowa. Title unannounced.

Holznecht, Dr. Guido, Vienna, Austria. "Conservative Deep Roentgen Therapy." (Paper to be read by Dr. W. C. Wescott of Atlantic City, N. J.)

Millwee, Dr. R. H., Dallas, Tex. "Some Observations on the Practical Application of High Voltage X-Rays."

Stevens, Dr. J. T., Montclair, N. J. "Report of Cases Showing Favorable Results of Deep Roentgen Therapy."

Martin, Dr. C. L., Dallas, Tex. "The Effect of the Erythema Dose on the Intestinal Tract."

Desjardins, Dr. A. U., Rochester, Minn. "Anatomical Cross-section Charts in Estimating X-Ray Dosage."

Readers of papers are asked kindly to forward abstracts for publication in the program as soon as possible.

An entire afternoon is being reserved for the lantern slide demonstration—this is always a very valuable addition to the scientific program, and every member is urged to contribute. In conjunction with the lantern slide exhibit the "sealed verdict" cases will be considered.

The lantern slide presentation is not limited to members only. Any guest of the Society has the privilege of reserving a place on this program.

Kindly send in your name as soon as possible and indicate the number and nature of the slides you intend to show. Address all communications, regarding lantern slides or "sealed verdict" cases, to Dr. William B. Bowman, 818 Brockman Bldg., Los Angeles, Cal.

There will be no scientific session in the evening except on Wednesday, September 13th, when Dr. William Duane of Harvard University will deliver the Caldwell Lecture—entitled "The Scientific Basis of Short Wave-Length Therapy."

On Thursday evening, there will be a dinner-dance to which the members and guests and their wives are invited.

Among the many social events arranged for by the Local Committee is an automobile trip on Saturday, the 16th, and also a sail to the Catalina Islands on Sunday, the 17th.

Pertinent questions of today in the field of roentgenology and roentgen or central bone ray therapy:

Have you a case on record of a periosteal sarcoma cured with *x*-ray or radium?

Have you had any experience with infinitesimal exposure of the pituitary gland to the *x*-ray in the treatment of deafness?

Have you any cases where you feel that *x*-ray treatment of the breast has caused the development of non-malignant changes in the lungs sufficient to be recognized roentgenographically? If so, how do you differentiate these changes from pulmonary metastasis?

All affirmative answers will be considered at the Los Angeles meeting. Kindly communicate with the President-Elect, Dr. W. H. Stewart, 222 West 79th Street, New York City.

ARRANGEMENTS FOR TOUR

Numerous members of the Society have expressed a desire to combine a tour of the western country with their trip to the Annual Meeting, and arrangements have been made for such a tour under the personal supervision of an experienced tour manager, Mr. E. R. Rochester, who will himself accompany us and care for all the details of travel.

A circular giving complete information with regard to expense, the proposed itinerary, and the time of arrival at and departure from principal points will be sent upon request to the undersigned.

There is no objection to the members of the Society inviting friends who are not members to accompany our party.

It is requested that all who are interested, or desire further information, correspond with the undersigned. Reservations for the trip should be made as soon as possible.

A. C. Christie, President
American Roentgen Ray Society,
1621 Connecticut Ave., N. W.,
Washington, D. C.

Note: There is still time to make reservations if communication is sent at once to Dr. Christie.

DR. HEBER ROBARTS

Dr. Heber Robarts, a native of Belleville, Ill., died May 1, 1922. His death was due to a general metastasis following *x*-ray burns developed during the pioneer days of experimental research with the roentgen rays.

Heber Robarts, M.D.

His father, Dr. James Robarts, a physician of great skill and learning, was actively interested in McKendree College, and in 1869, his son Heber was admitted to this same college at the age of seventeen, and soon afterward became an active member of the Philosophian Society.

After attending two courses of lectures at Jefferson Medical College, Philadelphia, he entered the Missouri Medical School and graduated as a physician in 1880.

During the early years of his life he was actively interested in the medical problems of his home state. In 1881 he served as secretary of the board of the United States Examining Surgeons, and later was appointed by the governor of his native state as a delegate to the Sanitary Convention of the Mississippi Valley and Gulf States. He was always interested in Health Departments and Health Ordinances, and he was the author of many of the latter which are practical models of efficiency even today.

He began experimenting with radioactive substances over twenty years ago while living in St. Louis. The first high frequency coil made for generating high voltage to excite an *x*-ray tube was made under his instruction. The instantaneous cut-off in the handle of the fluoroscope and the pocket for the sensitized plate were his early conception. He was likewise a pioneer in the advocacy of the *x*-rays in the treatment of lupus and other inflammatory skin infections, and very early realized both the safe and dangerous use of the rays in epilation.

In 1897 he published the initial number of the *American Roentgen Ray Journal* which was the first regular publication upon this subject in the world.

In 1890 the Roentgen Ray Society was organized, and he was its first president, presiding at the meeting in New York City in December, 1900, and at the Buffalo meeting in September, 1901.

During the year 1904 he went to Europe to procure radium and to study its physics and therapeutic application. He was the first to use aluminum carriers for radium, and the first to publish a bound volume devoted to the therapeutics of "Practical Radium." His most recent articles published were "Ions Produced by Radium;" "Radioactive Tissues;" "Radium;" "Thorad-X;" "Radium Applicators."

During the year 1905, with the aid of several Italian guides, he reached the crest of the crater of Vesuvius, and although the volcano belched forth sulphurous fumes, ashes, and lava, he procured samples of these ashes, and established the fact that radio-active matter is not confined to the thin crusts of the earth's surface.

He was in Austria in 1914 shortly before the war and purchased radium. He had considerable trouble on his return voyage, but eventually placed it at the disposal of St. Vincent's Hospital; and it was this same radium that he made use of in the treatment of his own condition.

Those who knew Dr. Robarts personally will bear testimony to the extreme interest he showed in medical science as a member of the local and state societies, including the American Radium Society and the Roentgen Ray Society of London.

In giving his life to the cause of science it should be remembered that Dr. Robarts made this supreme sacrifice only after the culmination of a series of lesser sacrifices, extending over a period of many years of suffering, meanwhile fulfilling his duties as only a true physician could do when the welfare of his patient was at stake.

Edwin C. Ernst.

A CORRECTION

In the article by Dr. R. Walter Mills on Small Intestinal States which appeared in the April, 1922, issue of the Journal there were two typographical errors.

On page 209, legend of Fig. 25, line 5, the word "hypomotility" should read hypermotility."

On page 222, in the last line of the article, the reference to Fig. 37 is incorrect. It should be Fig. 49.

TRANSLATIONS & ABSTRACTS

Bailey, Harold, and Quimby, Edith. The Use of Radium in Cancer of the Female Generative Organs. (*Am. J. Obst.*, February, 1922, iii, No. 2.)

This paper discusses the methods of radium therapy in the treatment of uterine cancer in use at the Memorial Hospital, and describes the efforts to determine accurately the dose by ionization measurement. There were 600 cases of uterine cancer and 32 cases of vulval and vaginal cancer treated in the six years from 1915 to 1921. The follow-up of these cases extends to May 1, 1921.

The full technique, using the external radiation as an aid to the capsule and bomb was not in routine use until 1918. If the advanced primary cancer and the recurrent cancer groups were taken together, there were 132 cases treated before January 1, 1918, and there are but 5 cases alive today. If these same groups are taken for 1918, there are 76 cases and 15 are alive; for 1919, 112 cases and 40 are living; for 1920, 129 cases and 85 are still alive. While the prospects of greatly reducing these figures are present and sure, nevertheless, the indications are that in these groups, we have had our greatest advance.

The follow-up of our operable and borderline classes will have to be continued through three or four more years before deductions may be made. Our present figures are remarkable and indicative.

In the prophylaxis after hysterectomy, great care must be used that the tissues are not over-radiated. The end results in this class are very good for the time elapsed since treatment.

We believe that these results cannot be duplicated without the use of massive doses of radium or without thoroughly radiating the parametrium.

Funk, E. H., and Manges, W. F. Eventration of the Diaphragm, with Report of a Case. (*Am. J. M. Sc.*, September, 1921, p. 348.)

Eventration of the diaphragm is known in the literature under several different heads. Such terms as "high position," "elevation," "dilatation," "relaxation" and "congenital insufficiency" are used. In 1916 45 cases had been reported, including one reported by Bayne-Jones. Since then, two cases have been encountered, which, with this case report brings the total number of cases to date up to 48.

The weight of evidence seems to favor a congenital origin of the condition. The authors note one case in a patient a few days old where the diaphragm reached to the 2d interspace.

Some arguments for the congenital nature of the condition are:

1. Its occurrence on the fetus and newborn.
2. Its association with other congenital anomalies.
3. Involvement of the left side almost entirely—this being the half of the diaphragm most complex in its fetal origin.
4. The absence of compression of the lung and contiguous structures.
5. The absence of deformity or irregularity in the contour of the chest.

A detailed report is given of the clinical history and physical findings in the case reported. The *x*-ray findings showed the left diaphragm considerably higher than the right and that it did not move on forced inspiration. No other evidence was present of disease of the lungs. No adhesions were present to the diaphragm. There was enormous distention of the colon with gas, but it was not thought that this had any influence on the height of the diaphragm.

Among the reported cases the left half of the diaphragm was the site of involvement in all except 3 cases. The dome was regular in outline and it was not associated with adhesions of the pleura. L. R Sante.

Taussig, Fred J. Radiotherapy in Malignant Gynecologic Diseases. (*J. Missouri M. Assn.*, 1921, xviii, No. 7, p. 224.)

The term radiotherapy includes treatment both with radium and *x*-rays. In benign gynecologic conditions these two are of nearly equal importance, but in the treatment of malignant conditions radium has many evident advantages, so that the *x*-ray is usually only supplementary to it and has seldom been used as an independent therapeutic agent. The personal experience of the author is given as 120 cases, 109 of which were cervical cancer treated during a period of three and a half years. He does not consider this number of cases sufficient and prefers to draw conclusions as to the ultimate usefulness of radium and *x*-ray from the much larger number of published cases.

The surgical treatment of cancer of the body of the uterus with 75-80 per cent cures leaves little excuse to employ radium.

In cervical and vaginal cancer, the problem is to destroy the growth with the least possible injury to the surrounding structures. Normal tissues vary greatly in their susceptibility to injury by radium. The cervix can stand ten times the dose safe for the vagina and fifteen to twenty times the dose tolerated by the rectum. Our aim therefore should be to so place the radium within the cervix that the entire tumor mass would be affected by the first treatment period, since by subsequent treatments the normal tissues become more susceptible and tumor tissue more resistant to radiation.

Diminution of the bleeding and discharge and temporary alleviation of pain will follow in the vast majority of cases, but this is of little significance as a criterion of the ultimate outcome. In the experience of a few men radium has been employed for a long period, so that at least some five-year experiences are available.

Out of 1114 cervical cancers, all stages treated with radium alone, 223 cases remained cured five years (about 20 per cent). Of 415 operable cases 131 remained cured after five years (31.5 per cent). This is about the same as has been obtained by operative measures alone. In early operative cases it was found that radium cured 35–40 per cent; whereas operation cured 45 per cent. In advanced operable or borderline cases, however, radium cured 23 per cent, while operation cured only 10–12 per cent. The author feels that where carcinoma is confined to the cervix, operation is still indicated, where in borderline and inoperable cases, radium and *x*-rays hold forth the greatest hope of cure. L. R. Sante.

Smithies, Frank. Diagnosis and Clinical Manifestations of Cardiospasm Associated with Diffuse Dilatation of the Esophagus. (*Am. J. M. Sc.*, September, 1921, p. 313.)

The paper is based on an observation of 76 instances of cardiospasm and a detailed analysis of 47 cases. A distinction is made between "Cardiospasm" and "spasm of the cardia," the term cardiospasm being applied to those cases in which, due to long-continued contraction of the cardiac sphincter, a diffuse dilatation of the esophagus results. The condition was found to be of equal prevalence in men and women. The average age was thirty-nine years; the youngest nineteen and the oldest seventy years of age. Occupation played very little part, and other ailments, except in very few instances, had very little association with the condition. The average duration of the condition was 5.6 years. Individual cases varied from three months to twenty years. Dysphagia was the most striking symptom.

The *x*-ray is given due credit in the diagnosis of the condition. Emphasis is laid on the oblique and anteroposterior positions for determining the position of the spasmodic contraction and for showing any irregularity in the lower end of the esophagus. Illustrations are presented showing similarity which can exist between the *x*-ray appearance of uncomplicated cardiospasm and a dilatation of the esophagus in association with carcinoma of the lower end of the esophagus. Fluoroscopic examination is of aid in passing a stomach tube or bougie into the stomach; but a procedure advocated by Mixter of Boston seventeen years ago, is thought to be the best method of passing a tube into the stomach. This consists in guiding a tube to the cardiac orifice along a silk cord attached to a metallic olive previously swallowed. An instance is cited of false passage of a bougie and death, where this procedure was not followed. Mention is made of an irregularity of rate of movement of the diaphragms in cases of cardiospasm and an increase in height of the dome of one diaphragm, which leads the author to the belief that cardiospasm may have some connection with a defect in the neuromuscular control of the diaphragm. Seventy per cent recover clinically and functionally. Twenty per cent show improvement, and in about ten per cent gastrostomy is necessary.
L. R. Sante.

Partsch, F. Effect of Roentgen Rays on Liver and Spleen. (*München. med. Wchnschr.*, 1921, lxviii, No. 50.)

In only a small percentage of his cases did the author find a decrease in the coagulation time of the blood at operation, as the result of a prophylactic application of roentgen rays to the spleen. Neither did he find any proof that the pre-operative application acted in any way to prevent post-operative complications, such as hemorrhage or hematoma. As regards the liver, irradiation was as uncertain as in prophylactic treatment directed toward the spleen. Therefore, from the view-point of the practical surgeon, it is quite useless to employ prophylactic irradiation of either the liver or the spleen, except perhaps in cases of hemophylia, jaundice, or others with marked retardation of the blood coagulation time.

Nordentoft, S. Roentgen-Ray Treatment of Brain Tumors. (*Ugesk. f. Laeger*, January 19, 1922, lxxxiv, No. 3.)

This article reviews the present condition of 18 patients with brain tumor treated with roentgen rays prior to 1919. Four new cases are reported, bringing the total number treated up to 24. In 7 cases of the first series, improvement was transient or not observed at all; in 2 others it was later proved that the diagnosis was incorrect. In 9 patients the treatment has apparently resulted in cure. Visual disturbances remain in a few of the patients. The cures had persisted four, or five or six years in the 9 patients reported apparently cured in this series. The author believes that brain tumors are especially susceptible to the roentgen rays. In those cases responding favorably to the treatment, there is no tendency to recurrence. The ages varied from seventeen to fifty-one. Full details of the cases are given.

Moll, K. (Freibourg). Deep Roentgen Therapy in Surgical Tuberculosis, Bruns' Beitraege. (*Beitr. z. klin. Chir.*, 1920, cxix, p. 445.)

In 1914 Oehler made the first report from this (Kraske's) Clinic on deep roentgen therapy of this group of affections. During the ensuing four years a much larger series of cases has been treated. Tuberculosis lymphoma, chiefly of the neck, has greatly predominated. In 1918 alone 102 cases have been under treatment and during the four year term a total of 263. Deep rontgen therapy is by all odds the method of choice for this condition. Of the total number under treatment no less than 219 were practically cured by it alone. Only in a few instances was it desirable for cosmetic reasons to remove the small fibrotic nodules which could not be further reduced in size. Caseous and fistulous cases recovered equally with the simple hyperplastic cases, save that scarring persisted. The response to treatment was immediate and the improvement very noticeable after two or three sessions. To complete the cure, time is required, and the author neglects to state the average duration of treatment. That 44 cases of lymphoma were not cured shows the limitations of the method; for while in some of these there was a greater or less degree of improvement, in others there was no benefit, or the improvement was followed by recurrence.

The series of cases of bone and joint tuberculosis numbered 171, and the results were so uniformly good that in but 19 of these was a mutilating operation necessary. The best results were obtained in diseases of the hands, wrists and elbows. It is a law that the more slender and superficially placed the bone the better the result; and for this reason the results were good in the few cases of tuberculosis of the ribs and sternum. Of the bulky joints the knees responded best to the treatment. Of 29 cases in this location 17 were cured without a trace of disease remaining. There were relatively few cases of surgical tuberculosis in other locations and results were in general less favorable.

Markovits. Concerning the Influence of Mesothorium on Unicellular Organisms. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 1.)

The experiments of the author by irradiating paramaecium caudatum with 10 milligrams of mesothorium confirmed the biological fundamental law of Arndt-Hugo Schulz. After short irradiations (ten to ninety minutes) a marked increase in the propagation of the animals occurred. Larger doses, however, paralyzed or killed them. Previous experiments with plants and seeds had also confirmed this fundamental biological law.

Lyon. Spondylitis Typhosa. (*Berl. klin. Wchnschr.*, 1921, No. 18.)

According to the author, spondylitis typhosa is a sequel, and rarely a complication of typhoid fever. It occurs anywhere in the spine, beginning with the cervical area down to the sacrum, most frequently, though, in the fourth lumbar vertebra. Inasmuch as the symptoms are very slight, the roentgen-ray findings may be the first to call attention to this condition. In one case nothing abnormal was noted about the spine besides the *x*-ray finding. The process almost always runs a benign course. Formation of kyphosis is rare. The author quotes the monograph of Bonhure (1912) who observed as the most constant lesion a coalescence between two vertebrae, changes of the intervertebral discs, and thickening of the perivertebral tissues, more rarely slight lesions of the bodies of the vertebrae.

Bittorf noted greater transparency of the bodies of the lumbar vertebrae and bending of a transverse process. According to Plate, spondylitis typhosa occurs most frequently in men under forty, spondylitis deformans in men over fifty. The roentgen-ray finding shows no exact differences.

According to Schanz, trauma may play an important rôle. (Haenisch, of Hamburg, has in his collection the plates of a case of spondylitis typhosa which has the appearance of a compression fracture or of a healed tuberculous spondylitis. The process occurred in the lower spine. Reviewer's Note.)

Lüdin (Bâle). Roentgen Therapy in Internal Medicine. (*Schweiz. med. Wchnschr.*, Nov. 24, 1921.)

The author is an assistant of Professor Stähelin of the internist's clinic of the University. The paper is based on a material of

600 cases, referred to the department of physical therapeutics for treatment. The author has no iontoquantimeter for measuring his dosage and has had to depend on the old Sabouraud-Noiré pastilles. The unit—so-called skin unit—dose is reached by application of 3 to 4 Sabouraud units under 4 mm. aluminum. In internal indications, save in inoperable tumors, successful results have been obtained with single dose under H. E. D. (skin erythema dose). Fixed numerical doses cannot at present be given in internal cases, because there is individual variation and because doses must often be experimental. Nothing can be inferred from gynecological deep raying aside from cases of malignant tumors.

The author first takes up leukemia, the oldest internal indication for *x*-rays. For the chronic myeloid form this treatment is still *the* method. Thus far no case of complete recovery is claimed, but one patient has been able to work for the past eight years. The chief symptoms, enlarged spleen and increased leucocytes in the blood, can be promptly controlled. But after this feat we are pretty sure to see a prompt recurrence. The author therefore regards intensive treatment of these cases as an error. Treatment should be directed to bringing up the hemoglobin index and red cell count, and to the general condition. After these are satisfactory there may be long periods between courses of treatment, even if the spleen and white cell count are still unsatisfactory, and despite the presence in the blood of myelocytes. Not infrequently the latter do disappear from the blood, although the mast-cells may show a great increase. The patient must be kept under constant observation. When the quiescent although usually still enlarged spleen begins to increase further in size, and the white cell count to increase further, radiation should be resumed.

Under this plan of treatment the patient may follow his occupation for years, although this is not the rule. In addition to the case of eight years' activity already mentioned, the author has had one of four years. At the other extreme some patients are so little helped that the rays must be discontinued.

In chronic lymphatic leukemia the results are not so good, but still, some patients have kept active for years. In the acute myeloid form the rays are quite worthless, and this is also true of Banti's disease.

In aleukemic lymphadenosis the results are quite favorable, and a case is given.

In Mickulicz's disease the author obtained a perfect result in one case, all the glandular swellings becoming reduced to normal.

In malignant granuloma the results in some cases were surprisingly good, and two examples are given. Such cases have been common in the clinic. But after a period of latency there is apt to be a recurrence, which, even if not extensive, may affect some vital organ. The affected tissues are specifically attacked and destroyed and the recurrences appear in parts of the body which have not been rayed. Therefore as far as possible all the lymph-nodes in the body should be rayed.

In polycythemia we now know that it accomplishes nothing to ray the spleen. In fact, the author avoids raying it at all, and since he adopted this course his results have been very good (3 cases). In primary polycythemia the long bones are rayed.

The results were absolutely negative in pernicious anemia and chlorosis, and in Basedow's disease it is very difficult to interpret the results. In certain cases some of the symptoms show improvement. The author denies that adhesions form about the thyroid and interfere with surgical intervention.

In lymph-node tuberculosis the results are good, and weak doses are best, for strong ones precipitate softening. The author is also full of praise for the results obtainable in peritoneal tuberculosis.

The author has nothing to offer in the treatment of sciatica which is praised by French authors. All cases in the clinic yield to a mixture of physical and drug therapy.

He was very skeptical about raying erysipelas, but obtained 6 striking result in succession; he is not quite ready to claim it as specfici and ideal treatment.

In mediastinal tumors he has obtained good results without wishing to claim too much.

He is less enthusiastic about internal malignant tumors and thinks the rays are not making good here. Intrathoracic and intra-abdominal cancer, etc., have given results which are quite unfavorable.

He has some hope in the field of otosclerosis and progressive deafness, and the rays certainly exert a specific action on the process, but it is too soon to go on record on this condition.

LOREY. Spondylitis Typhosa. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 1.)

The author quotes a case in which he considers the roentgenologically demonstrated compression of the 12th thoracic and 1st lumbar vertebrae as the result of typhoid which the patient passed through some time before. The pains in the back which appeared during the course of the typhoid and which radiated into the thighs still existed at the time of the roentgen-ray examination. The appearance resembled very strongly a very old compression fracture or a healed tuberculous process, but trauma and tuberculosis could be excluded etiologically or clinically. The cause of the compression, according to Fraenkel, is to be found in the numerous small necrotic foci which occur in spondylitis typhosa next to the trabeculae of the spongiosa, which in consequence becomes necrotic, the bone eventually collapsing as a result of weight. But Lorey also believes that a breaking down of the bony tissues through pus formation is possible. Notwithstanding the generally favorable prognosis, the author does not wish to have the disease treated lightly (prolonged rest in bed is necessary), because there may be a collapse of the diseased vertebrae with secondary spondylitis deformans, and rigidity of the spinal column may result.

Haendly. Pathologic and Anatomic Results of Radiotherapy. (*Strahlentherapie*, 1921, xii, No. 1.)

The author, after a series of thorough pathological and anatomical examinations found that retrogressive changes were caused by radiation on all body cells (epithelioma, connective tissue, muscle, vessels and nerves); also that complete necrosis of entire organs may occur. New formation of connective tissue is far behind the damaging influence of the rays. The effect of the rays upon the uterine muscle and upon myoma is, according to the author, largely a direct one. The white blood corpuscles are the most sensitive, but the change in the red blood corpuscles is the most important and has as a consequence a particular form of cachexia, which has no relation to the cachexia of carcinoma. Warnekros has employed, with success, blood transfusions in such cases. An appreciable increase of metastases with a stimulating effect was not observed by the author. Regarding the primary point of attack of the rays, there is no consensus of opinion among the various authors. Some believe that the rays injure the individual cells directly, while Ricker takes the stand that injury to tissues is caused secondarily by the injury to the blood supply; that by stimulation of the dilators which remain sensitive longest, the blood circulation is retarded and finally becomes stagnant. The observations of Haendly have led him to conclude that the rays have a direct effect and also an indirect influence by altering the circulation of the blood. In 125 cases of carcinoma previously irradiated, which came to autopsy, the author was able to demonstrate almost always, degenerative changes of the connective tissue, although very frequently much viable-carcinomatous tissue was present. He therefore refutes the theory of the absolutely selective effect of the rays on carcinoma, and says that the normal tissues regenerate more easily, and that carcinoma which is poorer in cells may lose its regenerative power more readily. The irradiations must take place at intervals sufficiently large to enable a regeneration of the destroyed cells in the normal tissues. The roentgen rays are superior to radium, because of their greater and more homogeneous effect in the depth of the tissues.

Gallus. Spondylitis Typhosa. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 1.)

The author recites the case of a young man in whom severe pain in the lumbo-sacral region led to a roentgen-ray examination which demonstrated only very minute concretions, at the third lumbar vertebra. Soon thereafter he came down with an atypical form of typhoid fever, but the next roentgen-ray examination (six weeks later) showed a loss of the bony structure of the third lumbar vertebra and compression of that vertebra. A roentgen-ray examination six months later, when the patient no more experienced any symptoms, showed scoliosis of the lumbar spine, marked narrowing of the intravertebral space, and processes of repair. This case is instructive roentgenologically because the observations were made from the incipiency of the disease to its cure.

Elving, H. Measures for Promoting Blood Coagulation. (*Finska Läk.-sällsk. handl.*, 1921, lxiii, Nos. 11 and 12.)

Elving studied the coagulation time of the blood of normal individuals, finding that there is little variation in the normal. He then carried out a series of experiments to determine the effects of roentgen-ray treatment over the spleen, liver, and heart as compared with the effect of the intravenous injection of various substances. Roentgen-ray exposures over the spleen resulted in a moderate acceleration of the coagulation time in all but one of 12 cases. The accelerating effect was most marked by the end of five hours, and persisted through the eighth hour. At 24 cm. target skin distance, the author administered one third of a skin erythema dose. The use of ice bags and other cooling measures was not found efficacious. The best means for shortening the coagulation time was the intravenous administration of a 10 or 15 per cent solution of calcium chloride, in doses of 10 to 20 c.c.

Blumenthal and Tugendreich. Concerning a Peculiar Favorable Influence of Roentgen Rays on a Tumor of the Skull. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 2.)

A malignant tumor, probably osteo-sarcoma, arising in the vertex of the skull, operation having been refused, was treated with four series of intensive radiations (0.1 mm. lead and 1 mm. aluminum filters) and by intra-muscular injections of large doses of arsenic and iodine (Alival); externally the tumor changed very little, but the general condition of the patient was materially improved. The objective symptoms choked disc disappeared. The roentgen-ray finding, after the irradiation, showed a *complete separation* of the tumor from the healthy tissue by a zone transparent to *x*-rays. The authors leave the question open as to how much irradiation through the lead filter and how much the iodine-arsenic injections have contributed to the favorable result. Important, however, is the fact that the tumor, which is generally considered insensitive to the rays, has lost its malignancy by encapsulation.

Béclère, A. What May One Hope and What Fear in the Use of Deep Radiotherapy? (*Presse méd.*, Nov. 23, 1921.)

Béclère answers these questions with reference to radiotherapy of deep organs with very penetrating rays. As the doses employed decrease from surface inwards, both because of the distance and because the superficial layers are able to absorb penetrating rays, different artifices of technique become necessary, the chief of these being cross firing. These partially offset the disadvantages, but it is only recently that rays have been produced which are not arrested extensively by the first few centimeters of surface tissues. These very penetrating rays have been obtained by increased voltage and a more intense filtration. At first the French experts were distanced by the men of other countries in obtaining these penetrating rays, but they are now catching up.

The very penetrating rays hold out much promise and represent an advance which is admirable. One may feel certain that our results in raying malignant growths will improve, be more thorough and more lasting. Seitz and Wintz obtained in this manner 23 out of 24 histological cures of cancer of the cervix. But these rays need not be regarded as a universal advantage, for some affections, like tuberculous glands, do better under the older methods.

Nor are these very penetrating rays wholly exempt from danger. In leukemia, Rosenthal, who sought to cure by intensive methods, lost 3 of his 11 patients, the symptoms being pernicious vomiting, cardiac insufficiency and dyspnea. In cancer of the cervix a condition like dysentery was set up, with bloody stools and colonic ulceration, perforation and stenoses. Other untoward effects have been seen in the blood, and even after cures of various affections the blood state apparently led to cachexia.

The Germans believe they have dosage so complete as to prescribe treatment which is specific, securing the desired result with certainty. In reality, however, doses may vary with the age, as in the case of the castration dose, or with some other factor. The dose for sarcoma varies with the tumor; for while lymphosarcoma is very radiosensitive, certain osteosarcomas are extremely resistant. In regard to cancer, Kehrer would begin with a trial dose, and then 4 days later make a biopsy. The permanent dose is then determined from the result of the biopsy.

We must not be too sanguine: The Germans seem too confident of the simplicity of the problem; very penetrating rays are a new advance but are not always necessary, not always harmless and not always efficacious.

Barsony. Serration of the Greater Curvature of the Stomach. (*Wien. klin. Wchnschr.*, 1921, No. 22.)

According to the author, serration of the greater curvature is caused by the coarse folds of the thick mucous membrane which has become inelastic. Spasm and peristalsis play no part in this. Normally there exists already an incongruence between the contractility of the musculature and the elasticity of the mucous membrane. This incongruence increases when the mucous membrane has lost its elasticity. The coarse folds which run across the greater curvature produce its serration. If the stomach is properly contracted, but also distended, strong folds are found. On the other hand, in the hypertonic or ectatic, but hardly contracted stomach, only slight fold formation is present.

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GRADUATE INSTRUCTION IN ROENTGENOLOGY*

BY J. S. SHEARER, PH. D.

Cornell University

ITHACA, NEW YORK

DURING a relatively short period roentgenology has established for itself a definite field of usefulness as an aid to the physician and surgeon. Like many other methods, it has solved problems where no one would have predicted success, and disappointed its votaries in fields where great expectations were at first entertained.

In common with most innovations in medicine, it has been compelled repeatedly to demonstrate its value, and struggle for adequate recognition, often retarded more by the extravagant claims of strenuous advocates than by the opposition of bitter enemies. Its development has been aided but little by the constituted machinery for medical education, or by the influence of great leaders in related fields, however clearly the latter now recognize its present or potential value.

Deeply as we may be interested in this development, and no matter how enthusiastic we may be as to its future, we should not forget that roentgenology is not an end in itself; neither can it reach its greatest value so long as it is not correlated with and adjusted to other methods of diagnosis and treatment.

For the purpose of discussion we may endeavor to define the term roentgenologist, and in part, at least, enumerate the mental qualifications he should possess. We might agree that a roentgenologist is a medical man who is skilled in the use of roentgen-ray methods for the diagnosis or treatment of disease. It is true that occasionally men who were not medical graduates have, in the past, become fully entitled to this designation; but they have acquired by practice, reading, and association what in the main the medical schools endeavor to teach, and in the future it may be expected that only medical men can properly qualify.

Assuming that the future roentgenologist is to be a medical graduate, and anticipating the introduction of the subject as an integral part of the courses in anatomy, physiology and pathology, let us consider what additional training is required and how it is to be obtained. In this connection we must not expect too much from undergraduate instruction solely through further additions; at least, not until some things are subtracted from the curriculum. The undergraduate curriculum is already overloaded, and almost invariably the specialist has a persistent habit of assuming that the student can devote an undue proportion of time to his specialty.

We are here concerned with the information or training, over and above that presumably acquired as an undergraduate, that is needed as a proper basis for the self-education that can only result from responsible work. Without the latter, no amount of instruction, however good, can provide a well-balanced roentgenologist.

First, there may be mentioned a minimum amount of technical knowledge,

* Read at the Midwinter Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 26–28, 1922.

covering only basic physical principles, the nature of the apparatus, the dangers involved and how to avoid them. The object is not to develop technical physicists or engineers, but to give a rational basis for instruction in the *use* of the roentgen-ray apparatus. I know there are some who hold themselves as absolved of all necessity for technical knowledge, who regard all such matters as beneath their intellectual level, and desire simply to appear as gifted interpreters of what may or may not be shown on the negatives; but I believe they are a minority.

Surely a well-trained roentgenologist should know his tools better than do those in his employ; otherwise he cannot secure the desired results, and is too often at the mercy of the technician.

A fundamental basic knowledge of the underlying principles, apparatus and measurements will tend to develop good sense and judgment in the purchase, arrangement and use of equipment. It should also tend toward emancipation from the dictation of agents, technicians and ill-informed people of all sorts whose influence is so unfortunate.

Do not imagine that I advocate long and arduous study of physics or engineering. The essential physics can be mastered in a few weeks in a well-organized laboratory under competent instruction. This should be given by men well grounded in physics who have acquired an interest in medical problems, and who can teach the subject without thinking the doctor should be a professional physicist.

The course should be given where there is a laboratory properly equipped, and a teacher of the right spirit and qualifications. There is need of only a few such laboratories, and those in charge should not be physicians, but physicists whose interest is aroused to the importance of this work, and who, moreover, are willing to acquire a knowledge of the mode of application of roentgenography in medical practice. Transplanting a physicist into a roentgen-ray laboratory will not lead to immediate results, and is quite as ridiculous as to put a physician in charge of a technical laboratory. All borderline subjects require cooperation to develop the best courses of instruction.

After such a course in the technical elements, there should be provided courses for the study of roentgenographic and fluoroscopic shadows of normal individuals of various ages. Only *good* negatives should be used in this work in order to impress on the beginner the type of negative best suited to diagnosis.

Following this, a study of negatives showing definite lesions should be made, and also a thorough review of the roentgenological aspects of gross pathology. Disputed and uncertain points should be avoided, and every effort made to correlate the *x*-ray evidence with that acquired by other methods.

Throughout all the work emphasis should be laid on the position of tube, plate and subject as related to the distribution of shadows observed. A reasonable amount of the history of the subject may well be included, but the discussion of obsolete apparatus and methods should be avoided as worse than useless, and confusing to the inexperienced.

Beyond this, instruction should proceed by actual practice both in the examination of patients and the interpretation of results under careful supervision of experienced and responsible roentgenologists. There is no substitute nor equivalent for this part of the training.

During the latter part of the course a fair portion of the student's time should be spent in studying the results of clinical examinations and in following to operation cases that have been diagnosed. He may hear the deductions of the roentgenologist fairly or unfairly criticised, but either will be an aid to him and he will learn what is of value to the surgeon and how it should be expressed. Such instruction should be given in hospitals that are under educational control.

We should never lose sight of the fundamental difference between roentgenology and most other laboratory methods. Excreta, blood and specimens are studied removed from the patient. But *x*-ray work is done on the living organism, and the element of responsibility for proper care and treatment of the individual is ever on the roentgenologist.

Assuming some such outline as a desirable solution of the problem, the next question is, how are we going to obtain it and where? Unfortunately the methods prevailing in the past are of less assistance than one might expect.

To summarize: We may hope that in some way the undergraduate may acquire a general knowledge of normal roentgen-ray anatomy, a clear idea of the diseases in which roentgenization is likely to be of diagnostic or therapeutic aid, and some familiarity with negatives showing indisputable proof of pathology; but all this without wasting time in the effort to make roentgenologists of inexperienced medical students.

The graduate intending to specialize in the use of this method should be provided with an opportunity to secure:

1. A knowledge of apparatus sufficient to enable him to judge of its necessity and worth.
2. Such a knowledge of dark-room work as will prevent domination by a photographer or technician.
3. A clear-cut knowledge of other methods of diagnosis in the lesions within his field.
4. As much gross pathology as can be secured.
5. Enough familiarity with operative surgery to enable him to know what information the surgeon needs, and the proper mode of expression.
6. Some familiarity with the main features of the historical development of his specialty.
7. Ability to judge of the relative importance of indications.
8. Such familiarity with the physical laws underlying the subject as will protect him from publishing irrational papers or accepting them from others.

How have the present generation of roentgenologists acquired their special knowledge? Reports in journals and at meetings have been available to some. In the majority of cases instruction has been unsystematic and uncoordinated. Often a student in a hospital course has had no responsibility and no check on his supposed proficiency. Mere observation will never fit men properly for work in roentgenology or any other specialty.

Most of the attempts to instruct, not only on the technical side, but on the clinical as well, have been made by salesmen of *x*-ray or photographic apparatus. Curiously, this encroachment in the field of medicine in combination with commercial propaganda has not only not been resented by the profession, but in general its statements have been taken as final authority.

I cannot refrain from quoting from an address by Osler in which we have only to read roentgenology instead of pharmacy to render it applicable to the present case:

"It may keep the practitioner out of the clutches of the arch enemy of his professional independence—the pernicious literature of our camp-followers, a literature increasing in bulk, in meretricious attractiveness, and in impudent audacity. To modern pharmacy we owe much, and to pharmaceutical methods we shall owe much more in the future, but the profession has no more insidious foe than the large borderland pharmaceutical houses. No longer an honoured messmate, pharmacy in this form threatens to become a huge parasite, eating the vitals of the body medical. We all know only too well the bastard literature which floods the mail, every page of which illustrates the truth of the axiom, the greater the ignorance, the greater the dogmatism. Much of it is advertisements of nostrums foisted on the profession by men who trade on the innocent credulity of the regular physician, quite as much as any quack preys on the gullible public. Even the most respectable houses are not free from this sin of arrogance and of ignorant dogmatism in their literature. A still more dangerous enemy to the mental virility of the general practitioner, is the "drummer" of the drug house. While many of them are good, sensible fellows, there are others, voluble as Cassio, impudent as Autolycus, and senseless as Caliban, who will tell you glibly of the virtues of bolism, and are ready to express the most emphatic opinions on questions about which the greatest masters of our art are doubtful. No class of men with which we have to deal illustrates more fully that greatest of ignorance—the ignorance which is the conceit that a man knows what he does not know; but the enthralment of the practitioner by the manufacturing chemist and the revival of the pseudoscientific polypharmacy are too large questions to be dealt with at the end of an address."

One only needs to note the condition of many laboratories, crowded with expensive, complicated, even dangerous apparatus, to realize the extent to which commercialism and the immorality of salesmanship has invaded this field. Every conceivable means of complicating equipment has been used and under the guise of selling service the whole has been paid for either by the sick or by endowments for their care. But all this is of minor importance compared with the so-called instruction on the clinical side or in therapy so brazenly offered and, alas, so eagerly received. The law may forbid a layman to practice medicine, but there is no bar to his undertaking to tell the doctor how dangerous agents should be used, or what is the dosage to be given. It is not at all to the credit of the medical profession that they tolerate, much less court this abominable state of affairs. Both the profession, and those responsible for medical education owe it to themselves and to the public to find a remedy.

I am not at all unmindful of the efforts of manufacturers to assist in the development of appliances needed in this work. I take pleasure in the public acknowledgment of aid from several of them; but they surely should recognize that the salesman whose earnings depend on volume of sales, who is neither physician, engineer nor scientist is not to be entrusted with the education of those responsible for human life. Frankly I do not believe it is possible, in the long run, for a manufacturer or commercial organization, to disseminate accurate and reliable information, without subtle evasions and half-truths, consciously or unconsciously aimed to increase financial returns. Do not delude yourselves that you are getting something without cost. "Free service" is a most expensive luxury. It must be charged to overhead or selling expense and someone foots the bill. The amount paid in this way would more than support proper instruction and provide for research.

Another source of danger in instruction is the aggressive technician, especially when organized to secure aggrandizement of class. He talks glibly of things up-to-date, no matter how untried or ridiculous. He also by, training is neither physician, scientist nor engineer, but he insidiously assumes the rôle of all three. One of his strong points is in convincing the hospital superintendent that medical roentgenologists are not needed. For lo, he can make pictures galore and he always flatters the uninformed among the physicians by a seeming deference. Like system, he is a useful servant when kept within bounds, but a dangerous master and a most horrible educational example. One needs only to read some of the opinions expressed in certain journals to realize how dangerous he may become.

The proposition to license technicians is essentially bad. A state license is a dangerous tool in the hands of a small class, and gives no real guarantee of fitness. The only remedy effective against such conditions is in provision of such adequate means of instruction as will replace those of an objectionable character. So long as the constituted agencies for medical education fail to provide instruction in roentgenology, just so long will even the earnest and well-trained young physician be compelled to seek what may be found, and thus perpetuate the system.

From what sources are we to expect the proper education? The main agencies must be medical colleges, hospitals, roentgenologists and possibly a special institute.

Some, at least, of our medical colleges should provide for instruction in the physics of roentgenology as applied to medicine, and for well-balanced courses in clinical roentgenology, both diagnostic and therapeutic. Hospitals associated with medical schools should provide for the use of their material for instruction by members of the staff. A hospital giving instruction to students with no college affiliations is quite prone to look upon the student as a cheap assistant who is welcome to what he can pick up if he does not interfere with routine, or if he does more than enough general work to make himself profitable. Only where the intent to instruct is a dominant feature, will there be well-developed courses. In such courses, those who intend to practice roentgenology must be required to carry through complete examinations, subject to check and criticism. No amount of reading, listening to lectures, or observation of the work of others will suffice. It is not that they should later do all the detail work, but that unless they know well how to do it they will be unable to get results from employees or assistants.

Perhaps the most important source from which we ought to receive both inspiration and aid is the medical profession, and especially the roentgenologists themselves. Unless they realize the defects of present methods and are brought to a conception of needs and possibilities, there is but slight chance of interesting schools and hospitals. Everyone familiar with good work with *x*-rays and radium should become a center of educational influence. Not of propaganda for more elaborate electro-mechanical equipment or for spreading extravagant claims, but an exponent by word and deed of the highest ideals in training and practice. You, as representatives of your specialty, cannot expect the world to place a higher valuation thereon than you yourselves are doing. You have no higher duty and possess no greater privilege than to provide such opportunities and inspiration to your younger associates as will bring results far superior to those you have been able to achieve. While only a few can actively engage in teaching, there is none among you who can not aid in urging provision for instruction and research. Whenever opportunity offers, aid and encouragement should be extended to beginners. Some among you may be able to permit an occasional earnest and qualified worker to spend sufficient time with you to carry away enough of your experience to provide a nucleus for real advancement. The old method of "reading" with the experienced physician had some advantages lost to great educational machines.

The sole legitimate excuse for meetings of societies and the publication of journals is their educational value. For this reason you have a responsibility for the future in insisting that only articles and papers of real value as judged by the highest standards of the time are allowed on your programs or in your journals. These should be used neither for self-advertisement nor commercial propaganda.

Another means of education is the publication of atlases of normals of various ages as well as those of various well-defined lesions. These should be transparencies to correspond in light and shade to what the roentgenologist actually sees. The price should be within reach of young practitioners. It would seem some man of wealth in this country could be found who would make this possible.

Finally, there should be provision for a combined teaching and research institution or institute of roentgenology, where the problems of the future may be attacked and where those who come can receive the inspiration that is only to be found where research is carried on. The relation of roentgenography to medicine is not a finished book: the introduction only has been written. He who regards our present views as final or our practice perfect, is intellectually dead even though still counted among the living.

Such institutions have been established or very soon will be, in several European centers.

In his presidential address to the British Roentgen Society, Knox said: "The Mackenzie Davidson Memorial Fund has been started with the object of providing an Institute of Radiology. It has been customary to appeal for funds in the hope that a philanthropic millionaire might be induced to provide and endow such an institution. To my mind it would be a much more satisfactory method if each and all of us became a collecting center for the fund. Let us take an example from Russia. A medical correspondent writing in *The Lancet* recently referred to the progress of medicine in Russia during recent times. Two new Institutes have been inaugurated at Petrograd; one of these is an Institute of Roentgenology and Radiology. It was instituted in a building of recent construction. In the courtyard of the

Institute is a tablet commemorating the discovery of x-rays by Professor Roentgen, and inscribed beneath his name are the names of physicists who have contributed to the subject.

"In the midst of the upheaval—the like of which the world has never seen—Bolshevik Russia can erect an Institute of Radiology. Are we in Britain going to be out-done in the matter of scientific research by Russia? We should lead in the subjects embraced under the general head of Radiology. It is with pride we regard the great advances in physics which have had their origin in this country.

"The subject is in its infancy; the discoveries of the past may well be eclipsed by those of the future. Let us be prepared to do our share in these advances. The only efficient way is by the organization and endowment of research."

When we in the United States compare the extent and wealth of this country with that of others, when we consider the enormous expenditures made here for elaborate equipment, when we realize that we are the largest producers of radium and of x-ray tubes in the world, we may well consider for a moment whether we have given our share toward providing for future developments. Why not have an Institute which would command the respect of the world and put us in the front rank in that greatest of human activities, the discovery of the truths of nature and their proper application to human needs?

Many of those who did pioneer work in this field have passed on, alas, often scarred and maimed even as those who fought other battles where destruction of life, not its preservation, was the aim. They suffered on account of lack of knowledge, but they made it possible for those who followed to walk safely. The world should somehow build an appropriate monument to them. What would be more fitting than an institution where the things they saw as visions might be realized and where might be continued the glorious tasks for which they made such noble sacrifices?

In the erection of such an institute we would show future generations that we appreciated such men, and in carving their names on a memorial tablet in an institute devoted to such work we would only in a small degree render honor to whom honor is due.

GRADUATE INSTRUCTION IN ROENTGENOLOGY

BY G. W. HOLMES, M.D.

Roentgenologist, Massachusetts General Hospital

BOSTON, MASSACHUSETTS

INTRODUCTION

I SHALL not attempt, in this brief discussion, to go into the history of this work in connection with roentgenology, or to present any data obtained from other teaching clinics, but will outline the courses which we are giving at the Massachusetts General Hospital in connection with the graduate teaching of the Harvard Medical School, and present some of the observations which I have made.

I. THE NEED OF POST-GRADUATE TEACHING

In order to establish a satisfactory course of instruction, one must first consider the need for post-graduate instruction in his vicinity, and second, the type of students likely to apply for instruction.

It is only within the last few years that roentgenology has been taught as a required subject in our larger medical schools; therefore, the medical profession as a whole has no definite knowledge as to its use or method of application either in diagnosis or treatment. There is a real need that these men who have been in practice for some time be given courses in roentgenology similar to those given under-graduate students, so that they may become familiar with its use. They should be able to decide in a given case whether an *x*-ray examination is necessary or not, and also be able to instruct the patient to some extent as to the nature of the examination and the time consumed in doing it.

Every physician should also have sufficient knowledge of radiology to enable him to judge the work of the specialists in this field, so that he may select competent men to whom to refer his patients. At the present time, if the quality of the plates shown is satisfactory, the consultant is usually satisfied. He is unable to go beyond this in a test of skill.

There are also men in the smaller towns engaged in general practice, who are doing considerable *x*-ray work. As a rule, these men have received most of their instruction from the dealer from whom they purchased their apparatus. Frequently, they are quite ignorant of the extent of the field in which they are working,—of its literature and of the standard of work which they should maintain.

In the smaller towns unable to support a specialist, it is necessary that someone be prepared, to do at least the simpler *x*-ray examinations; and I believe these men should be encouraged to do the best work possible.

There is a tendency, at the present time, for men engaged in the specialties, particularly those specialists who deal with a single organ of the body, to do all the work connected with their field. If these men are to do their own *x*-ray work, it is necessary to give them opportunity for special training in it.

In the larger clinics, the internist is gradually becoming a very important factor in the final diagnosis. After all the laboratory and clinical data have been collected, it usually falls to him to analyze it and decide upon the diagnosis and treatment. These men, as a rule, have had less training in roentgenology than in any of the other specialties with which they come in contact. In order that they may judge the value of the roentgen-ray findings in connection with other clinical and laboratory examinations, they should have some actual training and experience in this work.

If roentgenology is to continue and maintain its position among the other medical specialties, it is necessary that young men be trained particularly for it. These men should be selected from the student body, preferably those who show a special trend and adaptability, and who have had preparatory work in physics.

2. THE TYPE OF STUDENTS APPLYING FOR INSTRUCTION

That this opinion is held generally by the profession at large is shown by the type of students applying for instruction, a large number of whom are general practitioners who are not recent graduates, but who wish to obtain a general knowledge of the use of the *x*-ray, particularly in diagnosis.

Perhaps the second largest group consists of men engaged in a specialty, who wish to obtain a more extensive knowledge of radiology, so that they may use better judgment in selecting cases for examination and in estimating the relative value of the roentgen-ray findings. Many of this group, however, intend to do their own *x*-ray work in connection with their specialty.

The number of young men who wish to prepare themselves for roentgenology as a specialty is increasing gradually, and many of them are of the best type.

3. THE CHARACTER OF INSTRUCTION GIVEN

It is obvious from a study of the need for instruction, and the type of man seeking it, that no one course would be wholly satisfactory.

Short courses, consisting largely of clinical work, supplemented by lectures and conferences, are required for those men who do not intend to practice roentgenology as a specialty, but who wish a better understanding of the subject for use in their general work. This course, supplemented by well-directed reading, will be of value also to the practitioner in the small town who is doing some *x*-ray work. Time and expense with him are factors to be considered; and I believe that it is better for him to know what good work is, and to have a general knowledge of the literature on the subject than to remain purely a technician. A course of this kind of one month's duration, which we have been giving for the past five years, has, at least, been well patronized. Students are in the laboratory from nine a.m. to five p.m. The work is so arranged that they can observe the actual running of the clinic. From nine to ten o'clock in the morning, they attend the therapeutical clinic; from ten to eleven, plate interpretation. These are not selected plates, but the routine morning's work. Interpretations are dictated, and discussion of the cases is encouraged. From eleven to twelve o'clock, they observe fluoroscopy of the chest, and from twelve to one o'clock, plate-taking; from one to two p.m. is the lunch hour. From two to four o'clock in the afternoon, they observe gastrointestinal fluoroscopy. The students are not given actual work, but they see all cases examined, and there is opportunity to study the cases and to follow many to operation. From four to five p.m., the day's work is gone over and discussed in conference, or a talk is given, using specially selected plates.

For the specialist who wishes to do his own *x*-ray work, our facilities for teaching are not as satisfactory as desired. These courses should be at least of six months' duration. Observation in the special clinic, combined with reading and conferences, should be followed by actual clinical work. It has been our practice, after these men have had their preliminary instruction, to have them appointed as graduate assistants, and to allow them to be responsible, under a director, for the special clinic in which they are interested. Thus far, this has been done in therapeutical work, gastrointestinal work, and eye, ear, nose and throat work.

Probably the most important work in this field, at least to us roentgenologists, is the preparation of young men seeking to enter the specialty. In my opinion, this cannot be done satisfactorily outside of a large hospital clinic, preferably in a medical center. These men should be given special courses in physics, pathology and anatomy, and should have opportunity to obtain actual experience in the examination and study of cases. It is desirable that these cases be examined also by all other laboratory and clinical methods. They should become familiar also with the roentgen-ray literature. We have found that the investigative work going on in a teaching hospital is a stimulus to such men to do this, and if they can be given some problem for investigation with the preparation of a thesis, another incentive to study is brought about. A course of this kind should be at least of one year's duration.

The first part of the day, usually the forenoon, for the first three months, is given up to work in the pathological and anatomical laboratories at the Medical School, and in the physical laboratories at the college. During this time, they are assigned certain groups of cases, usually those requiring the taking and developing of plates, for study in the hospital clinic. Later, they are given other clinics, such as the chest, therapy and gastrointestinal, under the supervision of a director, their position being much like that of a house officer to the visiting man in a medical clinic. As early as possible, they are assigned some special subject for study; and the last few months of their routine work is made as light as possible, so that they may have opportunity to complete investigations and prepare their theses.

I realize that it is impossible properly to train a roentgenologist in one year's time. On the other hand, very few men, after their college and medical courses with a year or more of hospital training, can afford more than this period of time without a salary. As far as possible, men graduating from such courses should be placed in positions as paid assistants to older men, from which positions (after a period of five years) they should be prepared to take charge of a large laboratory or teaching clinic.

SUMMARY

There is a widespread need of post-graduate instruction in roentgenology.

That the general medical profession realizes the necessity of this instruction is shown by the number and class of men seeking instruction.

The radiologists connected with teaching hospitals should be prepared to give this instruction.

Courses should be adapted to the needs of the students.

MEASUREMENT OF ROENTGEN RADIATION BY MEANS OF AN IONIZATION CHAMBER AND GALVANOMETER

BY WILLIAM DUANE

Professor of Biophysics, Harvard University

CAMBRIDGE, MASSACHUSETTS

The method of measuring the quantity and quality of roentgen radiation described in this paper differs only in minor details from that presented by the writer to the American Roentgen Ray Society in 1914. (See also the reports of the Cancer Commission of Harvard University, 1913–1915.) The improvements in the method that have been made during the last eight years are due, largely, to the fact that more reliable and more sensitive galvanometers can now be purchased, and to the fact that modern *x*-ray plants produce more intense beams of rays. These facts have enabled me to reduce the size of the ionization chamber, and thus make it more convenient to manipulate. Whereas the volume of the ionization chamber in the instruments I employed eight years ago amounted to 200 c.c. or so, that of the instrument here described need not exceed 10 c.c.

The ionization chamber consists of a series of aluminum sheets, about 5 cm. long and 2 cm. broad, held parallel to each other at distances apart of about 2 mm. by hard rubber frames. Alternate sheets of aluminum are metallically connected together, thus forming two interlocking sets of sheets electrically insulated from each other. The sets of sheets thus form a small electrical condenser with layers of air between them. The condenser is joined in a simple electric circuit with a battery and a very sensitive galvanometer. The galvanometer should be so sensitive that less than 10^{-10} ampère produces a deflection of one division on its scale. The wires connecting the ionization chamber with the battery and galvanometer must be highly insulated, and they should pass through a flexible metallic sheath. The flexibility of this circuit allows the ionization chamber to be placed in any desired position in the *x*-ray beam.

If the ionization chamber lies in a beam of *x*-rays, the rays ionize the air between the sets of plates, a current flows through the circuit and the deflection of the galvanometer measures its strength. The deflection of the galvanometer may be taken as a measure of the intensity of the *x*-ray beam at the place where the ionization chamber lies.

In order that the readings made with different instruments and by different observers, etc., may be compared with each other, it is necessary for each instrument to be standardized. The standardization consists of two parts: (1) the calibration of the galvanometer; (2) the calibration of the ionization chamber.

Galvanometers as sensitive as those required for measurements of this kind do not all give the same readings for the same current. Further, one and the same instrument may show somewhat different deflections at different times for the same current. In order to determine the magnitude of the deflection produced by a given current at any particular time, I use a small box containing a Weston Standard cell and electrical resistances. These circuits are joined to the galvanometer in such a way that on pressing a key, a current passes through it from the standard cell. The values of the resistances in the box are so chosen that a given current passes through the galvanometer on closing the key. If the standard cell and resistances have been well constructed, the current obtained from the box remains always the same to within an accuracy amply sufficient for *x*-ray measurements.

If the electromotive force of the battery in series with the ionization chamber is not large enough, the current through the ionization chamber will depend upon its value; for the force pulling the ions in the gas across to the aluminum plates may not be sufficient to carry across all of the ions produced by the *x*-rays. In other words, the ionization current is not what is called saturated for small electromotive forces. If, however, the electromotive force has a high value, it becomes sufficient to drive practically all of the ions produced by the *x*-rays across to the aluminum plates. Under these conditions the ionization current is said to be saturated, and its value no longer depends upon the electromotive force of the battery. In calibrating the ionization chamber, the first thing to do is to determine how large the electromotive force of the battery must be in order to produce saturation. This can be done by altering the number of cells in the battery, and by noting the deflections produced in the galvanometer. If the galvanometer deflection no longer increases on increasing the number of cells in the battery, the saturation electromotive force has been reached. As a matter of fact, a few volts suffice to saturate the ionization current in an ionization chamber such as that described above, when it lies in a beam of *x*-rays produced under ordinary working conditions.

In order that the measurements made with one ionization chamber may be compared with those with other ionization chambers it is necessary to adopt some unit of *x*-ray intensity. The unit I was using in 1914 may be called the electrostatic unit. It may be defined as the intensity of roentgen-radiation that produces the electrostatic unit of ionization current per cubic centimeter of air under normal conditions of pressure and temperature.

In order that this unit may be available for accurate measurements, care must be taken that no secondary radiation from the electrodes of the ionization chamber passes through the cubic centimeter of air, and that the total ionization from all the secondary corpuscular radiation produced from the cubic centimeter of air is measured. The writer called attention, as early as 1905, to the fact that errors might be made in ionization measurements, if account were not taken of the absorption of corpuscular radiation by the walls of an ionization chamber. (See *Journal de Physique*, 1905, IV, 605.)

In the ionization chamber described above, the required conditions are not fulfilled. It becomes necessary, therefore, to compare the current in this ionization chamber with the current in a standard ionization chamber of large dimensions and so constructed that the rays passing through it do not strike any solid substance inside it. The standard ionization chambers that I was using in 1914 had volumes ranging from 500 c.c. to 2,000 c.c. They were constructed in such a way that the *x*-rays passed through holes in a sheet of lead 1 cm. thick, and so that the rays coming through these holes always passed between, but did not strike any of the electrodes inside the chamber. Probably the most satisfactory arrangement of electrodes is that adopted by Lord Kelvin in his standard Guard Ring electrostatic capacity. Friedrich describes an accurate ionization chamber based on this principle.

By comparing the ionization current in the aluminum sheet condenser described above, with those due to the same *x*-rays in a standard ionization chamber, it is possible to calibrate the aluminum ionization chamber, and thus determine the intensity of the *x*-ray beam in terms of the electrostatic unit of intensity.

When properly calibrated, the deflection of the galvanometer gives us the *intensity* of an *x*-ray beam. In order to measure the average or "effective" wave-length of the rays in a beam, I use the ionization chamber to determine the fraction of the roentgen-radiation passing through ½ mm. or 1 mm. of copper and then estimate the effective wave-length by means of the curve given on page 170 of the American Journal of Roentgenology, March, 1922. As an alternative measurement of an effective wave-length I use the ionization chamber to determine the thickness of aluminum that is equal in absorbing power to 1 mm. of copper, as described in Section 6 of the above-mentioned article.

ROENTGEN-RAY TREATMENT OF CHRONICALLY INFECTED TONSILS AND ADENOIDS*

BY CHARLES A. WATERS, M.D., PAUL B. MACCREADY, M.D.,

AND

CHARLES H. HITCHCOCK, M.D.

From the Departments of Roentgenology, Laryngology and Bacteriology, Johns Hopkins Hospital
BALTIMORE, MARYLAND

PROBLEM

THE roentgen-ray treatment of infected and hypertrophied tonsils and adenoids was undertaken with a view to determine (1) whether the same clinical results could be accomplished as in tonsillectomy and adenoidectomy, and (2) whether there was a persistence of the carrier state. Twenty-one cases were treated. As the records are incomplete in 7 cases, discussion is limited to the results in 14 cases. All these cases were seen in the Out-patient Department of the Johns Hopkins Hospital, and all of them were suffering from infected tonsils or adenoids.

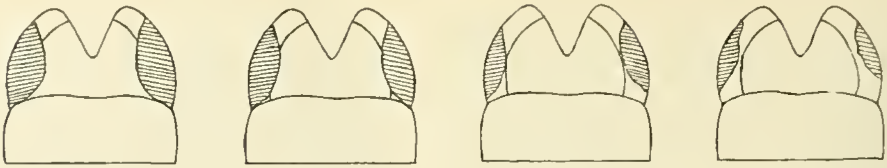
PROCEDURE

With the beginning of treatment, swabs were taken from the surfaces of both tonsils and the nasopharynx, and cultures made according to the method of Bloomfield. The distance between the two tonsils was measured and recorded on the forms shown in the diagrams. The successive measurements were made by one person, Dr. J. W. Baylor, so that the source of error would be minimal. A series of four *x*-ray exposures was given, approximately two a week for two weeks. After a rest of several weeks a second series was given. Cultures and measurements were taken frequently. Our thanks are due to the efficient aid of a social worker, Miss Foley, who saw to it that the patients came back for their treatments.

CHRONIC TONSILLITIS—TEN CASES

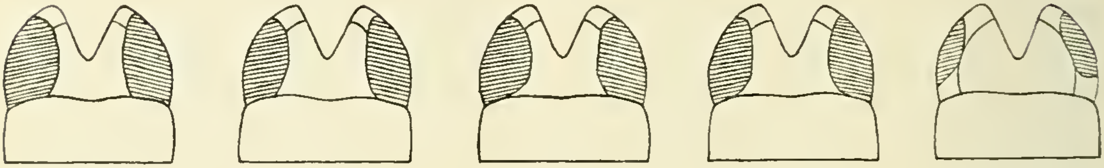
Ten cases were children under twelve years of age, who were suffering with

* Read before the Midwinter Meeting of the Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 27, 1922.



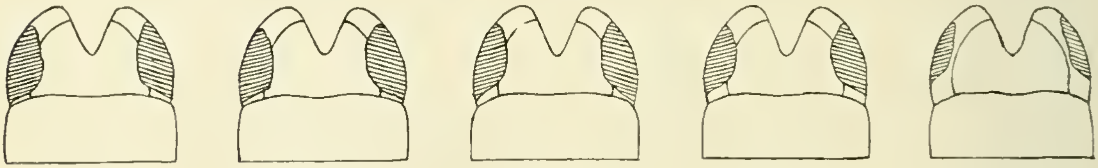
10-12-21 2 days after 1st series. | 10-28-21 18 days after 1st series. | 12-9-21 End of 2nd series. | 1-9-22 31 days after 2nd series.

Fig. 1. Distance between tonsils increased 6 mm. (W. R. C-M-9 yrs.)



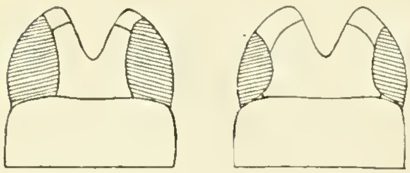
9-24-21 Before treatment. | 10-12-21 8 days after 1st series. | 10-28-21 24 days after 1st series. | 11-25-21 End of 2nd series. | 1-9-22 45 days after 2nd series.

Fig. 2. Distance between tonsils increased 11 mm. (C. S. C-M-9 yrs.)



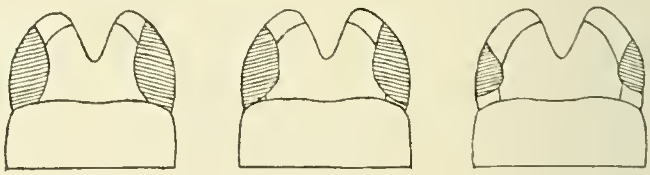
9-24-21 Before treatment. | 10-12-21 8 days after 1st series. | 10-28-21 24 days after 1st series. | 12-9-21 6 days after 2nd series. | 1-9-22 37 days after 2nd series.

Fig. 3. Distance between tonsils increased 6 mm. (B. S. W-F-7 yrs.)



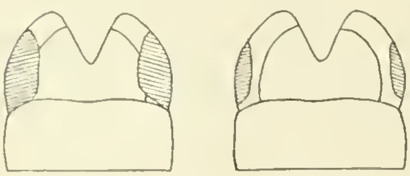
10-12-21 During 1st series. | 1-19-22 27 days after 2nd series.

Fig. 4. Distance between tonsils increased 6 mm. (E. H. C-F-12 yrs.)



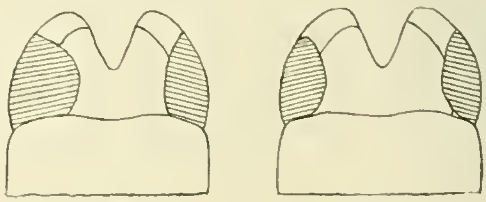
11-5-21 15 days after 1st series. | 12-16-21 End of 2nd series. | 1-19-22 34 days after 2nd series.

Fig. 5. Distance between tonsils increased 5 mm. (D. T. C-F-6 yrs.)



10-12-21 11 days after 1st series. | 12-17-21 77 days after 1st series.

Fig. 6. Distance between tonsils increased 9 mm. (R. C. W-F-11 yrs.)



9-24-21 Before treatment. | 10-28-21 24 days after 1st series.

Fig. 7. Distance between tonsils increased 5 mm (E. W. C-M-9 yrs.)

chronic tonsillitis and hypertrophied adenoids. In each case a diagnosis was made on the basis of a history of frequent colds and sore throats with occasional attacks of acute tonsillitis, the presence of enlarged tonsils and adenoids, palpable glands at the angles of the jaw and the absence of any general constitutional disease. Five cases had one complete series of four exposures; 5 cases had two complete series of four exposures each. Anatomically the tonsils have appreciably shrunken in all but one case. The distance between the tonsils has increased as follows:

5 cases which had two complete series:

W. R.	6 mm.
C. S.	11 mm.
B. S.	6 mm.
E. H.	6 mm.
D. T.	5 mm.

5 cases which had one complete series:

R. C.	9 mm.
E. W.	5 mm.
D. N.	6 mm.
R. B.	No appreciable difference
P. K.	7 mm.

The general appearance of the cases which had two complete series was that they had shrunken to normal size, and no further treatment was necessary. While the distance between the tonsils in the cases which had had but one series increased as much as in those which had had two series, it was felt that all would need another series of treatments except the case R. C. This case had had a tonsillectomy four years previous. Reference to the charts will show that in those cases in which the largest number of observations have been made, the greatest shrinkage took place about one month after the second series.

RESULTS

In each of these 10 cases, the clinical symptoms for which they originally came to the hospital have disappeared. The cases have not been observed for a long enough time to determine whether this is the result of the tonic effect of the *x*-ray treatment, or whether it is due to lessened absorption from the foci of infection which have been shown to persist. At the last examination, the glands at the angle of the jaw, which were enlarged on admission, were still palpably enlarged. The bacteriological results were completed in 5 of the cases which had two complete series, and the 3 cases which are to follow, which also received two series. The bacteriological studies are confined to these 8 cases, and the results noted under the section on bacteriology.

TECHNIQUE OF TREATMENT

While we have not followed the treatment technique as advocated by Murphy and his associates, yet the same general principles have been adhered to.

Our treatments consist of 5 ma. of current filtered through 4.5 mm. of glass and 1/2 inch layer of orthopedic felt, employing 120,000 volts, approximately a 7 inch spark gap, and using a 25 cm. focal distance for a period of five minutes.

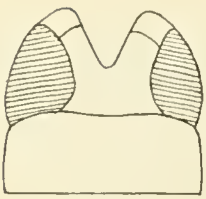
The exposures were given as follows: Mondays and Fridays for two weeks—which we termed one series of treatment. The patients were then allowed to rest for a period of three or four weeks before starting the second series of treatments. We followed this routine in our treatment of these 8 cases.

None of the patients have received more than two series—comprising in all eight treatments.

This, of course, is a larger *x*-ray dose than advocated by Murphy, Witherbee, Osgood and others, who recommended the sub-erythema dose, while our dosage has reached the reaction or mild erythema stage.

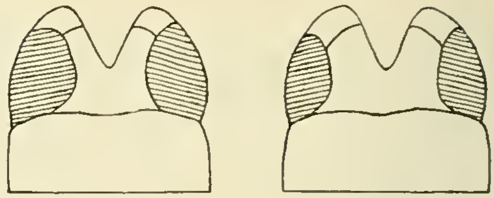
Whether the good or bad results in our series of cases were due to too much irradiation we hesitate to say; but surely it has not been the result of insufficient radiation.

The rays were directed in such a manner that the perpendicular beam passed below the lobe of the ear, under and just posterior to the angle of the jaw. The entire body, with this exception, was covered with a heavy piece of lead rubber sheeting, the parotid gland being doubly protected by a heavy piece of lead foil, one mm. thick. The exposed surface area measured approximately 8 × 9 cm.



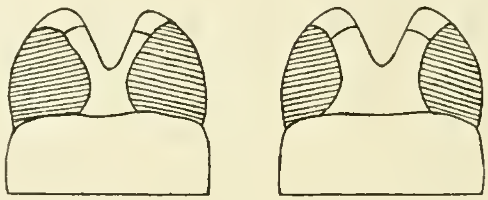
10-28-21 7 days after 1st series. | 1-19-22 95 days after 1st series.

FIG. 8. Distance between tonsils increased 6 mm. (D. N. C-F-8 yrs.)



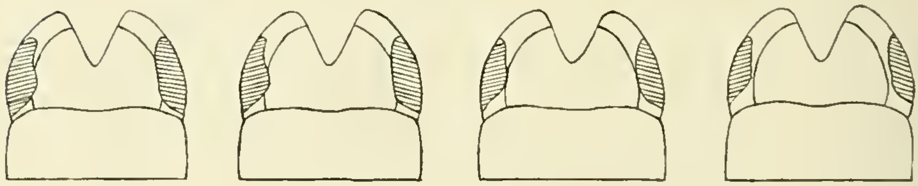
10-28-21 11 days after 1st series. | 1-19-22 95 days after 1st series.

FIG. 9. No appreciable difference in distance between tonsils. (R. B. C-M-5 yrs.)



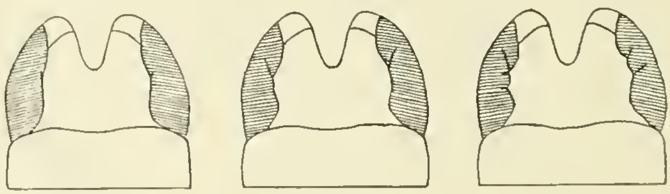
11-9-21 Before treatment. | 1-19-22 47 days after 1st series.

FIG. 10. Distance between tonsils increased 7 mm. (P. K. W-F-12 yrs.)



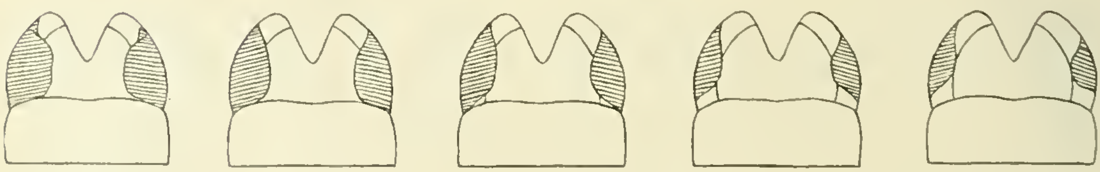
10-6-21 Before treatment. | 10-28-21 4 days after 1st series. | 11-5-21 12 days after 1st series. | 1-6-22 End of 2nd series.

FIG. 11. Distance between tonsils increased 4 mm. (H. C. W-M-12 yrs.)



10-28-21 17 days after 1st series. | 11-18-21 1 day after 2nd series. | 12-19-21 32 days after 2nd series.

FIG. 12. No appreciable increase in distance between tonsils. (B. T. C-F-56 yrs.)



9-24-21 Before treatment. | 10-12-21 8 days after 1st series. | 10-28-21 24 days after 1st series. | 12-9-21 6 days after 2nd series. | 1-9-22 37 days after 2nd series.

FIG. 13. Distance between tonsils increased 10 mm. (A. S. W-M-11 yrs.)

REACTIONS

Treatment. 1. Five cases had one series of treatments.

2. Five cases had two series of treatments.

3. Four cases had skin reactions after receiving one series.

4. One case had skin reactions after receiving two series.

5. In no case was there atrophy of the parotid glands.

The adult patients developed a very faint blush after the first series, which lasted about one week. In the men patients there was some epilation of the beard. In the children a more definite blush or mild erythema developed after the first series, which lasted a trifle longer than in the adults, usually about ten days or two weeks.

All the erythemas cleared up in a few weeks, with no tanning or telangiectasis, the skin completely returning to normal. *X*-ray plates of the jaws in every case showed no evidence of changes in the dental structures as a result of the *x*-ray treatments.

SYDENHAM'S CHOREA WITH CHRONIC TONSILLITIS—ONE CASE

This case, H. C., a boy of twelve years, developed chorea three years ago, following a severe attack of tonsillitis and joint pains. He has had more or less, choreiform movements ever since. This is usually worse in the spring of the year. Examination showed him to be suffering with chronic tonsillitis. He was given two complete series of treatments with the following results: Clinically the choreiform movements have improved since the treatment was begun. His mother states that she has not noticed any nervous twitchings since the treatment was begun, and he has had no colds nor sore throats. There has been a decrease in the size of the tonsils, so that the distance between them has increased 4 mm. The hemolytic streptococcus was present throughout the first course, but absent throughout the second course of treatment. No cultures have been made since the last *x*-ray treatment.

This case indicates one condition where roentgen-ray therapy would be extremely serviceable. In this condition it is especially desirable to relieve the patient from chronic focal infection in the nose and throat, and to prevent recurring colds and tonsillitis. Surgical operation in the acute or subacute stage of chorea may be a very dangerous procedure, for the operation may stir up an acute endocarditis, while roentgen-ray therapy would not do this.

CHRONIC INFECTIOUS ARTHRITIS WITH CHRONIC TONSILLITIS—ONE CASE

This case, B. T., a woman of fifty-six years, has had polyarthritis for fifteen years, and has had frequent sore throats since childhood. Examination showed large adherent irregular tonsils and a moderate-sized mass of adenoid tissue, as seen by the nasopharyngoscope. The patient received two complete series of *x*-ray treatments, with the result that clinically the general symptoms and throat condition were very much improved. However, there was no measurable decrease in the size of the tonsils, and the hemolytic streptococcus was still present four weeks after the second series.

It will require many cases to determine the effectiveness of roentgenotherapy in removing chronic focal infection in tonsils that are giving rise to a general constitutional malady, such as arthritis, glomerular nephritis, etc. In view of the results as brought out in the section on bacteriology it would amount to malpractice to resort to *x*-ray treatment alone when surgical removal might save the patient.

CHRONIC SUPPURATIVE OTITIS MEDIA WITH CHRONIC TONSILLITIS—ONE CASE

A. S., a boy of eleven years, gives a history of repeated sore throats and attacks of tonsillitis and a discharging ear, since infancy. Examination showed greatly enlarged tonsils, no adenoid tissue, palpable glands at the angle of the jaws and purulent discharge from the right ear. He was given two complete series of *x*-ray treatments, and at the same time his ear was treated with alcohol and hydrogen peroxide. Clinically he has been free from colds and attacks of tonsilitis. The ear has ceased to discharge. The tonsils have decreased markedly in size—the distance between them has increased 10 mm. The glands at the angle of the jaws remain palpable. The hemolytic streptococcus was found only on two occasions at an interval of one month, and was still present five weeks after the last treatment.

This case is interesting, in that it offers a possible way to clear up these chronic cases of suppurative otitis media. Evidently roentgenotherapy causes a shrinkage of the infiltrated mucous membrane lining the Eustachian tube and middle ear. However, no definite statement should be made on this until pathological sections have been studied.

ACUTE CATARRHAL OTITIS MEDIA—ONE CASE

This case was a college student who had been deaf in his left ear for one month following a very severe cold. Examination showed small tonsils, glands not enlarged, but a large inflamed mass of adenoid tissue compressing the right Eustachian orifice and, to a less extent, the left one. He was given one series of four treatments, but at the same time his nasopharynx was treated with silver nitrate. He had a marked reaction with considerable swelling of both sides of the neck and some sore throat after the first treatment. He had no reaction after the second treatment, and a very mild reaction after the third. A roentgen-ray dermatitis developed over the front and sides of the neck about one week after the fourth treatment. Examination at this time showed that there was no reduction in the size of the lymphoid tissue in the nasopharynx. Twenty-seven days after the fourth treatment, the patient had a tonsillectomy and adenoidectomy. A pathological section of one of the tonsils showed that apparently the germinal centers were not affected by the *x*-rays, but that the lymphoid cells between the germinal centers disappeared, and their place was taken by fibroblasts.

INCOMPLETED CASES

This series included 6 cases of chronic tonsillitis and one case of chronic catarrhal otitis media of two years' duration. This last case stopped treatment after two exposures, due to the severe reaction—swelling of the salivary glands and sore throat—which followed each treatment. Two of the cases of tonsillitis showed great improvement, with the almost complete disappearance of all their symptoms. It has been impossible to keep in touch with the other 4 cases.

BACTERIOLOGY

In addition to observations on the clinical progress of the cases under discussion, it was considered of interest to note such changes as might occur in the bacterial flora of the throats. If it could be shown that retrogression in the size of the tonsils was accompanied by the subsidence of the carrier state in such of the subjects as might harbor pathogenic bacteria in their throats, the advantages resulting to the individual would be obvious. The rôle of foci of infection in the production of local and systemic derangement need not be discussed here—the subject has been thoroughly treated in a voluminous and readily accessible literature. It is well known that tonsillectomy may be followed by marked improvement in divers disorders of varying degree. The importance of prophylactic eradication of these foci, if it could be accomplished by the methods described above, need not be emphasized—it will become apparent without further reflection.

Doubtless because of the novelty of the irradiation method of treatment, there is very little literature dealing with the changes produced in the bacterial flora. Murphy[1] and his associates noted the disappearance within four weeks, of hemolytic organisms from 30 to 36 carriers. No record is adduced of subsequent study of the individuals. The suggestion is made that proper drainage of the crypts is responsible for the change. Osgood[2] advances the same conclusion. In his paper there is no citation of case reports or bacteriological studies.

TECHNIQUE

The material for culture was obtained by means of surface swabs, systematically passed over the desired areas, in the endeavor to obtain a heavy inoculation which would be fairly representative of the actual flora present. For the first cultures, only the tonsils were swabbed. Later, for purposes of comparison, a swab from the pharynx was added. In every case, a separate culture was taken from each tonsil, and careful precautions were observed to prevent contamination of the swabs from surfaces other than those under consideration. The difficulties of the procedure with children of tender age will be appreciated.

For the study of the flora, 3 per cent rabbits' blood meat infusion agar, PH 7, 8–7.4, plates were used in every instance. It was found preferable to use media not more than forty-eight hours old. The first plate was rather heavily inoculated with the swab over about 1/5 of its surface. A heavy platinum wire, bent at a right angle, was used to obtain an even spread over the remaining surface of the medium, and was then transferred without flaming to a second plate, which was similarly inoculated over its entire extent. In this way, an even distribution of colonies was obtained over the second plate—occasionally even the first was suitable for study. The plates were incubated for eighteen hours, and then observed for the presence and relative numbers of colonies of the various bacteria under consideration. Identification of the organisms was accomplished by means of stained films, and subculture when necessary, in every instance. It soon became evident that the beta hemolytic streptococcus and the staphylococcus aureus were the organisms of choice for study—both on account of their well-known pathogenic potency, and because it was at once apparent that they were the only bacteria of such character to be present as more than transient visitors. Occasionally were found Friedlaender's bacillus, pneumococci, B. Coli, and rarely others—but never frequently enough to justify serious consideration in this paper. The influenza bacillus was of somewhat more frequent occurrence, but is not treated of here, in view of its somewhat uncertain potentialities. The ubiquitous non-hemolytic streptococci and chromogenic gram-negative cocci were omnipresent.

RESULTS

The results of the bacteriological observations in the 8 completed cases are presented in Table I.

Table I

Case D. T. First Series, 10–10—10–21
Second Series, 11–18—12–16

Date of Culture		Strep. Hem.	Staph. Aureus
10–14	Both tonsils	++	0
10–28	Both tonsils	0	0
11–14	Both tonsils	+++	0
	Pharynx	+++	+
11–18	Both tonsils	+++	0
	Pharynx	+++	0
12–5	Both tonsils	++	0
	Pharynx	++	0
12–12	Both tonsils	+++	0
	Pharynx	0	0
12–16	Both tonsils	0	0
	Pharynx	0	0

Case E. H. First Series, 10–8—10–12
Second Series, 12–3—12–23

9–28	Both tonsils	++	0
	Pharynx	0	0
10–21	Right tonsil	+	0
	Left tonsil	0	0
	Pharynx	0	0
12–2	Both tonsils	++	0
	Pharynx	++	0
12–9	Both tonsils	++	0
	Pharynx	0	0
12–16	Both tonsils	0	0
	Pharynx	0	0

Case H. C. First Series, 10–13—10–24
Second Series, 11–30—1–7

10–12	Both tonsils	+	+
	Pharynx	0	+
10–19	Both tonsils	+++	0
	Pharynx	+++	0
10–28	Right tonsil	0	++
	Left tonsil	++	++
12–5	Both tonsils	0	+
	Pharynx	0	0
12–9	Both tonsils	0	++
	Pharynx	0	++
12–16	Both tonsils	0	+
	Pharynx	0	+
1–6	Both tonsils	0	0
	Pharynx	0	0

Case C. S. First Series, 9-26—10-4
Second Series, 11-1—11-25

9-24	Both tonsils	+++	o
9-30	Both tonsils	+++	o
10-7	Both tonsils	+++	o
10-28	Left tonsil	o	++
	Right tonsil and pharynx	o	o
11-4	Left tonsil	+	o
	Right tonsil	o	o
11-11	Both tonsils	+++	o
	Pharynx	o	o
11-18	Both tonsils	++	o
	Pharynx	o	o
11-25	Right tonsil and pharynx	+	o
	Left tonsil	o	o
1-9	Both tonsils and pharynx	o	o

Case B. T. First Series, 10-1—10-11
Second Series, 1-1—11-17

9-30	Both tonsils and pharynx		
10-7	Both tonsils	+++	o
10-28	Left tonsil	+++	o
	Right tonsil and pharynx	+	o
11-4	Both tonsils and pharynx	o	o
11-11	Both tonsils and pharynx	o	o
11-18	Left tonsil	+	o
	Right tonsil and pharynx	o	o
12-19	Both tonsils	++	o
	Pharynx	o	o

Case B. S. First Series, 9-26—10-4
Second Series, 11-1—12-3

9-24	Right tonsil	+++	+++
	Left tonsil	o	++
9-30	Right tonsil	o	+++
	Left tonsil	++	++
10-7	Left tonsil	+	o
	Right tonsil	o	+
10-28	Left tonsil	++	o
	Right tonsil and pharynx	o	o
11-11	Both tonsils	++	o
	Pharynx	+	o
11-18	Both tonsils	+	o
	Pharynx	o	o
11-25	Both tonsils	+++	o
	Pharynx	o	o
12-2	Right tonsil	+	o
	Left tonsil and pharynx	o	o
12-9	Left tonsil	+	o
	Right tonsil and pharynx	o	o
1-9	Right tonsil	+	o
	Left tonsil	++	++
	Pharynx	+	o

Case W. R. First Series, 9-27—10-10
Second Series, 11-1—12-9

9-26	Both tonsils	o	o
9-30	Both tonsils	o	o
10-7	Right tonsil	+++	o
	Left tonsil	o	o
10-28	Both tonsils	+++	o
	Pharynx	o	o
11-11	Left tonsil	++	o
	Right tonsil and pharynx	o	o
11-18	Both tonsils	o	o
	Pharynx	o	o
11-25	Both tonsils	++	o
	Pharynx	o	o
12-2	Both tonsils and pharynx	o	o
12-9	Both tonsils and pharynx	o	o
1-9	Left tonsil	o	+
	Right tonsil	++	o
	Pharynx	o	o

Case A. S. First Series, 9-26—10-4
Second Series, 11-1—12-3

9-24	Both tonsils	o	o
9-30	Both tonsils	o	++
	Pharynx	o	o
10-7	Right tonsil	o	+
	Left tonsil	No record	
10-28	Right tonsil	o	+
	Left tonsil	o	o
	Pharynx	+	o
11-11	Both tonsils and pharynx	o	o
11-18	Both tonsils and pharynx	o	o
11-25	Right tonsil	+	o
	Left tonsil and pharynx	o	o
12-2	Both tonsils and pharynx	o	o
12-9	Both tonsils and pharynx	o	o
1-9	Both tonsils and pharynx	o	o

In the above tabulations, +++ indicates the presence of the organism in question in the proportion of at least one colony to four of the normal flora. The presence of not more than ten colonies on a plate containing from one hundred to three hundred or more colonies is indicated by +. Intermediate ratios are recorded as ++.

DISCUSSION

Certain outstanding features will at once become apparent upon even the most casual perusal of the above tables. Of 8 patients who received the full course of eight radiations, 5 were free from the hemolytic streptococcus and staphylococcus aureus at the time of the final cultures. Of these 5, 3 may be considered as incomplete studies, inasmuch as a control set of cultures was not taken at the end of at least four weeks following the last treatment. Two patients were therefore free from the bacteria under consideration, after the lapse of a considerable interval following treatment. These have not again been observed to determine whether this freedom persists. Three patients continued to yield to hemolytic streptococcus and staphylococcus aureus in large numbers at the end of the stated interval, and this, despite the fact that with two of them there was a certain tendency for the hemolytic streptococcus to disappear during the two courses of treatment. In the other case, the carrier state appeared and persisted in an individual (W. R.) whose flora was at first free from the organisms. The tenbency for the organisms to disappear during the treatment is also illustrated by the incomplete cases, but consideration of the cases W. R. and B. S. will show how fallacious it would be to draw conclusions without the aid of later control cultures.

From the point of view of the individuals concerned, this 40 per cent success, of the permanence of which we have even now no assurance, can scarcely be regarded as dramatic. Six of the 8 individuals harbored the hemolytic streptococcus upon the surface of the tonsils before the institution of irradiation. Of the remaining two, one showed a moderate number of the organisms one month after treatments were ended. This may be regarded as a definitely bad result, viewed from the standpoint of prophylaxis. The other yielded the organism at various times during the course of the treatments, and it is attractive to presume that the tonsillar crypts in this case acted as foci from which the bacteria occasionally made their way to the surface. The observations of Pilot and Davis,[3] who succeeded by the swab method in culturing the hemolytic streptococcus in only 61 per cent of cases from hyperplastic tonsils (which, after enucleation, yielded positive cultures from the crypts in 97 per cent) bear directly upon this point. Of similar import are recent observations of Davis,[4] and of Bloomfield,[5] that serial swabs from the throats of normal individuals will eventually reveal the presence of these organisms. Similarly, we have no proof that, in the 2 cases from which we were apparently successful in banishing the pernicious elements of the flora, they did not continue to exist in secluded pockets not reached by the ordinary swabbing. It is entirely reasonable that serial quantitative cultures from these children's throats would eventually disclose the undesirable organisms in either or both. The case A. S. was never heavily infected at any time, and perhaps of the entire group is the only example of a persistent approximately harmless flora. This individual may therefore be disregarded in our quest for an excellent result, upon the ground that he never showed a marked deviation from the normal. We are thus reduced to one example only of really marked improvement!

The above discussion has been presented as to its findings on the presence or absence of the hemolytic streptococcus. As pointed out above, of the other definitely pathogenic organisms encountered, only the staphylococcus aureus was ever present frequently enough in any one individual to entitle it to serious consideration. In the case A. S., it appeared in small numbers during the course of the first series of treatments, only to disappear again. In the case H. C., it was persistently present during the entire series of cultures with the single exception of the final set. This case has already been considered as one presenting a definitely encouraging improvement, but we have no proof that swabs taken tomorrow would not be loaded with this organism. As for the case B. S., his plates showed many colonies of this pathogen at the start, and its persistence one month after the termination of his course of treatments shows that the apparent eradication of the organism from his flora during the period of irradiation was essentially misleading.

Further comment seems unnecessary. The study of the changes in the surface flora offers no indication that reduction by radiation in the size of hyperplastic tonsils is necessarily accompanied by any diminution of the potentialities as foci of infection. Viewed from this angle, they continue to menace the health of the individual, perhaps to as great a degree as before. And for this very portentous reason, it may well be questioned to what degree we are justified in abandoning careful tonsillectomy, with its certain eradication of these foci, in favor of mere reduction in the size of the tonsils through the agency of the roentgen ray.

SUMMARY

Eight cases treated with two courses of four radiations each are discussed from the point of view of the bacterial flora of the tonsils and pharynx. Seven were found definitely to harbor the hemolytic streptococcus. Three are regarded as incompletely studied. In three other cases, the hemolytic streptococcus persisted at least four weeks following the termination of treatment. Of the remaining two, one presented an approximately normal flora throughout. The other may be regarded as improved from the bacteriological point of view, but there is no proof that this improvement is persistent.

There is no evidence that reduction in the size of hyperplastic tonsils by irradiation is accompanied by eradication of the carrier state in individuals harboring the hemolytic streptococcus in these tonsils.

GENERAL CONCLUSIONS

1. Roentgenotherapy causes a decrease in the size of chronically infected tonsils and adenoids, particularly in the large cellular glands, and less so in the small fibrous glands.

2. Our experience indicates that roentgenotherapy will not cause the hemolytic streptococcus to disappear permanently from the surface of the crypts of the tonsils, but will cause a small percentage of the palpable glands at the angle of the jaw to disappear. Out of 14 cases on which we have notes, one case, R. C., showed the palpable glands completely disappeared. In 3 cases the glands were barely palpable, and in 2 cases the glands on the left side disappeared, and were still palpable on the right side. In the other 8 cases the glands were unaffected.

3. Clinically, roentgenotherapy gives relief from symptoms, but this may be only temporary. In some cases, the objective signs of the chronically infected tonsils do not disappear after this treatment; that is, the size of the tonsils is unchanged, hemolytic streptococcus is still present, and the glands of the neck are palpable, although subjectively they are well. In the arthritis case mentioned above, this improvement might be due to the tonic effect of the *x*-ray.

4. Generalized use of *x*-rays for treatment of chronically infected tonsils and adenoids is not advisable.

Practically 100 per cent of chronic carriers of hemolytic streptococcus and diphtheria can be cured by operative removal of tonsils and adenoids. *X*-ray and radium treatment must be effective in an approximate percentage, and at the same time more comfortable than operation, and be associated with fewer complications.

5. The *x*-ray treatment of tonsils and adenoids is especially indicated in those cases where a surgical operation is inadvisable—such as chorea, pulmonary tuberculosis, and cardiac and renal lesions. It is our impression that the greatest field of usefulness will be in the treatment of children. Children rarely have a chronic infection of the tonsils comparable to that of adults. Their tonsils and adenoids are very cellular and of the type that responds most readily to roentgenotherapy. Their symptoms are largely due to hypertrophy of the lymphoid tissue in the throat and nasopharynx. It is possible that when the technique is perfected, roentgen-ray or radium treatment will entirely supplant surgical measures in children.

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SOME PROBLEMS OF RADIATION THERAPY*

BY GIOACCHINO FAILLA, E.E., EDITH H. QUIMBY, M.A., AND ARCHIE DEAN, M.D.

Memorial Hospital

NEW YORK CITY

A PERUSAL of the literature on the subject of radiation therapy reveals the difficulty of comparing doses of radiation used by different radiologists. The reason for this lies in the more rapid empirical development of the *art* as compared with the *science* of radiation therapy. In the present paper are given some generalizations which facilitate the comparison of skin doses given under different conditions of treatment. They are based on the results of experiment, and corroborated by clinical observations.

I. FILTRATION

The sources of radiation at our disposal are the *x*-ray tube and radioactive substances. In either case the radiation emitted is very heterogeneous. An *x*-ray bulb emits radiation of many different wave-lengths, ranging from a minimum wave-length, which is determined solely by the maximum voltage applied to the tube. This is true no matter whether a fluctuating or constant voltage is used. A radioactive source such as radium, emits three entirely different types of radiation, each of which is heterogeneous. The necessity of filtering the radiation is due to its heterogeneity. This is especially important in deep therapy, where the tumor to be treated is surrounded entirely by healthy tissue, through which the radiation must necessarily pass.

Like any other substance, tissue absorbs radiation of long wave-length more easily than it does radiation of short wave-length. Therefore, if the incident beam is heterogeneous, the soft, or long wave-length components will be absorbed to a greater extent by the tissue than the hard, or short wave-length components. As a result, the radiation which reaches the deeper layers of tissue will be, *on the average*, harder than the initial beam.† The superficial layers of tissue will receive a larger dose of radiation than the deeper layers, for the following reasons: 1. The surface layer receives radiation which is more easily absorbed, and therefore absorbs a larger percentage of the amount falling on it. 2. The deeper layers receive radiation which is more penetrating, so that a smaller fraction of the amount reaching the respective layers is absorbed by each than by the first layer. 3. As some of the radiation has been absorbed by the superficial layers, a smaller amount reaches the deeper layers. 4. There is an additional diminution due to the greater distance from the source at which the deeper layers are. For the present, however, we shall not consider the effect of distance.

Examining more closely the above factors, we find that to overcome the first two difficulties, we need radiation which is absorbed to the same extent by successive layers of tissue. It is the aim of proper filtration to accomplish this result. The third difficulty can never be overcome entirely, because, no matter what kind of radiation is used, if it is to produce an effect, it must be absorbed to some extent by the tissue. However, the more penetrating the radiation is, the larger will be the dose delivered to the deeper layers for the same skin dose. We may conclude, then, that for deep therapy the radiation used should be homogeneous and as penetrating as possible.* We shall consider now how far these requirements can be satisfied in practice.

The most penetrating radiation available for therapeutic purposes is emitted by radioactive substances. However, they emit also softer gamma radiation and beta rays, which, in comparison, are easily absorbed by tissue. For deep therapy it is necessary to use a filter of sufficient thickness to remove at least all the beta rays.

* A Leonard Prize Paper.

† Of course the wave-length of the hardest component of the unfiltered and filtered beams is the same. Matter cannot affect radiation in such a way as to shorten the wave-length.

* The effect which the quality of radiation used may have on the physiological effect produced is not definitely known at the present time. It seems, however, that within wide limits of wave-lengths the biological effect is independent of the quality of radiation.[1]

On the other hand, as we shall see presently, practical considerations make it undesirable to use such filters as will allow only the most penetrating gamma rays to reach the tumor. In the first place, human tissues are made up principally of chemical elements of low atomic weight. Accordingly, the decrease of the intensity of radiation, as the latter traverses the tissue, is due primarily to the scattering effect of the atoms, and not to true absorption.[2] As the scattering effect is nearly the same for radiation of different wave-lengths,[3] the penetration in tissue of gamma rays of different wave-lengths is not very different. Therefore, it is possible to have a heterogeneous beam of radiation which is absorbed exponentially by tissue. That is, each successive layer of tissue will absorb substantially the same fraction of the radiation reaching it.

The relative amounts of radiation of different wave-lengths *emitted* by radioactive substances are determined by the radioactive changes which take place spontaneously. As these cannot be influenced by any means at our disposal, we cannot change the emission of radiation, either as regards quality or quantity. The use of a filter to remove the softer components of the radiation results necessarily in a decrease of the intensity of radiation. The same is true of x-rays, for, with a given machine and voltage used, the type of radiation emitted is also fixed. Accordingly, for economical reasons, it is important not to use excessive filtration. The proper filter to use can be determined experimentally.

In a previous paper[4] was described the experimental procedure for the determination of a suitable filter for deep radium therapy. It is unnecessary, therefore, to give the details here. It should be noted, however, that animal tissue was used as the absorbing medium to test the radiation passing through each filter. The criterion for correct filtration was the exponential absorption of the filtered radiation by tissue, as indicated by the absorption curves, when plotted to a semi-logarithmic scale. The proper thickness of filter was less than 2 mm. of brass, or its equivalent; but for convenience, 2 mm. was adopted. A secondary filter of low atomic weight, such as a few mm. of rubber, must be used in addition to the brass, in order to remove the soft secondary radiation emitted by the metal.[5]

The experimental apparatus used to determine the effect of different filters on the x-rays emitted by a Coolidge tube

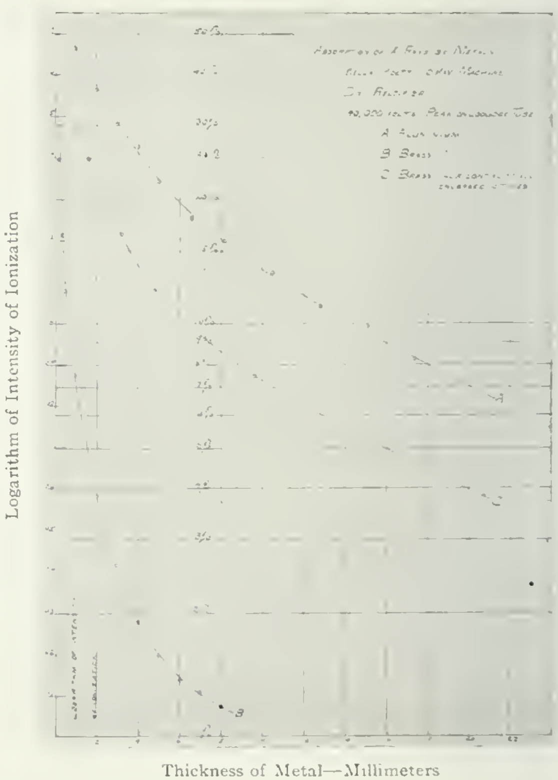


Fig. 1.

operated at 140,000 crest voltage was similar to the one used for radium rays. Here, however, the conical ionization chamber had to be at a greater distance from the source, on account of the glass bulb and the high voltage. The thin mica window was larger, so that larger slices of meat had to be used for the tests. On this account more of the scattered radiation entered the chamber, and the values of the absorption coefficients are not comparable to those obtained previously for radium rays.

In Figure 1 are given the aluminum and brass absorption curves for x-rays produced by a voltage whose crest value, as measured by a sphere gap, was 140,000 volts. The curves are plotted to a semi-logarithmic scale, and therefore the fact that they are not straight lines shows that the x-radiation of these experiments is not absorbed exponentially by aluminum or brass. The decreasing slope of these curves with increasing filter thickness shows that the radiation becomes gradually more penetrating as the filtration increases. This should be contrasted with the straight lines obtained in the case of radium rays beyond a filter of 2 mm. of brass or 6 mm. of aluminum, showing that further filtration did not increase the penetrating power of the transmitted gamma rays appreciably. From the curves we obtain the thicknesses of the two metals corresponding to the same ionization in the measuring instrument. They are given in Table I. The first column shows the

Table I

Per Cent Radiation Transmitted	Thickness Brass Mm.	Thickness Aluminum Mm.	Ratio
25.6	0.15	4	26.6
22.2	0.20	5	25.0
19.5	0.25	6	24.0
16.0	0.34	8	23.6
13.5	0.43	10	23.2
11.8	0.53	12	22.6
9.0	0.77	16	21.8
7.1	1.05	20	19.1

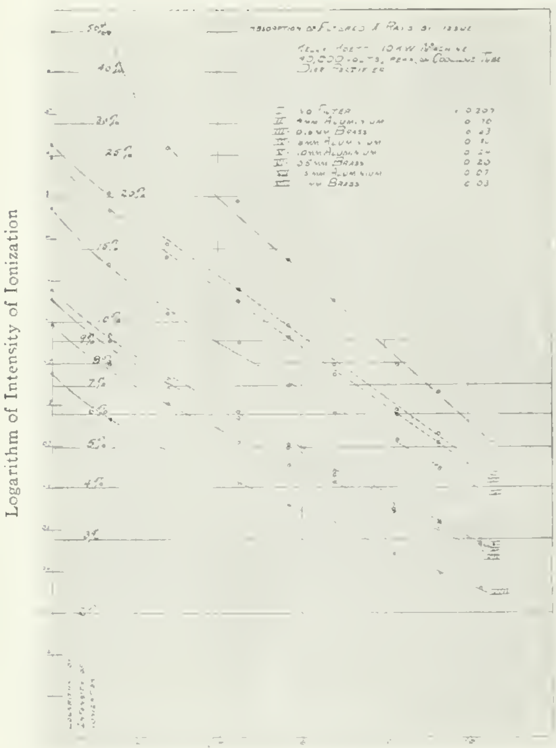
percentage ionization produced by the radiation passing through the filters, taking the ionization produced by the unfiltered radiation as 100 per cent. It should be noted that since the quality of the radiation is affected by the filter, strictly speaking, these figures do not represent the relative *amounts* of transmitted radiation. The last column shows the ratio between corresponding thicknesses of aluminum and brass. If these metals absorbed radiation of different wave-lengths in the same proportion, the ratios of thicknesses would be all the same. It will be seen, however, that for lightly filtered radiation, brass is relatively more effective as a filter than aluminum, since the ratio is larger for the thinner filters than for the thicker ones. Therefore brass* is a better filter for the x-rays of these experiments because it absorbs relatively more of the soft and less of the hard radiation, in comparison to aluminum. This effect is due to the fact that the decrease in the transmitted beam due to scattering is nearly the same for all wave-lengths within wide limits,[6] and in the light elements like aluminum the scattering plays a more important part than in heavier elements.

In connection with the filter thicknesses given in Table I it should be emphasized that the thicknesses and brass of aluminum which correspond to the same ionization, cannot be said to be "equivalent." As already stated, brass absorbs relatively more of the soft radiation, and therefore, while the ionization is the same in both cases, the quality of the transmitted radiation is slightly different. For practical purposes, however, the values of Table I can be regarded as equivalent thicknesses.

In Figure 2 are given the curves showing the absorption of filtered x-radiation by tissue. They are drawn in their correct relative positions. The slope of the different curves, which determines the coefficient of absorption (that is, the percentage of radiation absorbed per cm. of tissue) is appreciably different. To compare the penetrating power in tissue of the rays filtered through different thicknesses of metal it is best to calculate the absorption coefficients for the parts of the curves which are straight. They are given in Table II. It will be seen that the coefficient of absorption decreases steadily with increasing filtration up to 1 mm. of brass, the heaviest filter used in these experiments. This means that the penetration of the filtered radiation increases considerably (column 3). However, the amount of radiation transmitted by the filter as measured by the ionization (column 4) decreases more rapidly. Accordingly, the time of treatment to give the same skin dose (column 5) increases markedly. It is evident from these results that no general conclusion can be reached as to the neces-

* Commercial brass may contain a considerable percentage of lead, whereas copper is usually free of impurities. Since lead is very objectionable as a filter for x-rays because it absorbs abnormally the shorter wave-lengths, copper is preferable for therapeutic purposes. Our experiments show that copper and zinc have substantially the same absorbing power as brass.

sary and sufficient filter to employ with this type of roentgen radiation. The requirements of the particular case to be treated, as well as practical considerations and limitations, must be taken into account. It is probable, however, that 0.5 mm. of brass is a sufficient filter for the deepest



Thickness of Tissue—Centimeters

Fig. 2.

radiation therapy which would be attempted with this voltage.

The difficulty experienced in deciding what is the most suitable filtration for the *x*-rays of these experiments does not exist in the case of radium rays. The conclusion reached is that 2 mm. of brass is sufficient as a primary filter, and actually this is a little more than the minimum necessary thickness. The reason for this lies in the composition of the heterogeneous beam of radiation which we wish to filter in the 2 cases. The radiation emitted by ordinary radium containers consists of beta and gamma rays. The beta rays are easily absorbed by matter and can be eliminated by a filter of 2 mm. of brass. The gamma rays include a wide range of wave-lengths, but the distribution of energy in their spectrum is such that a filter of 2 mm. of brass removes all the soft radiation, and the transmitted radiation is of much shorter wave-length than ordinary *x*-rays. In other words, the range of wave-lengths present in *x*-rays is inconspicuous in gamma rays. Therefore there is a sharp change in the quality of the transmitted radiation occurring at a point between 1.5 and 2 mm. of brass filter. While the radiation passing through this filter is still heterogeneous, it is made up of such short wave-length components that it is absorbed exponentially by tissue. The reason for this, as already mentioned, is that under such conditions the scattering by the light atoms of which tissue is made up, and not the true absorption, is the predominant effect. In the case of *x*-rays the energy in the spectrum[7] is distributed differently. The shorter components, including the characteristic radiation of tungsten, are very strong, and therefore the increase in penetration with filter is more gradual. If we were to push the filtration to the point where the characteristic radiation is absorbed out, we would have hardly any radiation left.

Table II

1		2	3	4	5
Filter		Coef. of Absorption, Cm.[1]	Half Val. Thickness, Cm.	Per Cent Rad. Trans. by Filter	Time of Exposure
Metal	Mm.				
Al..........	4.0	0.170	4.08	26.6	1.0
Brass.......	0.16	0.163	4.25	24.9	1.07
Al..........	6.0	0.130	5.33	18.8	1.41
Al..........	10.0	0.124	5.60	12.0	2.21
Brass.......	0.5	0.120	5.77	11.4	2.33
Al..........	15.0	0.107	6.47	9.90	2.77
Brass.......	1.0	0.103	7.50	7.50	3.53

Brass has been selected as the most suitable filter for deep radium therapy, not only on theoretical grounds but for practical reasons. Theoretically any metal of medium atomic weight and of the proper thickness is satisfactory. Brass is convenient because it is cheap and is easily worked. Metals of high atomic weight, like lead, are not as economical because they absorb relatively more of the penetrating radiation, even if the minimum required thickness is used. For treatments where space is an important factor, however, platinum is to be preferred, because a smaller thickness suffices. Brass, or better, copper, is recommended as a filter for x-rays because the scattering effect on the shorter wave-length components is not so pronounced in comparison as when aluminum is used. Metals of high atomic weight are unsuitable as x-ray filters, since they absorb abnormally the short wave-length components. This point is clearly brought out by some of Duane's spectra.[7] Other things being equal, the filter which gives the largest amount of penetrating radiation should be used, for this makes the treatments shorter. For our purposes brass or copper fulfil this condition, both in the case of radium and x-rays.

II. ERYTHEMA DOSES FOR DIFFERENT FILTRATION

Considering the absorption curve for radium radiations, using brass as the absorber, we may assume at first that it enables us to compare doses of radiation given under different conditions of filtration, provided the other factors remain the same. That is, if we take the ionization produced by the radiation from the bare emanation tube as 100 units, the absorption curve gives us the relative values of the ionization produced by radiation filtered by different thicknesses of brass. Thus, for a filter of 0.5 mm. of brass, the ionization is 15 units. We might think, therefore, that the mc.-hour dose to produce the same skin effect as the bare tube would be $^{100}/_{15}$ or 7.3 times larger, other conditions remaining the same. This, however, is not the case. It was decided, therefore, to determine the mc.-hour doses which produce the same skin effect under different conditions of filtration empirically, by making suitable tests on the skin of many patients.

The experimental conditions for these tests were as follows: In a cork 4 cm. in diameter and 2 cm. high, a hole 2 cm. in diameter was bored. A thin silk ribbon was fastened across the top, and a slot was provided into which the brass filters were fitted. As secondary filters, disks of pure gum rubber were used, fitting into the hole of the applicator to make up the desired thickness. The source of radiation was, in every case, a tube of radium emanation 14 mm. in length and 0.5 mm. in external diameter, whose value in mc. was known accurately. It was fastened to the silk ribbon with a little paraffin, so that it was always at a distance of 2 cm. from the skin of the patient. This distance was adopted in order to minimize errors due to possible slight variations in the distance of application. The applicator is shown in cross-section in Figure 3.

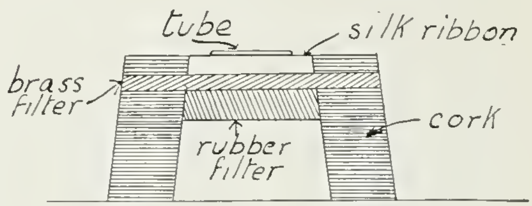


FIG. 3.

A skin erythema was adopted as the effect which we wished to produce by radiation of widely different quality. In general, this is very indefinite, for everyone has a different idea of an erythema dose. However, special precautions were taken to insure uniformity and reliability of results. In the first place, we used the skin erythema as a biological indicator, not as a measure of the radiation effect. At the present time, it is impossible to use any biological effect of radiation in any other way than as an indicator. For instance, if we irradiate an animal with a suitable dose of x-rays we produce certain blood changes. Then we irradiate a similar animal with double the dose previously employed, all other conditions, biological as well as physical, remaining the same. The blood changes which result and which we can determine, do not enable us to tell that double the dose of x-rays was used on the second animal. We may be able to say that a stronger dose was given, qualitatively, but not quantitatively. The same is true in the case of skin erythema. It is also very difficult to compare erythema effects on different patients, or even on the same patient, and be able to tell whether they are of the same intensity or not, especially when the comparison is not made at the same time.

To overcome these difficulties we proceeded as follows: It is well known that the degree of erythema produced on the skin of different patients by the same dose of radiation is not generally the same. Therefore, there must be a dose of radiation such as will produce no visible effect on the skin of the less radio-sensitive patients, and a slight, but definite effect on the skin of the more radio-sensitive patients. If we adopt this type of reaction as our standard of comparison we can eliminate almost entirely the personal element on the part of the observer. In the experiments it was only necessary to determine whether an erythema did or did not appear following the application of a certain dose of radiation to the skin of many patients. If no erythema appeared on all patients tested, the dose was too low; if every patient showed an effect, the dose was too high. By repeated trials it is possible to determine the dose which produces an effect on 50 per cent of all the patients, while the others show no apparent effect, the individuals treated being chosen at random. To be sure of such a dose, however, it is necessary to test a large number of patients in each case, for doses differing slightly from each other. Bearing in mind the practical applications of these experiments, it is evident that such extreme refinement is unnecessary. Accordingly it is sufficient to determine the dose which produces a definite erythema in the majority of patients, but still produces no visible effect on a certain percentage of the individuals treated. The latter point is very important, because it indicates that the dose is not too high, without relying on the intensity of redness observed.

It may be contended that one observer may see an erythema where another does not. In these experiments such errors were negligible because, on account of the type of applicator used, the small area affected by the radiation was completely surrounded by normal skin. Another precaution consisted in making the tests always on the same part of the body—the volar aspect of the forearm, immediately below the antecubital fossa—on account of the different sensitivity exhibited by different skin areas of the same individual. Differences due to the age of the patient, complexion, general physical condition, etc., were taken account of by treating a large number of patients without selection. The doses arrived at, therefore, are for the average cancer patient. It should be mentioned also that the erythema on which the doses are based appears, as a rule, within the fourth week after radiation, but variations of one week earlier or later are not uncommon. In a considerable percentage of cases the erythema proceeds to the stage of bleb formation, and then subsides. This requires usually about a week. Then bronzing appears, and may persist for an indefinite period. In some cases it has been noticed distinctly eighteen months after the treatment. Telangiectases have never been observed following these tests. The texture of the skin months afterward is normal, even though slight pigmentation persists. The primary reaction, which takes place within the first week, bears no definite relation to the final effect, and therefore is unsuitable for our purposes. In some cases showing definite secondary effects there is no visible primary reaction. This is especially true when filtered radiation is employed. On account of the long time required for the maximum effect to manifest itself, the experiments have extended over a period of more than two years.

The actual experimental procedure may be summarized as follows: We wish to determine the erythema dose, as already defined, when the cork applicator of Figure 3 is used without filter, with the source of radiation previously described. The radiation traverses about 0.1 mm. of glass, the silk ribbon of the applicator, and a thin layer of paraffin before reaching the skin. It consists mainly of beta rays, and the effect will be mostly on the superficial layers of skin. We make some preliminary tests to determine the dose which will produce an effect on the skin. Then, by varying this dose slightly, and treating several patients with each slightly different dose, we determine the dose which produces the desired erythema. This dose is then checked on a larger number of patients. The same process is repeated for the case of filtered radiation, with each filter used. To facilitate the work of determining the erythema doses for filtered radiation, each patient was treated at the same time on the other forearm with a cork applicator without filter, giving the erythema dose previously determined for unfiltered radiation. By this means it was possible to tell whether the patient was especially sensitive to radiation or not. Then, by comparing the intensity of redness on the two arms, it was easier to arrive at the proper dose. The mc.-hour doses corresponding to different filters, obtained in this empirical manner, are shown in Table III.

Table III

Filter		Erythema Dose
Brass, Mm.	Rubber, Mm.	Mc. Hrs.
0.0	0.0	7.5
0.16	1.2	30.0
0.32	1.2	100.0
0.50	1.2	250.0
0.75	2.4	475.0
1.0	2.4	630.0
2.0	2.4	830.0

It will be noticed that between the mc.-hour dose for unfiltered radiation and that for radiation filtered by 2 mm. of brass and 2.4 mm. of rubber, there is a difference of more than 100-fold. On this account it would have been very difficult to have kept the time of application approximately the same for all the tests made. Actually, the applications with filtered radiation were considerably longer than with unfiltered rays; but, within the limits of time variation of these experiments, this had no detectable effect on the dose. Special tests were made before this conclusion was reached.

If we analyze the results of Table III, we find that the mc.-hour doses increase with the filter for two physical reasons: 1. The radiation reaching the skin through the filter is less in amount. 2. It is also more penetrating, and hence a smaller amount will be absorbed by the tissue. Since the biological effect is brought about by the radiation which is absorbed by the tissue, the mc.-hour doses of Table III are related to the radiation which is effective in producing the observed changes. Furthermore, in the tests, all the physical conditions but

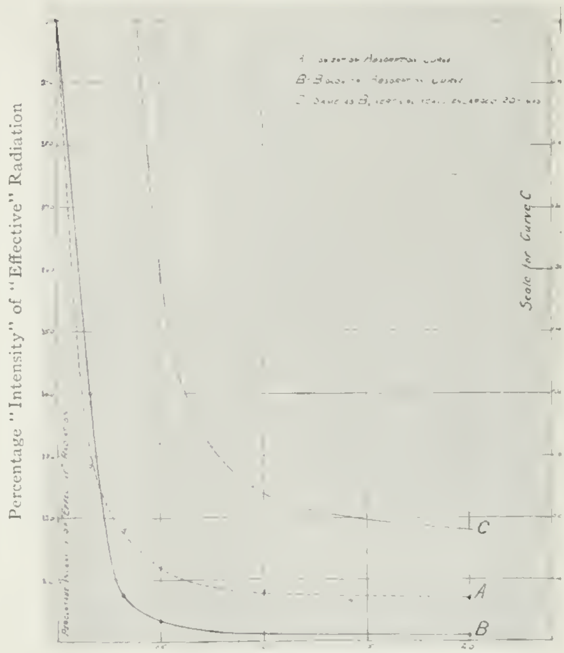


Fig. 4.

one—the filtration—were kept the same, and therefore the mc.-hour doses are inversely proportional to what we may call the "effective radiation" corresponding to the different filters. Taking the reciprocals of the mc.-hour doses we obtain figures which are directly proportional to the "effective radiation." For convenience, we may call the value corresponding to "unfiltered" radiation 100 units, and then the other values will represent in percentage the effective radiation for the different filters. Plotting these values we obtain curve B of Figure 4, which we may call the "biological absorption curve." It will be noted that a smooth curve can be drawn through the experimental points. Since each point was determined independently of any other by a series of skin tests, this shows that the biological reaction adopted as a standard of comparison is quite definite and reliable for our purposes.

Having obtained this curve we can now define the standard erythema *objectively*. That is, it is that intensity of redness of the skin resulting from a radium application under the conditions described above, giving the dose which, on the biological absorption curve (or simply from Table III) corresponds to the filtration used. For instance, if a radium tube of 50 mg., whose total filtration is 2 mm. of brass, is available, it should be applied to the patient at a distance of 2 cm. (*center* of tube to skin surface) for sixteen hours to obtain the standard erythema. To make the conditions as nearly as possible like those of these experiments, the proper distance should be obtained by means of a cork support as already described, and the secondary filter should be 2.4 mm. of rubber. Tests should also be made on several patients, in order to get an idea of the average erythema obtained. If a thinner brass filter is available it should be used in preference to the thicker one, as the mc.-hour dose will be smaller and the test will be more convenient. However, the unfiltered radiation from a radium tube does not quite correspond to that from an emanation tube, because the glass is thicker and the salt itself absorbs more of the radiation. The dose here given for unfiltered radiation, therefore, cannot be checked by those who do not use the emanation.

It may be instructive now to compare the biological absorption curve with the one previously obtained by ionization measurements. The two are shown in Figure 4. In either case the ordinates, that is, the distance of any point on the curve from the scale of brass thicknesses, represent "effective" radiation. In one case it is the radiation which is effective in producing a skin erythema, and in the other, in producing ionization. Neither curve gives the *quantity* of radiation passing through the filters. This is due to the fact that the quality of the transmitted radiation changes very considerably with the filtration in the range of brass thicknesses here considered. Curve A was obtained with the ionization chamber described in the paper already referred to.[5] The effect on the ionization of the secondary rubber filters used with the different brass thicknesses of the skin tests has been included in this curve, since it is involved in the "biological" absorption curve. The additional filtration due to the rubber is very considerable for the thin brass filters, and should not be overlooked. If metals other than brass are used as filters, precautions must be taken to secure approximately the same quality of radiation as employed in the skin tests, in order to obtain the same results. The fact that rubber was used with all the brass filters is useful in this connection, since rubber tends to equalize the quality of the radiation transmitted through filters of different composition. Using radically different ionization chambers (including a very small one with thin mica walls) other curves were obtained which differed considerably from the above. Still none even approached the biological absorption curve. The difference is clearly brought out by the figures of Table IV.

Table IV

A	B	C	D	E
Filter, Mm.		"Effective" radiation		Ratio C/D
Brass	Rubber	Ionization	Erythema	
0.0	0.0	100.0	100.0	1.0
0.16	1.2	28.5	40.0	0.71
0.32	1.2	18.1	7.5	2.41
0.50	1.2	11.8	3.0	3.93
1.0	2.4	7.63	1.19	6.31
2.0	2.4	6.74	0.90	7.49

If we assume the intensity of radiation from the unfiltered radium emanation as measured by the two effects, ionization and erythema, to be 100 per cent, the other figures represent the other "intensities" of the filtered radiation in percentages. It will be seen from column E that the discrepancy between the two increases with the filter. For the last filter the difference is 749 per cent. Therefore if, knowing the erythema dose for unfiltered radiation, we had used the ionization curve to determine the dose for radiation filtered by 2 mm. of brass and 2.4 mm. of rubber, the calculated dose would have been 7.49 times too small. On the other hand, if the calculation had been based on the gamma ray dose, the dose for unfiltered radiation would have been 7.49 times too large.

In considering the great discrepancy which exists between ionization measurements and the production of skin erythema, we should bear in mind that, in the range of filtration here considered, the radiation changes not only in quality, but in type. The unfiltered radiation is mostly of the beta type whereas the radiation filtered by 2 mm. of brass is wholly gamma. It is not surprising, therefore, that there should be no parallelism between ionization measurements and erythema effects in this case. Nor do the results disprove the statement usually made that the biological effects are dependent on the ionization, for in this connection we mean ionization in the tissues. Our measurements are based on ionization in air, since at present there is no method of measuring tissue ionization.*

In special cases where the quality of the radiation is not very different, there is a parallelism between biological effects and the ionization in a suitable chamber, as has been shown by Friedrich.[1] Bearing in mind that the radiation filtered by 2 mm. of brass is practically "homogeneous," as far as tissue absorption is concerned, it follows that we can extend the biological absorption curve to larger thicknesses of brass filter by ordinary ionization measurements without introducing serious errors.

III. DISTANCE

Filtration is only one of the factors which determine the dose of radiation delivered to a deep-seated tumor. The effect of distance is no less important. It is a consequence of the law of conservation of energy that the intensity of radiation emitted by a point source varies inversely as the square of the distance. The intensity of radiation at any point is defined as the amount of energy flowing per second through unit area (1 sq. cm.) perpendicular to the line of propagation. Whence if the source emits Q units of energy per second, the intensity of radiation at a distance d is

$$I = \frac{Q}{\text{area of sphere of radius d}} = \frac{Q}{4\pi d^2} = \frac{Q}{4\pi} \cdot \frac{1}{d^2}$$

Since the factor $\frac{Q}{4\pi}$ is always the same for a given source, the intensity I varies inversely as the square of the distance.

On account of the inverse square law, the radiation reaching the deeper layers of tissue is always less than the radiation falling on the skin even if we neglect the absorption entirely. The smaller the distance of the source from the skin, and the deeper the tumor, the greater will be the difference between the skin and tumor doses. If we could place the source at an

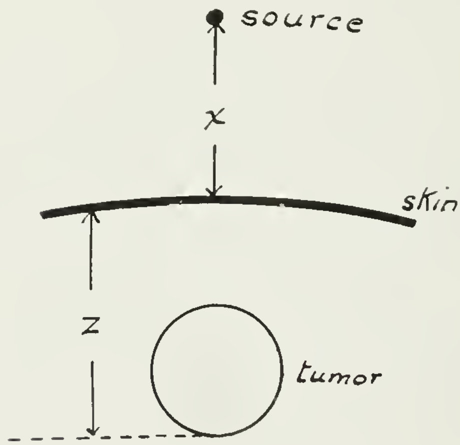


Fig. 5.

infinite distance from the skin, we would get parallel rays, and the intensity (which would then be infinitesimal) would be the same along the beam of radiation. The reason for this is that any infinite distance would then be negligibly small in comparison to the infinite distance of the source. We have here the clue to the practical solution of the problem. The condition to be fulfilled is that the difference between the distance from the source to the skin and the distance from the source to the tumor shall be small in comparison to either. This is evident from the following

* An attempt to overcome this difficulty led to the use of kerosene as the ionized medium. Even in this case, however, the absorption curve did not check curve B.

considerations: Let the relative positions of tumor, skin, and source be as shown in Figure. 5. Then the intensity on the skin is $I_x = \frac{k}{x^2}$, and the intensity at the back of the tumor is $I_z = \frac{k}{(x+z)^2}$, where k is a constant depending on the unit of radiation adopted. The difference between the skin intensity and the tumor intensity is $I_x - I_z = \frac{k}{x^2} - \frac{k}{(x+z)^2}$ To make this small for any given value of z, all we have to do is to make x very large in comparison. For instance, if $z = 1$, and we make $x = 100$, then $\frac{k}{100} - \frac{k}{101}$ is practically zero.

It will be seen that this relation will be true, no matter what unit of distance we adopt, provided that both x and z are expressed in the same unit. For a tumor 1 cm. deep, ($z = 1$ cm.) according to this example the distance of application would be 100 cm. ($x = 100$ cm.). For a tumor 1 *inch* deep, x would be 100 *inches*. For a tumor at any depth, x would be 100 times z. It is evident that the controlling element is the *ratio* between the intensity of radiation at the tumor and that at the skin; that is, the *fraction* of the skin dose which reaches the tumor. We can then plot a curve between these two ratios which will be of *general* applicability. It is shown in Figure. 6. At first a small increase in $\frac{x}{z}$ results in a large increase in $\frac{I_z}{I_x}$, but after $\frac{x}{z}$ reaches the value 11.8 the relative tumor dose, $\frac{I_z}{I_x}$, increases much more slowly. The curve never coincides with the 100 per cent line, but can be made to approach it as closely as we please by taking a large enough value for $\frac{x}{z}$. Practical considerations determine just how high we can afford to make the ratio $\frac{I_z}{I_x}$, since the time of exposure increases as the square of the distance x. If we wish to make it 90 per cent, the distance of application must be 19 times the tumor depth, *no matter what the latter may be*. It seems, however, that in practice it is hardly justifiable to try to obtain a better ratio than 80 per cent, corresponding to a value of $\frac{x}{z}$ of 8.5. For a tumor at a depth of 10 cm. the

Fig. 6.

distance of application would then be 85 cm., which is already a considerable distance and entails a long exposure to obtain a skin dose.

The absorption of radiation by tissue has no effect on the determination of the theoretical optimum distance of application. The reason for this is as follows: For deep therapy the source of radiation is always placed at a considerable distance from the skin.* Then the thickness of tissue z (Fig. 7) which affects the radiation reaching the back of the tumor is sub-

* If placed within the tumor the problem is evidently different, and presents no *physical* difficulties.

stantially the same for all rays entering the tumor, no matter how far the source may be. Even the volume of radiated tissue is nearly the same, if the proper diaphragm is used. Consequently the decrease of radiation due to the intervening tissue, and the scattering effect are the same for all practical distances of application (when the same quality of radiation is used).

can be used to determine the difference in the amounts of radiation received by the skin and tumor from the operation of the inverse square law. The decrease due to the intervening tissue is additional and quite independent of that due to the relative distances of skin and tumor from the source. In practice, economy of time is an important factor to consider. Therefore such a combination of filter and distance (as well as other factors) should be used as will give the desired amount of radiation at a given depth with the minimum expenditure of energy. If we know the effect on the deep dose of each factor which influences it separately from all the others, we can best arrive at the proper combination.

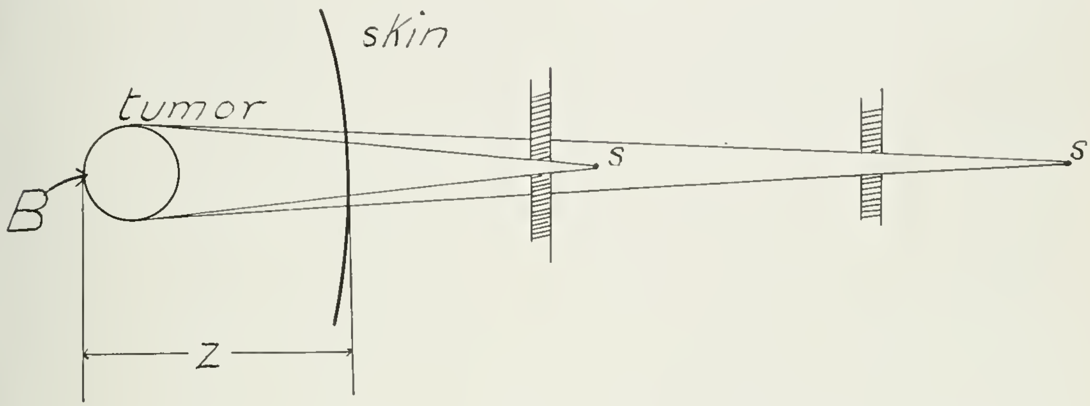


Fig. 7.

The effect of absorption on the curve of Figure 6 is simply to lower the 100 per cent line and every point on the curve in the same proportion. It amounts really to a decrease of the scale of $\frac{I_z}{I_x}$. Suppose, for instance, that the radiation reaching the point B (including primary, scattered, and secondary radiation) for any one position of the source is 50 per cent of what it would be if the tissue were not present. Then the maximum *relative* amount that we could ever get by placing the source at a very long distance is $\frac{50}{100} I_x$. For any other distance the value of $\frac{I_z}{I_x}$ can be obtained from the dotted curve which approaches as a limit the 50 per cent line. Thus for a value of $\frac{X}{Z}$ of 19, the value of $\frac{I_z}{I_x}$ is 45, which is again 90 per cent of the possible maximum for this case, that is, $\frac{45}{50}$ = 90 per cent. Hence for any given set of conditions (distance, depth of tumor, quality of radiation, etc.), the upper curve

The curve of Figure 6 can be used for either *x*-rays or radium, provided the linear dimensions of the applicator are so small in comparison to the distance of application that the source of radiation can be considered to be a point. In *x*-ray work this is always the case because the focal spot on the target is very small. But in deep radium therapy this is seldom the case, and should never be. Here large applicators are used, and they are placed rather close to the skin. The latter is a limitation imposed by the scarcity of radium. The inverse square law holds only for a point source. But in a distributed source it holds for every point of that source. This furnishes the method of attack for the solution of the problem. Since this paper was first written, one of us has published[8] curves which make it possible to determine the mc.-hour doses for different applicators, placed at different distances from the skin. It is unnecessary, therefore, to describe the method and results in the present paper. However, it may be well to emphasize certain points. 1. In taking account of the decrease of radiation due to the filter of the applicator, the "biological" absorption curve was used. This makes it possible

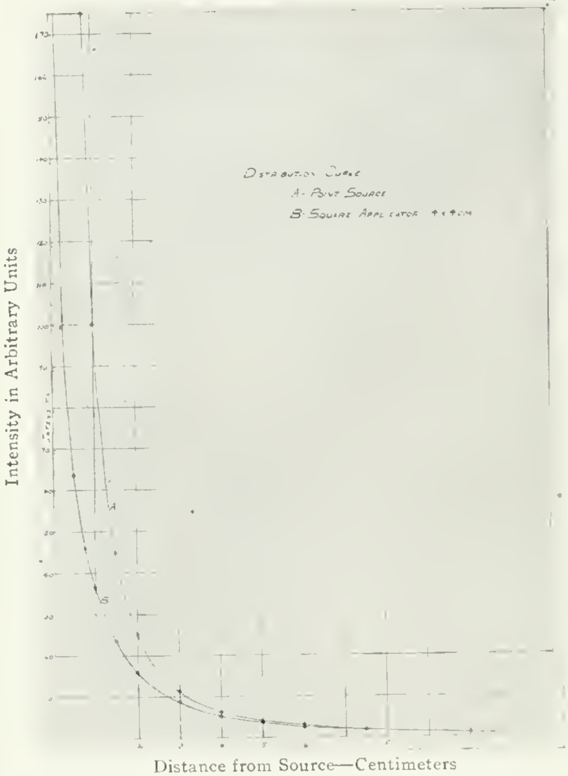


Fig. 8.

to work out curves for applicators having a filter less than 2 mm. of brass. In this range of filtration the radiation is very far from being homogeneous, and in addition to the absorption by the filter the absorption by tissue of the transmitted radiation from different parts of the applicator must be taken into account. 2. The curves given are of general applicability; that is, they can be used for applicators of widely different shape, size, and filter. Considering the large number of applicators of various shapes and sizes used by different workers in this field, and the amount of labor involved in the "point by point" calculations, the desirability of a general solution of this problem for practical purposes is obvious.*

The method of arriving at the "general" curves may now be described briefly. Taking a square applicator 4×4 cm., with a filter of 2 mm. of brass and 2.4 mm. of rubber, containing a given amount of radium, we can calculate the "intensity" of radiation at different distances from the radium by the point by point method. We can then plot the curve B of Figure 8. If the amount of radium in the square applicator were concentrated at its center we would have a point source and the inverse square law would give us curve A.

It will be noticed that beyond a distance of 8 cm. the two curves practically coincide. In other words, at a distance of 8 cm., the 4×4 cm. applicator can be considered as a point source. This conclusion does not depend on the unit of length adopted, for this is equivalent to changing the scale of the curves and does not affect their relative position. If the applicator were 4×4 in. it could be considered a point source when placed at a distance of 8 in. The necessary condition is, therefore, that it be placed at a distance of $\frac{8}{4}$ or 2 times its linear dimension. Similarly the variation from the point source curve will be the same for any square applicators at distances which are the same multiple of the linear dimensions of the applicators. That is, at a distance of 4 cm. from a square applicator 4×4 cm., the radiation is 5.4 while at a distance 4 cm. from a point source it is 6.4 arbitrary units. The amount of radiation delivered by the square applicator at a point 4 cm. away from it is then $\frac{5.4}{6.4} = 84$ per cent of the radiation at the same distance due to a point source of the same strength. If now we take an applicator 8×8 cm. at a distance of 8 cm., it will deliver also 84 per cent of the radiation which a point source would deliver at a distance of 8 cm. Therefore, in order to have a general curve which can be used for

* Data and curves for definite applicators have been worked out by other investigators 9, 10, 11, 12. These, however, are not "general," so that the calculations have to be repeated for each applicator. Furthermore, they apply only to gamma ray treatments. The reader should consult these papers for gamma ray doses delivered at different tissue depths.

any square applicator we must (1) express the distance from the radium in terms of the side, a, of the applicator, and (2) express the amount of radiation at different distances as a percentage of the radiation delivered at the same distance by a point source of the same strength. Such curves are given in the paper already referred to for tubular, circular, square, and rectangular applicators having the following filters:

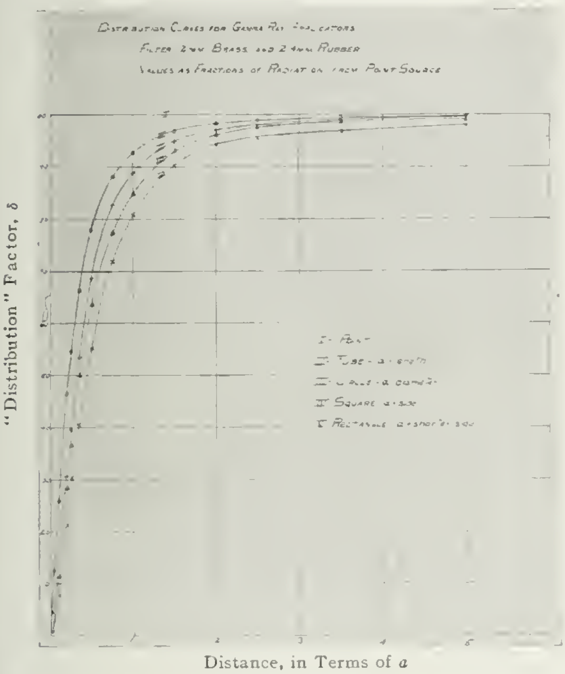


Fig. 9.

None; 0.16 mm. brass and 1.2 mm. rubber; 0.5 mm. brass and 1.2 mm. rubber; 0.75 mm. brass and 2.4 mm. rubber; 2 mm. brass and 2.4 mm. rubber. The set of curves for 2 mm. brass and 2.4 mm. rubber is given also in Figure 9 to illustrate a further application of such curves in the next section of this paper.

As previously mentioned, in deep radium therapy we cannot place the applicator at a favorable distance on account of the small amount of radium available. Our main reliance in this case is on the penetrating power of the gamma radiation. The curves of Figure 9, however, enable us to determine the effect of distance alone on the amount of radiation reaching different depths. An example will illustrate this point. Given an applicator 4×6 cm., which is placed at a distance of 5 cm. from the skin, what is the relative amount of radiation reaching a depth of 3 cm. below the skin, neglecting absorption by the tissue? The relative distances in terms of a are shown in Figure 10. From the curve for the rectangle, Figure 9, we find at 0.5 a the radiation is 55.0 per cent of the point source value. At 1.25 a the radiation is 85.4 per cent of the point source value. The

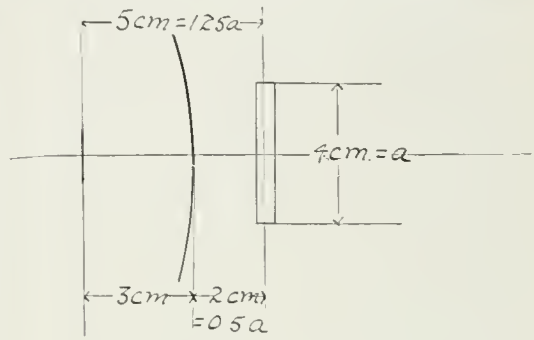


Fig. 10.

intensity of the radiation for the point source can be calculated according to the inverse square law. Thus at 2 cm. the intensity is $\frac{k}{2^2}$ arbitrary units; at 5 cm. it is $\frac{k}{5^2}$ arbitrary units. Hence for the rectangle we have;

On skin surface

$$\frac{k}{2^2} \times 55.0$$

At depth of 3 cm.,

$$\frac{k}{5^2} \times 85.4,$$

neglecting tissue absorption, and the radiation at a depth of 3 cm. is

$$\frac{\frac{k}{5^2} \times 85.4}{\frac{k}{2^2} \times 55.0} = \frac{85.4 \times 4}{55.0 \times 25} = 24.8 \text{ per cent of}$$

the amount falling on the skin. If a point source had been used it would have been $\frac{2^2}{5^2}$ or 16 per cent.* From this we see the advantage of a distributed source when applied close to the skin. An additional

* If we included the absorption of the radiation by the 3 cm. of tissue we would get a still smaller fraction of the skin radiation at the given depth.

advantage is due to the fact that the radiation from the large applicator is distributed more evenly over the skin surface immediately under it.

IV. SKIN DOSES

The important physical conditions which determine the physiological effect on the skin are (*a*) the strength of the source of radiation; (*b*) its distribution; (*c*) the filtration; (*d*) the time of exposure; (*e*) the distance; (*f*) the absorption of radiation by the skin. The strength of the source is expressed in mgm. of radium element or in mc. when the emanation is used. The time of exposure is usually expressed in hours. The radiation *emitted* by the source in any given time is then kx (mg.) x (hours)

$$k \times (\text{mg.}) \times (\text{hours})^* \qquad (1)$$

where k is a constant of proportionality depending on the units adopted. The amount of radiation reaching the skin varies directly as the quantity emitted, and depends on factors (*b*), (*c*), and (*e*). The physiological effect on the skin depends on the amount of radiation reaching it and the percentage of this which it absorbs,—factor (*f*). We can now set up an expression for a skin dose, involving the above six factors.

For a point source without filter the radiation falling on 1 sq. cm. of skin directly below the applicator may be represented by

$$R = k\,\frac{(\text{mg}) \times (\text{hours})}{(\text{cm.})^2} \qquad (2)$$

when the distance of the source from the skin is expressed in cm. When the source is not a point the radiation reaching the same square cm. of skin is less than the value obtained from expression (2). Therefore we should introduce a numerical factor δ, less than unity, to take into account the effect of the distributed source. The equation then becomes

$$R = k\,\frac{(\text{mg.}) \times (\text{hours})}{(\text{cm.})^2} \times \delta \qquad (3)$$

Values of δ for applicators of different shapes and sizes can be obtained from the curves explained in the previous section and published in a separate paper.

If a filter is used the value of R will be still less because some of the radiation emitted is cut out by the filter. A factor ϕ can be used to denote the fraction of the emitted radiation which passes through the filter. Hence

$$R = k\,\frac{(\text{mg.}) \times (\text{hours})}{(\text{cm.})^2} \times \delta \times \phi \qquad (4)$$

It should be noted that the "distribution" factor δ is not independent of the filtration, and therefore its value must be determined from the curves corresponding to the filter in the applicator.

Equation (4) represents the amount of radiation reaching the skin for any practical applicator placed at any distance from the skin. However we are mainly interested in the biological effect which this radiation produces. For practical purposes skin erythema is a convenient effect to use as a guide in dosage. Furthermore the experiments described in Section II indicate that an erythema as there defined is suitable as a standard of comparison. If then we take this as our unit skin dose we have:

Skin dose =

$$q\,\frac{(\text{mg.}) \times (\text{hours})}{(\text{cm.})^2} \times \delta \times \phi \times \psi \qquad (5)$$

where ψ is the fraction of the radiation falling on the skin which is effective in producing the erythema, and q is a constant of proportionality. For our purposes we need not have separate values of ϕ and ψ. The biological absorption curve of Section II enables us to determine values of the product of $\phi \times \psi$ corresponding to different brass filters. We may denote this as one factor, α, and the formula for a skin dose becomes:

Skin dose =

$$q\,\frac{(\text{mg.}) \times (\text{hours})}{(\text{cm.})^2} \times \delta \times \alpha \qquad (6)$$

Before equation (6) can be used to solve actual problems, it is necessary to determine the value of the constant q. At the Memorial Hospital several applicators have been used for a number of years, so that the respective mc.-hour doses required to produce a mild erythema are known with considerable accuracy. If we take the skin dose delivered by one of these applicators as one unit, we can determine

* The emitted radiation can also be expressed in "mc. destroyed."[13] This notation, which is used mostly in France, has no real advantage over the mgm.-hour notation.[14]

the value of q in equation (6). Thus, for an applicator 4×5 cm., having a filtration equivalent to 2 mm. of brass, and with the radium placed at a distance of 3 cm. from the skin, the dose necessary to produce a mild erythema is 2,000 mgm.-hours. The value of δ for a source 4×5 cm. placed at a distance of 3 cm. can be obtained from Figure 9. It is 0.75. The value of α is 0.0090 according to the biological absorption curve of Figure 4. Substituting in equation (6) we get

$$1 = q \times \frac{2,000}{(3)^2} \times 0.75 \times 0.0090$$

whence

$$q = 0.66$$

We can make use of the data for the other applicators in the same way and thus arrive at an average value for q. Table V shows the values of q corresponding to five different applicators. It will be seen that the agreement among the first four is certainly as good as can be expected in this work. The skin doses for these applicators were determined empirically by the clinicians using them, and are entirely independent of any curves in this paper. The value for the cork applicator is appreciably lower than the others. This, however, is as it should be, since a skin erythema results from treatments with the above applicators only in the minority of cases. It will be remembered that in the skin tests with the cork applicator an erythema developed in the majority of patients. This dose, therefore, is a little higher than the one used in our clinical work. If we take the average value of q from Table V, equation (6) will give us the proper doses for therapeutic purposes. The final equation is

TABLE V

Applicator	Size, Cm.	Distance Cm.	Distance $\times$ a	Mc. Hrs.	Distrib. Factor, δ	Absorp. Factor, α	q
"Tray".....	4×5	3	0.75	2,000	0.75	0.0090	0.66
"Pack".....	8×12	6	0.75	9,000	0.72	0.0090	0.61
"Pack".....	8×12	10	1.25	20,000	0.85	0.0090	0.64
"Block".....	4×6	4	1.0	3,200	0.81	0.0090	0.68
Cork........	1.4×0.05	2	1.43	830	0.96	0.0090	0.56

Average value of q = 0.63

Skin dose =

$$0.63 \frac{(\text{mg.}) \times (\text{hours})}{(\text{cm.})} \times \delta \times \alpha \qquad (7)$$

It should be noted that the filtration for all the applicators of Table V is such as will give only gamma radiation, and is equivalent to 2 mm. of brass plus a suitable secondary filter. The data from the skin tests with less filtration are not included because they would not give us independent values of q, on account of the fact that the absorption factor, α, is determined from these tests. To obtain as reliable a value for q as possible it would be desirable to use data for large applicators with light filtration. But the skin doses for such applicators corresponding to the above gamma ray doses are not known. It is safe to say, however, that the equation will give the correct doses even for lightly filtered applicators of considerable size, and placed fairly close to the skin. Tests are being made to check the accuracy of the equation for applicators placed very close to the skin. Until this work is completed, while the equation may give us the correct doses even in extreme cases, we should not expect it. The equation can be used with confidence for all gamma ray applicators because these are always placed at a distance from the skin. Another point which deserves mention is that equation (7) does not take into account the "intensity" of the treatment, that is, the effect of the length of the treatment on the biological reaction. That this has some influence, no one doubts, but the extent is not known. Some of our skin tests showed that, as long as the number of mgm.-hours is the same, the amount of radium and the time can be varied within wide limits without appreciable effect on the degree of erythema. A similar conclusion is also reached by Kroenig and Friedrich in their work with *x*-rays.[1] In practice, therefore, this factor can be neglected.

If we wish to calculate the mgm.-hour dose which we should give with a certain applicator to produce a mild erythema on the average patient, equation

(7) can be written in a more convenient form:

$$\text{mg.} \times \text{hours} = 1.59 \frac{(\text{cm})^2}{\delta \times \alpha} \qquad (8)$$

The values of α corresponding to different brass filters, obtained from the biological absorption curve, are given in Table VI.

Table VI

Filter, Mm.		α
Brass	Rubber	
0.0	0.0	1 0
0.10	1.2	0.62
0.20	1.2	0.26
0.30	1.2	0.085
0.40	1.2	0.050
0.50	1.2	0.030
0.60	1.2	0.0210
0.80	2 4	0.0145
1.00	2.4	0.0119
1.25	2.4	0.0105
1.50	2.4	0.0098
1.75	2.4	0.0094
2.00	2.4	0.0090

If any filter other than brass is used, its absorbing power in terms of brass must be determined. This can be done approximately by means of curves published by one of us.[5] In such determinations account must be taken of the quality of the transmitted radiation. This point is clearly brought out in the paper referred to. The values of δ for any particular applicator and distance of application can be determined from the curves explained in Section IV. Since δ varies according to the size of applicator, distance, and filtration, it is not practical to give its values in tabular form. Here also the filter is to be reduced to the equivalent brass thickness. In addition, if the thickness is not the same as one of those for which curves have been plotted, the value of δ has to be obtained by interpolation.

Equations (7) and (8) are based on the unit erythema dose used at the Memorial Hospital for gamma ray applicators. If any one wishes to use his own unit, he can do so simply by redetermining the value of the constant q from his own data.

We shall now give a few examples to illustrate the uses of equations (7) and (8):

Example 1. A five-hour treatment is given with 100 mg. of radium in an applicator 4×4 cm. at a distance of 2 cm. from the skin, the filter being 2 mm. of brass and a few mm. of rubber or similar material. What is the skin dose given? First we have to determine the value of δ for this applicator when placed at a distance of 2 cm. The side of the square is 4 cm., therefore the distance of application is $2/4$ or 0.5 in terms of the linear dimension of the applicator. From the curve for the square applicator in Figure 9 we find that for a distance of 0.5 a the value of δ is 0.63. The value of α according to Table VI is 0.0090. Hence

$$\text{Skin dose} = 0.63 \times \frac{100 \times 5}{(2)^2} \times 0.63 \times 0.0090 = 0.45 \text{ of an erythema dose.}$$

Example 2. With the applicator of the previous example we wish to given an erythema dose. How long must the treatment be? Using equation (8), we have

$$\text{mg.} \times \text{hours} = 1.59 \times \frac{(2)^2}{0.63 \times 0.0090} = 1{,}120.$$

Therefore the time of exposure must be $1{,}120/100$ or 11.2 hours. The same answer could have been obtained by a simple proportion from the data of the previous example. For, if the 500 mgm.-hour treatment corresponds to 0.45 of an erythema dose, to give a full dose under the same conditions we must use $\frac{500}{0.45}$ or 1,110 mgm.-hours.

Example 3. We wish to administer an erythema dose in four hours with an applicator 4×5 cm. at a distance of 3 cm., the filtration being the same as in the preceding examples. What quantity of radium must we employ? In Figure 9 there is no curve for rectangular applicators of the proportions of the one used in this example. However we can obtain the value of δ by interpolation. We note that the given applicator is bigger than a square 4×4 cm. and smaller than a rectangle 4×6 cm. From the curves of Figure 9, corresponding to a distance of $\frac{3}{4}$ or 0.75 a, δ is 0.77 for the square and 0.72 for the 4×6 cm. rectangle. Therefore, to a sufficiently close approximation the value for the 4×5 cm. rectangle is 0.75. The value of α is as before 0.0090. Hence from equation (8)

$$\text{mg.} \times 4 = 1.59 \frac{(3)^2}{0.75 \times 0.0090} = 2{,}100 \text{ or mgm.} = 525.$$

The applicator of this example is the same as the first one in Table V, for which the mgm.-hour dose, empirically determined, is 2,000. The discrepancy between this and the calculated dose, 2,100 mgm.-hours, is small, and is due to the fact that the value of q in the equation is an average value, and not the one which we obtained for this applicator.

Example 4. If in Example 1, the filter had been 1 mm. of brass and 2.4 mm. of rubber, what dose would have been given? On account of the length of the present paper, applicator curves for filters other than 2 mm. of brass are not included. By referring to a previous publication[8] we find that we have curves for 0.75 mm. of brass filter, but not for 1 mm. To determine the value of δ we must have recourse to interpolation. From Example 1 we know that $\delta = 0.63$ for 2 mm. of brass. From the 0.75 mm. curves we find that $\delta = 0.55$. Referring to the biological absorption curve, we find that the "effective" radiation values are 0.0157, 0.0119, and 0.0090. Hence, as a filter, 1 mm. of brass stands practically midway between 0.75 and 2 mm. Then, if we take the arithmetical average of the two values of δ we obtain a value which is sufficiently accurate for our purposes, $\frac{0.55 + 0.63}{2} = 0.59$. The value of α (Table VI) for this filter is 0.0119. Therefore,

Skin dose =

$$0.63 \times \frac{100 \times 5}{(2)^2} \times 0.59 \times 0.0119 = 0.55$$

This paper as originally written, included an equation for x-ray skin doses similar to equation (7). It is not given here for two reasons: The paper is already too long, and we hope to make the equation of more general applicability. That is, the equation was applicable only to the 10-in. machines then in general use for deep therapy. Now that higher voltages are being employed, it is desirable to modify the equation so as to include these voltages. This will be done as soon as we have obtained sufficient clinical experience with the new machine. Also, a complete report of the skin tests will be made later by one of us. The results given here are only those needed for the development of equation (7).

SUMMARY

I. The problem of *filtration*, for both roentgen and radium rays, is discussed, and conclusions are reached based on experimental evidence. The criterion for correct filtration is the exponential absorption of the radiation by tissue. Therefore, raw beef muscle, which has essentially the same absorbing power as human tissue, was used to test the quality of variously filtered radiation.

1. (a) For x-rays, filtration increases the average penetration of the radiation steadily.

(b) For x-rays produced by 140,000 volts (crest) a change of filter from 4 mm. of aluminum to 1 mm. of brass makes the radiation nearly twice as penetrating and increases the time of exposure $3\frac{1}{2}$ times, other conditions remaining the same. A table is given showing the quality of the radiation for intermediate filters.

(c) "Equivalent" thicknesses of brass and aluminum are given for different degrees of filtration. From these we see that brass is the better material to use as filters for x-rays. Brass, zinc, and copper have the same absorbing power, and can be used interchangeably.

2. (a) For radium rays filtration increases the penetration, but, beyond a small initial filter, much less rapidly than in the case of x-rays.

(b) The amount of radiation coming through the filter decreases considerably with thickness of filter.

(c) From (a) and (b) we conclude that in practice it is not advantageous to push the primary filtration beyond 1.5 or 2 mm. of brass. An additional filter of low atomic weight must be used to remove the soft secondary radiation.

3. For deep therapy the radiation should be absorbed exponentially by tissue and should be as penetrating as possible.

II. The question of erythema doses is discussed.

(*a*) It is shown that we can use skin erythema as a biological *indicator* with considerable accuracy.

(*b*) Making use of this fact, skin tests on many patients were made, from which a "biological" absorption curve for brass and rubber filters was determined.

(*c*) The results of the skin tests enable us to define a unit erythema dose *objectively* in terms of the physical factors of the skin tests.

(*d*) Comparing the "biological" absorption curve with an ionization absorption curve, we find that there is no parallelism between ordinary ionization measurements and erythema effects when radiation changes from a preponderance of beta rays to gamma rays.

III. The problem of *distance* in radiation therapy is considered in detail.

1. (*a*) A general curve is given from which the most advantageous practical distance of application can be obtained for any depth of tumor. This can be used for either *x*-rays or radium when the applicator can be considered a point source.

(*b*) It is shown that the distance of application should be considered with respect to the depth of the tumor. When the distance is 19 times the tumor depth, the amount of radiation reaching the tumor is 90 per cent of the amount falling on the skin, due *solely* to the "*dispersion*" of the radiation. For a tumor 10 cm. deep this would place the source at a distance of 190 cm. from the skin, which is, of course, impractical. If we are satisfied with a ratio of 80, the source may be placed at 8.5 times the tumor depth. This question must be decided by each individual worker.

2. On account of the scarcity of the element, radium applicators are never placed at the most advantageous distance from the skin. Here, reliance is placed on the greater penetration of gamma rays to obtain a favorable ratio between the skin and deep doses.

3. (*a*) General curves are given for tubular, circular, square, and rectangular applicators having a filter of 2 mm. of brass and 2.4 mm. of rubber. From these we can determine the relative amounts of radiation at different distances from a gamma ray applicator of any size. Similar sets of curves for thinner applicators are given in a previous paper.

(*b*) In the calculations for these curves, use was made of the biological absorption curve. This made it possible to determine the curves for lighter filtration than 2 mm. of brass.

(*c*) From these curves we conclude that when the applicator is placed at 3 or more times its linear dimension from the skin, for practical purposes it may be considered to be a point source, as far as the axial radiation is concerned. The curves give the variation from a point source for any distance.

(*d*) The advantage of a distributed source over a point source for deep radium therapy is brought out.

IV. The problems of *skin doses* is discussed in detail, and equations of general applicability are given.

1. (*a*) For radium rays the equation is

$$\text{Skin dose} = q \times \frac{(\text{mc.}) \times (\text{hours})}{(\text{cm.})^2} \times \delta \times \alpha$$

where q is a factor of proportionality depending on the unit of dose adopted. δ is the distribution factor, values of which, for different gamma ray applicators may be obtained from the curves of Figure 9. α is the absorption factor, values of which may be obtained from the biological curve of Figure 4.

(*b*) The value of q corresponding to the unit of skin dose adopted, that is, a slight erythema, is 0.63. The equation then becomes

$$\text{Skin dose} = 0.63 \times \frac{(\text{mc.}) \times (\text{hours})}{(\text{cm.})^2} \times \delta \times \alpha$$

and can be used to determine the skin dose under different conditions of application.

(*c*) If a different unit of skin dose is adopted, a new value for q must be obtained to conform with it. This can easily be calculated as indicated in the paper.

2. (*a*) The accuracy of the general equation worked out in this paper is shown by

the close agreement of the values of q among themselves. These were determined from widely different physical conditions of treatment, independently of any curves or tables given in this paper. The doses were determined empirically by clinicians, and are based on their experience in treating a large number of patients.

V. In the work presented in this paper it has been the rule not to draw conclusions from *physical* experiments unless they were substantiated by clinical experience. The necessity for this precaution is brought out by the data of Table VI.

In conclusion we wish to express our indebtedness to the staff of the Memorial Hospital for their kind cooperation in this work, and to Mr. James Sarros for his assistance in making some of the calculations and curves of this paper.

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THE EFFECTS OF ROENTGEN RAYS AND RADIOACTIVE SUBSTANCES ON LIVING CELLS AND TISSUES*

BY LEO LOEB, M.D.

From the Department of Comparative Pathology, Washington University
ST. LOUIS, MISSOURI

THE following is a summary of the more important effects of roentgen rays and radioactive substances on living matter: 1. There are intrinsic sources of radioactivity within the body. Zwaardemaker especially draws attention to the fact that potassium, an important constituent of the body, sends out penetrating beta rays and gamma rays. He believes that potassium in the body fluid exercises its functions by means of its radioactivity,—an opinion which has not remained uncontroverted, and which recent studies have made improbable.

Lazarus-Barlow has shown that in certain individuals, especially in a number of those affected by cancer, there is a residue of radium emanation. It is present not only in the cancer itself, but may be found even in other tissues of such individuals.

2. If we compare the action of radiation on a great variety of isolated cells, tissues and whole organisms, we may discern the factors which determine the degree of sensitiveness of living matter to radiation. They are in the main as follows:

(*a*) Actively dividing cells are considerably more sensitive than resting cells and tissues. (*b*) Cells or tissues consisting of simple protoplasmic material in which a nucleus is embedded are much more sensitive than cells which are embedded in a large amount of transformed cell protoplasm, or in products of cell secretion, fibers and paraplastic material in general. (*c*) Especially resistant are entirely resting cells or tissues, especially if they have been dehydrated. (*d*) Tissues which are generally more resistant to all kinds of injury are likewise usually more resistant to radiation. In some cases, active division of cells may be the expression of great vigor; and in these cases cells which tend to divide actively may be more resistant than the same kind of cells in a less active condition; for the same reason cells with a simpler structure may be more resistant than more differentiated cells of a related

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character. There may be, in addition, a species difference in the sensitiveness of analogous tissues, which may be quite considerable.

3. Radiation affects cytoplasm as well as nucleus. But interference with the nucleus is usually of much greater significance for the functioning of the cell than localized changes in the cytoplasm. The lesion of the nucleus becomes apparent in its consequences very much more readily. The nucleus is a more delicate reagent. In addition, it may be that weaker intensities of radiation may solely affect the nucleus. Again, there exist differences between different kinds of cells in the comparative readiness with which cytoplasm and nucleus are affected.

4. There is a graded series of effects of radiation on cell functioning. The most delicate and intricate functions are affected by the smallest quantity of radiation. The coarser functions require larger doses. If we begin with the most delicate function, we can arrange the functions in the order of their sensitiveness as follows:

(*a*) A transmission of species differentials and of hereditary factors in general. These depend upon the proper functioning of the chromosomes. During mitosis cells are especially sensitive, and more particularly during the metaphase of mitotic division. (*b*) Processes of differentiation and growth of the most delicate and most differentiated organs like eye and brain. (*c*) Processes of differentiation and growth of the more simple and basic organs and tissues. (*d*) Motor activity of cells (ameboid, ciliary movements, movements of spermatozoa). (*e*) Oxydation processes as expressed in CO_2 production. (*f*) The visible structure and life.

5. According to the intensity of the radiation we may further grade the action of the rays. Weak intensities may stimulate motility, excitability of nerves and metabolism; greater intensities may weaken or destroy them. The same holds good in the case of growth processes.

Growth processes, especially, lend themselves to further differentiations of the actions of radiation. In some cases a period of stimulation of growth is followed by a period of depression and death. In these cases more severe injuries become apparent after a preceding latent period. Again, a first period of retardation in growth may be followed by a subsequent acceleration. The accelerating effect becomes apparent after early injurious consequences have disappeared, or after substances produced through radiation have become sufficiently diluted to act as a stimulant.

A further gradation is possible of the weakening or inhibiting effects of radiation on growth. All degrees of retardation of growth are possible. Conditions intermediate between cell death and full growth vigor may be maintained for some time, but usually this condition of intermediate growth energy represents an unstable equilibrium which tends to pass either into full vigor, when after a temporary depression the tissue regains its full growth, or into cell death and, in the case of tumors, into absorption. In the case of the cancers, transplantation into a new host is specially liable to stimulate the regaining of full growth vigor after a temporary depression. It is, however, probable that under special conditions, which are unfavorable to the vigorous activity of cells, without being destructive, cells may remain in an intermediate stationary condition for considerable periods of time.

6. These graded effects on growth are not peculiar to the action of roentgen rays and of alpha, beta and gamma rays, but are very similar to the effect which we had previously found in tumor cells, exposed *in vitro* to the action of heat, and subsequently transplanted into living animals.

7. The intensity of radiation which is required for these graded effects varies with the sensitiveness of the cells and tissues upon which it acts. The doses are much smaller in the case of sensitive tissues. A dose stimulating a sensitive tissue may be without effect in the case of a more resistant tissue. A dose which is stimulating in the case of a more resistant tissue may already be inhibiting in the case of a more sensitive tissue.

8. A summation may take place between the effects of radiation and of unfavorable factors within the cell. This summation

may convert an otherwise stimulating dose into a depressing one, or it may convert an otherwise depressing dose into a destructive one. A summation may also occur between the effects of radiation and experimentally produced injuries of a different kind, like those produced through heat (Bovie, Rohdenburg and Prime).

9. In the case of certain effects of radiation, a latent period separates the time of application of the rays and that of the appearance of the first manifest consequences—stimulation or depression. The duration of the latent period varies approximately inversely with the intensity of radiation. A latent period may be absent, in case the intensity of radiation used is very great. It may be lacking in the case of certain cell functions, production of CO_2, motor activity and even cell division. The latent period depends either on the fact that during embryonic development the most delicate adjustments appear last in the developing organism and that with a weak intensity of radiation only the most delicate mechanisms are affected; or it depends upon the occurrence of what we would call "chain reactions," one injurious change being the cause of a succeeding injury of a different character; gradually the total effects of these injuries may become very severe.

10. The effect of the various kinds of rays does not differ in a way corresponding with their fundamental physical differences. The positively charged alpha particles do not have an effect diametrically opposed to the negatively charged beta particles; but essentially the difference between the effects of various rays is of a quantitative nature; in the case of all of them, relatively small doses may stimulate, while large doses injure. The character of stimulation and injury depends on the character of the living system which they affect more than on the character of the rays. Alpha rays have the most severe effects and may cause structural changes in cells kept *in vitro*, when beta and gamma rays would not produce such changes. Beta rays may cause directly a localized necrosis of the brain, whereas gamma rays merely produce lesions of the blood-vessels and hemorrhage (Bagg). But these are essentially differences of a quantitative nature; in principle the effects of these radiations on living matter are the same. There is reason for assuming that only those particles or rays are effective which are held back within the cell.

11. There are indications that through repeated radiations an immunization of tissues against the effect of radiation can take place. This has been especially observed in radiation in the case of tumors and leukemia. It may depend on the formation of new cell races more resistant than the old ones; a formerly depressing dose may thus become a stimulating one if acting on a more resistant cell or tissue. This immunity is presumably an acquired cell immunity; but the problem needs further investigation.

12. All we have said so far about tissues in general applies equally in the case of cancers, with the additional statement that cancers are especially vulnerable for several reasons: (*a*) Cancer cells are dividing rapidly. (*b*) They are often dividing rapidly under abnormal conditions, as demonstrated by irregularities in the cell divisions and irregularities in arrangement and character of cells. This is probably due to the presence of unfavorable conditions, as for instance, an inadequate relation between vascularization and expansion of the tumor, or to the presence of a growth stimulus which is overactive, if measured by the metabolic function of the cells. (*c*) The rapid cell multiplication prevents or retards the production of paraplastic structures in the tumor which tend to protect the cells, and to make them less sensitive. In the case of cancers a summation of internal unfavorable factors and of the effects of radiation takes place, and thus makes them more vulnerable than normal tissues. Those parts of the tumor in which the conditions are most unfavorable, namely, the central ones, usually succumb first. Otherwise we find parallel differences in the resistance of various kinds of tumors and of the normal tissues from which they developed. Thus lymphocytes are very sensitive to radiation; correspondingly, lymphosarcoma is relatively vulnerable. The simple basocellular carcinomata are

more sensitive than the more differentiated keratinizing squamous cell carcinoma. The fibrosarcoma which is richer in paraplastic structures is more resistant than the round cell sarcoma which is poor in fibrillar substance.

In addition, there is probably in the case of cancers the same factor of a specific resistance involved which we noticed in the case of normal cells and tissue, and which to some extent may counteract otherwise unfavorable conditions, like active cell division.

There are indications that in the case of tumors also the lesion of the nucleus plays a prominent part in the destruction of the cell. Morphologically, swelling of nucleus and cytoplasm and vacuolization of the latter are the most prominent changes following radiation (Ewing, Alter). This is succeeded by destruction of the cells. Lesser degrees of injury in more resistant tumors may lead to an acceleration of keratinization and to the production of relatively inactive cystic or gland-like formations (Alter).

13. The effect of radiation on tumors is primarily a direct one, acting on the tumor cells themselves. Only secondarily do the ingrowth of connective tissue and increased fibrosis come into play. But it is very probable that while in the case of normal, vigorously growing tumor cells the influence of the host connective tissue is not sufficiently strong to hold effectively in bounds the cancerous tissue, it might be able to do so, at least for a longer or shorter period, if the tumor had previously been weakened in growth energy. Under these unfavorable conditions the tumor cells might ultimately die, or their recovery might be retarded. In experiments in which the transplantable tumors were used in testing the effects of radiation, the transplantation itself acted as a stimulus which would be lacking in spontaneous tumors in man. The effect of radiation on tumors is in many respects similar to the effect of heat on tumors. We have observed that a tumor whose growth energy has been experimentally diminished through heating, may regain its full growth energy after transplantation. The same may take place in the case of radiation (F. C. Wood).

Possibly lymphocytes may contribute to a certain extent to the injury of the radiated tumors. However, in the case of tissues belonging to the same individual,—and spontaneous tumors are of such a character,—lymphocytes are usually not attracted. But it may be that if for any reason tumor cells have been injured and changed in their metabolism, they may in some respects behave like strange tissues of another individual and attract lymphocytes. However, exact investigations on this point are, as yet, lacking.

14. There exist certain other indirect effects of radiation which may have to be considered in estimating the influence of radiation on tumors. Murphy has shown that it is possible to increase the number of lymphocytes in animals through a small dose of soft roentgen rays. He showed, furthermore, that the immunity against tumors may be increased with an increase in the number of lymphocytes and diminished with a decrease in the number of these cells. It must, however, be stated that these effects may perhaps be very weak or absent in certain cases, and that they were not noticeable in the experiments of Prime. Murphy also showed that radiation of a tissue with soft roentgen rays increases the number of lymphocytes in this tissue and *pari passu* makes it unsuitable for transplantation of tumors. However, we must hesitate to apply directly these results to radiation of human tumors. In the case of the latter we have to deal with well-established autochthonous tissues of the same character as the tissues among which they live, while in the former we have to deal with transplanted tumors. Now during the first phase following transplantation the tumors are much more accessible to injurious influences than later, when they are well established. Furthermore, in most cases we have to deal in these experiments with strange tumors which originated in a strange organism. Our investigations have shown that the degree of relationship between host and transplant is the deciding factor in the destructive activity which the lymphocytes may bring to bear on the tissue. Their activity is almost nil, if the transplanted tissues are identical in origin with the lymphocytic tissue of the host.

In the case of a spontaneous tumor, lymphocytes would, therefore, not be very active. It is, of course, possible that here also radiation, either of the affected individual or of the tumor, might somewhat change the relationship between tumor and host, and this may perhaps explain why Murphy found a certain immunizing effect of radiation even in the case of autotransplantation of spontaneous tumors. However, as stated, we are not aware of a noticeable effect of an experimentally produced increase in lymphocytes on a spontaneous, not transplanted, tumor.

We cannot, therefore, apply these experiments, interesting as they are in themselves, to the effect of radiation on spontaneous human tumors; or at least we must make certain reservations which limit their applicability. Nevertheless it is possible that even in spontaneous tumors lymphocytes may play a seondary part in injuring the radiated cells.

15. In appraising the effects of radiation on tumors we must, therefore, take into account the indirect effects of radiation which depend upon reactions of the host tissue against the tumor, as well as the direct effects on the tumor cells; among the former the connective tissue reactions are probably of the greatest importance. Lymphocytes may play a certain rôle.

It is furthermore, possible, that as the result of radiation, the body fluids may be modified in such a way that growth processes are affected thereby. Thus it has been observed that states of cachexia or intoxication following radiation may influence unfavorably the means of defense of a rayed individual against tumor growth. Murphy showed in a mouse the development in the blood of a substance which favors the growth of lymphocytes following the application of a small dose of soft roentgen rays.

Radiation of pieces of tumor *in vitro*, with subsequent transplantation of the radiated piece into the living animal, may differ from radiation in the living organism in several respects: (*a*) Radiation of the surrounding tissue and even of the more distant organs may exert a certain effect which is lacking *in vitro*. (*b*) The radiated piece of tumor is less active during the time of radiation *in vitro*, where the conditions of oxydation and nourishment are less favorable than *in vivo*. A diminution in the activities may possibly diminish the sensitiveness of the tumor cells to radiation. (*c*) Transplantation practised in these experiments may have a certain stimulating effect on tumor growth. (*d*) Radiation *in vitro* eliminates the action of the scattered rays which may surpass in intensity the direct rays.

16. The toxemia following radiation with a large dose of penetrating rays likewise represents an indirect effect. It has been interpreted as due to the autolytic solution of tissues under the influence of radiation (Edsall and Pemberton). Recently Hall and Whipple pointed out a similarity between the radiation-toxemia and the intoxication after parenteral ingestion of proteoses. These authors identify these two processes; as the result of the application of a large dose of penetrating roentgen rays they found intestinal changes which they hold responsible for the proteosis intoxication. However, in the roentgen-ray intoxication the coagulation of the blood is apparently accelerated, while in proteosis intoxication it is markedly delayed. These two processes are therefore in all probability not identical with each other.

17. Long-continued stimulating action of roentgen rays (and probably also of radium) on previously normal tissues may convert these tissues into cancerous tissue, carcinoma or sarcoma. This transformation represents, in all probability, another instance of the stimulating effect of radiation on the growth processes in tissues. It is as yet doubtful how much non-specific stimuli of a regenerative character are concerned in it. It is furthermore possible that an active immunization of the cells against radiation may convert otherwise injurious rays into stimulating ones, and thus contribute to the cancerous transformation.

THE PRESENT FIELD FOR THE USE OF THE X-RAYS AND RADIUM IN THE TREATMENT OF MALIGNANT NEOPLASMS*

BY WILLIAM S. STONE, M.D.

Clinical Director, Memorial Hospital

NEW YORK CITY

ROENTGEN rays and radium in the treatment of malignant neoplasms are still accepted reluctantly by the surgeon, except as palliative agents in the advanced stages of the disease. Their application before the patient is in an incurable stage appears to be an insufficiently tested method. In the case of *x*-rays, it is particularly so, for, before the recent advent of the high voltage machine, *x*-ray therapy had become so overshadowed by the results of radium that it had lost somewhat of its early reputation.

It seems, therefore, to be an opportune time to review this work, as it has been presented to the writer during a service of seven years at the Memorial Hospital. During this period more than 10,000 cases of neoplastic disease have been under his observation, to the majority of which *x*-rays or radium has been applied. We feel that we have now arrived at a position in this work from which we may discuss *the surviving old, the established new,* and *the still experimental.*

As to the *surviving old,* the operation no longer maintains its former position of being the only method of treating cancer in the curable stage. It is no longer in many fields the method of choice. There still remain, however, numerous fields in which our enthusiasm for the physical agents must not allow the postponement of the operation to lessen or take away its chances of success. In all the well-advanced cases, and in those designated as being in the borderland of operability, in which formerly a radical operation was attended by a high primary mortality and a low percentage of cures, the surgeon's responsibility is not fulfilled until all the aid has been enlisted which *x*-rays and radium can supply. In fact, there are few, if any, early cases of malignant neoplasm, in which these agents do not merit consideration, if only as an adjunct to the operation. In other words, the surgeon's position as a technician has been made easier, but from the viewpoint of diagnosis and proper selection of cases, his responsibility has become greater. Even in diagnosis, the therapeutic test of irradiation will often render an exploratory operation unnecessary. Instead, therefore, of being supplanted by these agents, the field of applicability of the operation has been limited strictly to the earliest stages, by which, also, we may hope to define more accurately its curative value.

Of the *established new,* we now have numerous facts relating to the conditions upon which the effects of irradiation depend. While the early observations have been confirmed, that tumor cells, in general, respond more promptly to the action of the *x*-ray and radium than the normal tissues, such wide variations are shown among the different types of tumors, even between tumors of the same type in different parts of the body, that we can hardly appreciate the basis for speaking of a carcinoma or a sarcoma dose. Just as wide variations also occur among the sarcomas as among the carcinomas.

The effects of irradiation depend upon the size, extent and condition of the tumor. The size, however, is of less importance than with the operation, some of the bulkiest of abdominal tumors, for example, disappearing within a few weeks. The extent of the tumor is also of less importance, but an extension to a neighboring bone, unless the tumor is of the most responsive type, will seriously interfere with the result.

The condition of the tumor and its neighboring tissues, next to its type, determines the success or failure of irradiation more than any other factor. Infected tumors respond unfavorably, and a syphi-

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litic base, in a lesion of the tongue, for example, invariably hinders the progress of the regression. A tumor also with altered nutrition, in which the general condition of the patient may still be apparently good, may soon become so necrotic from the irradiation that the terminal period of the disease is prematurely initiated. The fear of toxicity, however, from the absorption after irradiation of the products of disintegration in a normally nourished tumor has been, I believe, somewhat exaggerated in the literature. Fibrosis resulting from an operation or a previous irradiation makes a tumor less responsive. The greater effects of these agents upon tumors and normal tissues which have not been previously irradiated is universally accepted by all observers. The existence of normal neighboring tissues and their preservation by the avoidance of overdosage constitute an important factor in the process of cure. The killing of the cancer cell is only one of the essentials, to which must be added a proper amount of inflammatory reaction on the part of the stroma of the tumor and normal tissues. For this reason, also, a poor condition of the general health, altering the nutrition of the tissues about the tumor, makes conditions which are unfavorable for regression of the tumor.

The general health of the patient must be considered, also, because of the toxemia which necessarily results from the application of these agents—a subject which deserves more consideration, especially in the case of elderly people, than it has hitherto received. The effect of these agents upon the blood must also demand our attention. It is not improbable that the cell count may become an aid in determining the intervals between treatments. In observing the general condition of the health, it is necessary to distinguish between a condition resulting from hemorrhage or toxicity from a necrotic tumor, and the cachexia from the generalization of the growth. In the latter condition, any treatment is contraindicated, but in the other conditions a stoppage of the hemorrhage or the removal of a necrotic focus may enable irradiation subsequently to produce satisfactory results.

Much confusion exists regarding the relative merits of *x*-rays and radium, but so far as we are able to judge clinically, the effects of *x*-rays and the gamma rays of radium are the same. With a supply of 4 gm. of radium, however, we have been able to obtain more marked effects upon deeply situated tumors than we have from the use of the *x*-ray machines delivering not over 100,000 volts. The effects of each depend upon the power of absorption the tissues possess for rays of certain wave-length. Some of the gamma rays, we know, are of such short wave-length that they penetrate the tissues without being absorbed, and without, therefore, producing therapeutic effects. We hope, then, to obtain from the transformer producing a higher voltage a quantity of *x*-rays of sufficiently short wave-length to make this agent an efficient substitute for radium in cases in which deep effects are required. It will be an error, however, to undervalue the therapeutic effects that have already been obtained by the use of the lower voltage machines. Numerous cases do not require rays of shorter wave-length than these can produce, and with a technique in which distance, filtration and time are increased materially, we await improved results with the old machines.

A review of the material from which these general facts were obtained enables us to present numerous clinical fields in which, although the response to irradiation varies widely, the results indicate that *x*-rays and radium have a specific field of applicability.

Lymphosarcoma, metastatic teratoid tumors of the testicle, certain embryonal tumors of the kidney in children and a type of bone sarcoma recently described by Ewing as endothelial myeloma, represent types of neoplasm which promptly respond either to the gamma rays of radium or *x*-rays after a single application. The unfortunate results of biopsy or operation in lymphosarcoma may be avoided by the therapeutic test in cases of a doubtful nature. The metastatic teratoid tumors of the testicle are even more responsive than lymphosarcoma, but we are not yet prepared to offer definite conclusions regarding the treatment of the primary tumor. For the present, we think it should be excised after a preliminary irradiation. We have observed only a few embryonal kidney tumors in children, but in each case the regression has been favorable. The endothelial myeloma may be best discussed with the other bone tumors, but the response to irradiation is so similar to lymphosarcoma that they are included in this group.

There are other tumors in which the response to these agents is often prompt, but the results vary. *Mixed tumors* of the *parotid*, depending upon their individual structure, vary widely, but on account of the nerve palsy and deformity that so often follow the operation, a preliminary trial of irradiation should always be made.

The results in basal cell epithelioma, or rodent ulcer, discovered by the pioneers in *x*-rays to be susceptible to that agent, have been so greatly improved by radium that operation is rarely indicated. Errors in diagnosis, however, are easily made, and the condition of the growth has been so often altered by unsuitable previous treatment that it may be wise to give a guarded prognosis. In lesions near the eye, in which ectropion so invariably follows the operation, the superiority of radium is well shown.

There is a large field of ulcerating growths of the skin and mucous membranes, in which, by the additional use of the beta rays and by implantation of radium into the tumor tissues, results have been achieved in many instances beyond those that have hitherto been accomplished by the knife or cautery. In this way, during the past three years, lesions of the lip, tongue, mouth, tonsil, larynx, etc., have been brought into a group in which the operation has been supplanted, practically, by the use of radium. This use of radium, however, is taking advantage to some extent of its caustic qualities, concerning the action of which there remains much to be investigated. In all these lesions, especially of the lip and tongue, the regional invasion of the lymph-nodes presents the most difficult part of the problem, for the solution of which a judicious combination of surgery and these agents is required. For the performance of this work considerable experience in their use, and radium in a suitable form, are necessary, so that the choice of procedure may depend upon the amount of experience in the use of these agents that the patient is able to command.

In uterine cancer, radium has achieved its most brilliant success as a curative agent, especially in lesions of the cervix, in which surgery has now a very limited field, if any, of applicability. The results of surgery, however, in early lesions of the uterine body are so good that, for the present, at least, operation after a preliminary use of radium appears to be the method of choice. A most conservative statement would be that any uterine lesion requiring more than a simple hysterectomy for its cure should be treated by radium. Our experience with the *x*-ray does not justify our reliance upon this agent alone in the treatment of uterine cancer. Even in Germany, there have been only a few cases, I believe, in which radium has not been used in connection with *x*-rays.

The results in all the other growths of the mucous membranes fall short of those we have just discussed. There is little evidence of practical accomplishment in cancer of the esophagus and stomach. Our primary results in tumors of the bladder, because of the frequency of their papillary and non-infiltrating character, justify the expectation that these agents will have definite curative value. There is already no doubt of the palliative value of radium. There is also much evidence of its palliative value in cancer of the prostate, but special care is needed in the selection of cases, because the treatment temporarily adds to the patient's discomfort, and the prolongation of life must, therefore, be sufficient to justify the attempt.

Cancer of the rectum has proved a more difficult problem than our first results led us to expect. The extreme sensitiveness of the normal mucosa makes it difficult to give a sufficient dosage, and in an annular growth a permanent stricture is practically impossible to prevent. Life in such instances may be prolonged, but it is usually at the expense of suffering. In any serious effort to cure this lesion by irradiation a preliminary colostomy is necessary. Annular lesions, to be suitable for radium treatment, must be practically of the same early type in which the operation is indicated. In lesions limited to part of the circumference of the rectal wall, surface irradiation combined with the implantation of radium in the growth, and followed subsequently by excision, has produced better results than could be obtained by the operation alone. Cessation of bleeding and pain in a few advanced lesions have been accomplished by the use of the gamma rays. It may be that x-rays will accomplish much better results.

There is little need of discussing the applicability of these agents to inoperable and recurrent lesions, except to direct attention to the abuses, which the circumstances surrounding the patients in these stages of the disease so often lead us to practice. It is surprising how long an interval will elapse before a patient with a recurrence is referred to a radiologist, whereas there is the same necessity of treatment in the early stage as there is in the case of the primary growth. Neither agent is applicable for the terminal period of the disease. It too often happens that, instead of receiving morphine and good nursing care, the patient is dragged about in the forlorn hope of being helped by x-rays or radium. Both the surgeon and radiologist are responsible for these abuses. The surgeon, whose enthusiasm for the use of irradiation may only begin when he sees the opportunity of avoiding a disagreeable situation, too often emphasizes its value then, and the radiologist is able only to carry out what he knows to be a hopeless undertaking. The performance of an incomplete operation before the case is referred to a radiologist is fortunately becoming less frequent. In New York, we have seen this most frequently in the case of uterine cancer, in which the removal of the uterus materially lessens the value of irradiation. However, in the proper selection of cases, some of the most advanced growths have yielded to irradiation in a remarkable way. As with the primary tumor, success depends upon the type, size, extent and condition of the growth. Regarding metastases, the writer has been fortunate in observing favorable results following the application of the gamma rays of radium to bone metastases from mammary cancer. There appears to be more than an even chance of relieving pain, and in a few instances, the repair of the lesion, as shown in the roentgenograms, and a temporary restoration of the general health have justified our efforts.

Of the *still experimental*, it may fairly be said that all this work is experimental, because, even in the fields where much has been established there is much more awaiting both laboratory and clinical research. There are a few clinical problems, however, in which we are now especially interested.

The prophylactic use of irradiation before and after operation is, perhaps, one of the most important, and cancer of the breast, although much has already been established regarding the irradiation of this tumor in its advanced stage, presents a profitable field for the discussion of this subject. Growths of these organs vary widely in their nature and in their response to irradiation. We have observed that a few primary tumors apparently disappear after the application of x-rays and radium. A partial regression has been observed in a large number, and after repeated applications they have shrunk to an inactive lump. We have also seen tumors inoperable because of their extent and fixation become transformed into tumors that were apparently operable. As our technique has improved, and radium has been implanted in the tumor tissues, much better results have been observed, so that a few cases, in which for special reasons the operation was contraindicated, we have trusted to irradiation alone. From such observations we must conclude to make use of these agents in conjunction with the operation during the early stages of the growth.

The postoperative application is becoming a routine procedure, and it is reasonable to believe that an increased number of permanent cures will result. We do not yet know, however, how soon after the operation to begin the treatment, how often to apply it, how long it should be continued, or what dosage to apply. We have assumed that it will do no harm. Recurrences take place in spite of this treatment, and, according to the writer's experience with irradiation of Hodgkin's disease, nodes, which appear in areas that have been prophylactically irradiated do not respond as promptly as those occurring in areas that have not been previously treated. In Hodgkin's disease, also, after irradiation over long periods, injurious effects have been demonstrated at the autopsy table, on normal structures. In a case of mammary cancer, one year after operation, in which a few supraclavicular nodes had been the only evidence of the disease for several months, one application of *x*-rays to the chest wall and neck was followed in ten days by a rapidly fatal recurrence in the chest wall and pleura. While such observations do not condemn the procedure, the necessity is suggested for closer study of the effects of these agents upon normal tissues.

The pre-operative treatment of mammary cancer is much less popular, but it appears to the writer to rest upon a more scientific basis than the postoperative application. From our own observations we must believe that the injurious effects of the operation are thereby minimized. Numerous objections, however, to this procedure are offered by the surgeon, a few of which deserve our discussion. The objection that the healing of the wound is delayed, is based apparently upon a few scattered observations. On the contrary, a prominent surgeon recently stated that after irradiation he observed that wounds healed better and left a better scar. A greater liability to wound infection appears to have some basis of fact. The writer has made several observations of a peculiar erysipeloid skin infection, occurring several weeks after treatment in the presence of an open wound, which suggests a relationship to the previous irradiation. The objection that the operation is made more difficult is the one most frequently offered, but, in the case of the breast, except for a slightly increased tendency to hemorrhage, if performed too soon, it is difficult to conceive that such an objection is valid. It is most often observed in connection with the performance of a hysterectomy for uterine cancer. It is usually based in this field upon an erroneous conception of the extent of the lesion before treatment. If there has been little or no extra-uterine tumor tissue, there will be no hard tissue to cut through. If, however, as a result of the irradiation, a considerable amount of extra-uterine tumor tissue has been converted into a fibrotic scar, the operation will naturally be difficult. A correct conception, however, of the original lesion would have shown that the operation was contraindicated. The general adoption of preoperative treatment in mammary cancer will soon show, I believe, that the field of applicability of the radical operation should be much restricted. It already seems to the writer that the presence of hard, fixed nodes in the apex of the axilla makes the cases as unsuitable for a radical operation as does the presence of supraclavicular nodes. It is a question how long it will be before the *radical* operation in mammary cancer will be entirely discarded.

The use of the *x*-ray and radium in the treatment of primary bone sarcoma is in the experimental stage, but a few facts have been definitely established, and our results suggest that, with greater accuracy of diagnosis, with an improved technique, and with more frequent resort to the use of these agents prior to operative procedures, more substantial progress will be made. First, our work has confirmed the experimental results of the physical laboratory which show that the bone structures offer but little more resistance to the penetration of the rays of these agents than the soft tissues. The most substantial evidence of this is seen, in addition to the clinical improvement, in new bone production as demonstrated in the roentgenograms. As in the soft tissues, we have found that the effects depend upon the nature, size, extent and condition of the tumor. Infection and necrosis from overdosage are greater obstacles to success in bone tumors than in tumors of the soft parts. Bone tumors that responded well at first did badly after they had become infected. The type of the tumor is the most important factor.

In the malignant osteogenic tumors, which were most often of the periosteal type, our clinical results were practically negligible, except in one or two instances. In numerous cases, however, the evidence of new bone production, although often slight and temporary, in the roentgenograms showed that effects had been produced; and it leads us to hope that, by irradiating such tumors prior to amputation, the final results will prove to be better than they were when the operation was the only resource.

In the giant-cell tumors, or relatively benign giant-cell sarcoma, varying in type from those which closely resemble the osteitis fibrosa or bone cyst, to those in which their local extension and recurrence show considerably malignant qualities, our progress has been both encouraging and disappointing. Radium has been applied to the wound after curettage to prevent recurrence, and in numerous instances, the local recurrences after the operation, either by surface irradiation or by implantation into the tumor, have completely disappeared. Necrosis and infection, however, have often made the progress of repair slow, and, in a few cases, failure of the wound to heal, although the growth had been stopped, made amputation finally necessary. The results of the use of *x*-rays or the gamma rays of radium in tumors of this type, which were inoperable on account of their location, lead us to think that, with their earlier recognition by means of the clinical history and *x*-rays, this form of therapy may ultimately prove to be an efficient substitute for incision and curettage.

In the progress of this work a tumor presenting many of the features clinically of a malignant periosteal sarcoma responded primarily to irradiation by the gamma rays of radium as promptly as lymphosarcoma. A similar response occurred in several other cases of bone tumor, all of which showed the same histological features, and which Ewing has described as endothelial myeloma. Although they differ from the characteristic features of each of these tumors, histologically and clinically they resemble both. From the *x*-ray standpoint they resemble giant-cell sarcoma and myeloma, but differ from each. In the long bones they begin in the shaft. Clinically, they occur in youth, are often multiple when first observed, and in general, present the picture of a malignant tumor. They are usually described as round cell sarcoma of the bone. If, like myeloma, they have a multiple focus of origin, we may expect nothing more than a palliative result, which we obtain by the use of irradiation in that disease.

In conclusion, in addition to supplanting the operation as the method of choice in a number of fields of malignant neoplasm, the use of irradiation has so limited the field of applicability of the *radical* operation in numerous others that it is becoming a questionable procedure. In uterine cancer, it is entirely eliminated, and, in mammary cancer, it is a question of accurate diagnosis.

The use of irradiation, therefore, has made greater refinement in diagnosis necessary.

To this end, the patient's interests are best conserved by obtaining the conjoined knowledge of the surgeon and radiologist. In fact, cancer therapy has become an institutional problem requiring more clinical experience and knowledge of surgical pathology to use physical agents than does the operation.

ANTE-OPERATIVE RADIATION OF CARCINOMA OF THE BREAST*

BY RUSSELL H. BOGGS, M.D.

PITTSBURGH, PENNSYLVANIA

A SUFFICIENT number of cases of carcinoma of the breast have received ante-operative radiation with such favorable results as to justify advocating preraying of every case of cancer of the breast, regardless of the stage of the disease. By so doing, more lives will be saved and a greater amount of suffering will be obviated. The surgeon will then be operating on a breast the greater part of whose cancer tissue has been destroyed by radiation, and the remaining cells will be in a latent condition. The lymphatic channels, instead of being wide open, will be partly blocked and there will not be the same danger of metastases.

It is surprising that surgeons have not before now realized the value of ante-operative radiation, especially since the fact is well known that even in the early cases, when the axilla is free microscopically, there is a recurrence in about 20 per cent of the cases, and that when the axilla contains cancer, microscopically, only about 20 per cent are cured by surgery alone.

It is a question in cases of well-established cancer of the breast whether anything besides removal of the breast should be performed, depending upon radium and *x*-rays to cause retrogression of cancer cells in the adjacent lymphatics. After radiation, the glands in the axilla which are palpably enlarged can frequently be obliterated, and when they are removed and examined often contain very few or no cancer cells. Therefore, as a routine procedure, ante-operative radiation should be given in every case, and since such pronounced results have been obtained in advanced cases, every early case should certainly be included in the attempt to lessen the danger of metastases at operation.

In estimating the value of ante-operative raying, it is necessary to determine the structural type of cancer under treatment. The prognosis is different in schirrhus, adeno- or medullary carcinoma, and also depends on whether the growth is circumscribed or infiltrated. The stage of the disease and the extent of the metastases must be taken into consideration before we can decide whether a cure should be expected or whether palliation with retardation is all that can be hoped for. Better results will naturally be obtained when the tumor is localized in the breast than when the axillary glands contain cancer cells, and better results will be obtained in cases in which the cancer cells can be found in the axilla microscopically than when the axillary nodes are palpable. When there is a well-established cancer of the breast, with general metastases, any kind of an operation, unless it is preceded by radiation, always hastens the progress of the disease and may increase the patient's suffering.

The present operation, however perfect it may seem, always shortens the patient's life, and never affords any palliation in such advanced cases. An operation at this stage is followed, in almost every instance, by a local recurrence, edema of the arm with unbearable pain, and rapid spread of internal metastases. The patient's condition is made so much worse that there is not the same response to radium and *x*-rays as in cases which have not been operated upon. It is generally true, that recurrence and metastases do not respond as readily as primary carcinoma. In some cases, at least, an incomplete operation transforms a slowly growing carcinoma into one of much greater malignancy. During the past few years, postoperative radiation has been so popularized that the public is demanding it; and the surgeon is always willing to let the radiologist share the responsibility of the recurrence. In the past, surgeons as well as radiologists believed that, after the bulk of the cancer had been removed by operation, the

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remaining cancer cells could be eradicated by radiation; but with the increasing number of cases we treat postoperatively, the lesson taught us is that this is a difficult task even when the best technique is used in both radium and deep *x*-ray therapy. It seems safe to estimate that in over 20 per cent of the cases which are being operated upon today, cancer cells cannot be totally eradicated surgically. This alone is sufficient reason for advocating ante-operative treatment at the time when the radiation gives the most favorable results.

Groover, Christie and Merritt advocated ante-operative raying in the following words: "Personally, we are of the opinion that this large group is in a worse condition than before operation. To state the case more succinctly, we believe that for every cancer of the breast cured by surgery alone, 4 have been made definitely worse. We are rather strongly convinced that they are worse, not only from the standpoint of the patient's actual condition, but also from the standpoint of any anticipated benefit from radiotherapy. It has already been intimated that it has been our experience that recurrences of breast cancer respond much less favorably to radiotherapy than do primary growths. This is true of cancers in general, and is particularly notable in cancers of the uterine cervix. In cases referred for postoperative radiotherapy, while it is true that we are not called upon to treat a recurrence, we are called upon to treat a traumatized cancer, and the analogy is not as far-fetched as might appear at first thought."

Sittenfield[1] states: "It has been shown experimentally that radiated cancer cells do not grow on transplantation. This has been taken advantage of by the surgeons, reducing to a minimum the risk of transplanting cancer cells during the surgical removal of carcinoma of the breast."

Quick[2] concludes his paper as follows: "Finally, we wish to point out certain theoretical considerations which strongly encourage us to pursue the study of the treatment of mammary cancer by radium and *x*-rays. When one embeds radium emanation needles in a primary tumor and in invaded lymph-nodes and follows with massive *x*-ray dosage through the skin, a powerful destructive effect is produced on the tumor tissue amounting to local necrosis; the lymphatics may reasonably be considered sealed, invisible vagrant cells are incarcerated or destroyed, and all this is accomplished without removing the natural barriers which exist against progressive carcinoma. In fact, both types of radiation tend to increase the exudation of lymphocytes and plasma cells and the growth of connective tissue around the tumor, and these are the only natural agents of resistance to carcinoma that we know anything about. The treatment of mammary cancer by these physical agents is, therefore, based on sound theory, since it intensifies the natural reaction of the tissues to carcinoma, while producing in addition a very strong destructive action on the tumor cells."

Holmes[3] concludes by saying: "Recently we have had a small group of cases of carcinoma of the breast in which there was evidence of metastasis, glands being palpable in the axilla and above the clavicle. For this or other reasons they were not operated on, but were subjected to *x*-ray treatment alone. These cases have certainly done much better than similar cases operated upon and followed by radiation. I cannot but feel that the operation in some way breaks down the natural resistance of the patient, and interferes with the walling-off process which is the result of connective-tissue stimulation."

Hernaman-Johnson[4] advocates pre-operative raying, as follows: "In the opinion of many competent to judge, it has been experimentally proved that *x*-rays in suitable doses raise the immunity of the body to cancerous invasions. Radiotherapy should, therefore, be administered before operative removal. Such pre-operative treatment has the dual advantage of depressing the cancer cells locally before any surgical trauma has disturbed them, and, at the same time, increasing the general powers of resistance to any subsequent migration. In view of what Sampson Handley has shown as to the radiating growth of cancer along the lymphatics, it is obvious that local treatment should embrace a very wide area."

Pfahler[5] states: "It has been shown that thorough radiation treatment of cancer tissue will devitalize the cancer cells so as to interfere with their inoculation or further development. This justifies our recommendation of ante-operative treatment."

The work accomplished by these authorities as well as other radiologists has been the means of inducing surgeons to advise ante-operative radiation. Surgeons who have made an extensive study of carcinoma of the breast admit that even with their perfect technique, all cancer cells cannot be removed by the most thorough dissection, except in early cases. They are now looking to the radiologist for the best method of radiation, and it is incumbent upon us to advocate ante-operative radiation.

The treatment of carcinoma of the breast by imbedding radium throughout the breast and the adjacent glands, *preceded* by surface applications of radium and heavy filtered *x*-rays, makes radiation as thorough as amputation with the most careful glandular dissection. After such radiation, removal of the breast may be indicated, but a radical operation may not be necessary.

The reason for advocating radium by the method described is that early cases can be clinically cured without opening the lymphatic channels, and, if operation is indicated later, it is performed when the cancer cells are nearly all destroyed; that is, when cell proliferation is checked and only latent cancer cells are removed. In some cases, imbedding radium would at least take the place of operation, but until we have more data, it seems advisable to operate between three and eight weeks after radiation, depending upon the case. In late cases, radiation as just described is certainly superior to any form of operation primarily, and, if the breast is removed, the axilla should rarely, if ever, be opened following the radiation.

The lethal dose has created much discussion, and the radiologist's success depends upon his ability to give this dose without producing superficial ulceration or necrosis. For most types of cancer of the breast, the erythema dose is seldom the lethal dose. In my opinion the lethal dose may sometimes be from three to six times the erythema dose. This is why I imbed radium in carcinoma of the breast, in addition to giving deep therapy through the skin surface. By imbedding needles, very much more radiation can be given without serious injury to the uninvolved tissue. It is to be remembered that implantation of radium, if sufficiently deep, in no way interferes with applying full doses of deep *x*-ray over the surface. *X*-rays are always applied as thoroughly as though no radium had been imbedded.

The Germans, and a few American radiologists, believe that less than an erythema dose is a lethal or cancer dose. I am sure this is not true of all types of breast cancers. I still believe we must follow, to a certain extent, the older method of crossfiring, even with the best combination of the above factors, and give more than an erythema dose to certain glandular areas in which metastases are prone to occur, especially when radium cannot be imbedded.

No uniform technique has been established in deep *x*-ray therapy. At present it is applied by the use of a transformer, backing up a spark varying from 9 to 20 in., and the filtration employed is from 3 to 10 or 20 mm. of aluminum or its equivalent in copper or zinc. Some radiologists use only two ports of entry while others use smaller ports and crossfire as much as possible. It can be seen that the opinions of radiologists greatly differ. Some believe that as much radiation can be delivered by the use of a 9 in. back-up as by considerably higher voltage, provided sufficient length of time is employed, while others claim that there is some difference in the quality of radiation when the higher voltage is used. There is some confusion in regard to the size of the ports of entry. A deep erythema dose can be given by the 10 in. transformer, provided a sufficient length of time is employed, and, on the other hand, there is no question that the higher voltage machine has come to stay. Every one using deep *x*-ray therapy should work with a physicist and know the amount of radiation received in every centimeter of tissue beneath the skin from the anterior to the posterior surfaces.

The only practical method by which the radiologist may estimate the x-ray dosage is to determine the skin erythema with sphere gap voltage, milliampèrage, skin target distance and filtration, together with measurements of the patient. Then by tables of dosage he must decide upon the size and number of ports of entry. By increasing the size of the port of entry, the secondary and scattered radiation increase the depth dose. Many have been led to believe that they should use the largest port of entry possible in order to secure a greater ratio of secondary and scattered radiation; but this is not entirely true. In a great many instances it is much better to increase the number of ports of entry, because the radiation can thus be better directed to the glands in which metastasis has occurred. According to Friedrich, there is a greater increase in scattered and secondary radiation when the size of the port of entry is increased from 5 × 5 cm. to 10 × 10 cm. than when increasing its size from 10 × 10 cm. to 15 × 15 cm. The percentage effect of scattered and secondary rays is greater at a depth of 10 than at 5 cm. In filtering through 10 mm. of aluminum, at a depth of 10 cm. from the surface, using a 5 × 5 cm. port of entry, the depth dose is .22; by using a 10 × 10 cm. port of entry, the depth dose is .27, and by using a 15 × 15 cm. the depth dose is .31. This shows that increasing the size of the port of entry, when you calculate it in square centimeters, is much greater between 5 cm. and 10 cm. than between 10 cm. and 15 cm. Using two ports of entry, 10 × 10 cm. would include 200 sq. cm. of skin exposed to radiation. The depth effect from the two 10 × 10 cm. portals gives 2 × .27, or .54, while the depth effect from the single 15 × 15 cm. portal (225 sq. cm.) is only .31. Hence, for about the same skin area involved with two smaller portal areas (10 × 10) the depth effect is $^{54}/_{31}$ or 74 per cent greater effect than through the one larger skin portal (15 × 15). When the dosage has once been obtained, this is only true with the same x-ray apparatus working exactly under the same conditions. It cannot be transferred to other makes of apparatus by any process of arithmetic. Therefore, the dosage must be checked for different transformers.

I have not adopted the German technique of one or two large areas in the treatment of carcinoma of the breast, because there are 20 or more chains of lymphatics connected with the mammary gland. Each one should have the most efficient radiation possible. The same depth dose could not be given by one or two large ports of entry to all the lymphatic chains which are likely to metastasize as is given by the following ante-operative technique, using over 20 ports of entry, including almost the entire skin area of the whole chest. This outline of treatment is a general one, subject to modifications; but in all cases the utmost care must be taken to direct the radiation through each port of entry directly towards the main glandular junctions. The outline of my technique is as follows:

The breast is divided into four areas:

5th area, in axilla (or radium packs).

6th area, 4 in. square, above the breast, extends to the clavicle above, and on the inner side from a line drawn through the sterno-clavicular junction.

7th area, 2 to 3 in. square, to the outer side of the above area, treatment directed through the axilla.

8th area, 2 × 4 in., above the clavicle.

9th area, 4 × 4 in., over the scapular region, adjoining the supraclavicular area.

10th area, 4 × 4 in., subscapular, directed upwards through the mediastinum.

11th area, 3 × 4 in., external to scapular area directed through the axilla.

12th area, 4 × 4 in., below the above area, directed upwards through the axilla.

13th area, 4 × 4 in., internal to scapular area, directed through mediastinum.

14th area, 4 × 4 in., internal to subscapular area, directed upwards through the mediastinum.

15th area, 4 × 4 in., internal to 6th area, directed through the sternum to the mediastinum.

16th area, 4 × 4 in. below this area, diiected through the mediastinum.

The series is completed by taking areas of similar size through the opposite shoulder, axilla, supraclavicular and scapular areas, and if the tumor is situated on the inner side of the breast, the opposite breast should never be omitted. An area is given over the pit of the stomach and also through the liver, in all advanced cases.

The *x*-ray dosage I have adopted is the following: filter of 10 mm. of aluminum; 8 in. target skin distance; 5 milliampères of current; 9 in. spark back-up, and from twenty to thirty minutes' exposure. The most important factor is a constant voltage passing through the tube. This is extremely difficult to maintain and requires constant attention during the treatment. Thirty minutes are given over the breast, axillary, clavicular and supraclavicular areas, and in most instances twenty minutes is given to each of the other areas. The axilla on the affected side is usually treated by a radium pack 6×6 cm., placed at a distance of 2 cm., the radium being filtered through ½ mm. of silver and 1 mm. of brass, giving from 1,000 to 1,200 mg. hrs. Two to four weeks after the surface radiation, where cell proliferation has been checked, 10 mgm. radium needles are imbedded, placing them about 1 cm. apart, usually using 35 or more needles and giving from five to ten hours' exposure. Unless these needles are completely inserted, a necrosis on the skin will be produced. Radium so imbedded has more effect on the cancerous tissue than any form of surface application, not only because it can be placed in the center of the growth, but because the subcutaneous tissues will tolerate at least from three to five times as much as the skin without producing necrosis. Therefore, 350 mgm. of radium imbedded in 35 needles will have the same effect on the cancer cells as 1½ gm. placed on the surface.

In the *x*-ray treatment, usually from two to four ports of entry are given each day, and to include the number of fields described usually requires between one and two weeks. I have found that most patients will tolerate this amount of radiation without suffering to any great extent from radiation sickness. Besides, I believe it matters very little whether the radiation is given all in one day or within a week or ten days. At the Memorial Hospital I found that the results produced by imbedding small emanation seeds were identical with those we are producing by radium needles. The radium emanation seeds are quite active for a period of nearly two weeks, while the radium needles are left in place from five to ten hours. I believe the same holds true in giving deep *x*-ray therapy, whether the areas are all treated in one day or in a week or ten days. The *x*-ray technique mentioned above has been carried out with the 10 in. transformer. I am about to install a high voltage machine; hence, I am unable to state from personal experience how much advantage will be gained, but I feel certain it is a step in advance.

During the past two and one-half years, following the surface applications, I have been imbedding radium in the breast, in the glands leading to the axilla, in the axilla and in the glands beneath the clavicle; but the present time limit prevents going into details regarding the number of cases operated upon except to refer to the clinical results. In most of the advanced cases, the disease in the breast and in the glands has clinically retrogressed. Of course, in some cases, there still is thickening due to fibrosis from the radiation. In the inoperable cases we were usually inclined to leave well enough alone, and the early cases treated had in most instances refused operation. My advice has been, even in the advanced cases in which the disease has clinically receded, to have the breast removed after radiation without opening the axilla. In every instance in advanced cases in which the axilla was opened, the operation was harmful, because the patient would usually return with a swollen arm and in a much worse condition than before the operation. The few cases in which the breast only was removed seemed to be benefited by the operation.

In this connection, report of the following case is especially interesting:

Female, aged seventy, was referred with inoperable carcinoma of the breast. There was a mass about the size of a hen's egg in the upper third of the breast with a more or less diffuse infiltration throughout the entire breast. The skin was adherent to the mass, and there was retraction of the nipple, and marked axillary involvement, one gland being as large as a hickory nut. A thorough course of surface radiation was given, followed by implantation of 350 mg. of radium into the breast, into the glands leading to the axilla, into the axilla and beneath the clavicle. After the radiation, the growth in the upper part of the breast was reduced to a fibrous mass and the axillary glands were scarcely palpable. The breast was then enucleated by Dr. J. W. Robinson.

The following is the pathological report of Dr. DeWayne Richey, who made sections of the entire breast:

"Sections of the tissue from the breast showed vast expanses of dense, particularly acellular, pink hyaline fibrous connective tissue, scattered throughout which were eosinophiles, lymphocytes and plasma cells. At one end was a non-encapsulated mass of the epithelial tumor cells. These masses were solid in nature and were supported by heavy fibrous bands. Many of the tumor cells occurred singly, being separated from each other by the fibrous stroma. In these instances the cells were small and shrunken and the nuclei were pyknotic. The larger tumor cell masses were made up of polygonal cells with round, vesicular nuclei. Mitotic figures were not frequently observed. There were no areas of necrosis. The tumor cell masses were decidedly invasive in character. The small size of the cells and the extensive fibrosis suggested probable results of radium and *x*-ray therapy."

If the above results can be accomplished in a case so far advanced, there is obvious justification for treating all cases anteoperatively in both early and late stages.

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THE DOSAGE AND TECHNIQUE IN THE X-RAY TREATMENT OF GOITER, TUBERCULOUS GLANDS OF THE NECK, TONSILS AND ADENOIDS*

BY W. D. WITHERBEE, M.D.

NEW YORK CITY

BEFORE proceeding with the description of dosage and technique it might be interesting to note some of the more recent contributions and clinical evidence of the association of these diseases with pulmonary tuberculosis.

Van Zwaluwenburg and Grabfield have published a study of a shadow representing a thickening of the pleura over the apex of the lung and its relation to tonsillar and cervical gland tuberculosis. This shadow is said to be present in 10 per cent of all roentgen-ray examinations: occurring in 93 per cent of all cases showing tuberculous deposits in the faucial tonsils, and in 59 per cent of cervical gland tuberculosis. It is suggested that the common route of infection may lie through the tonsil and cervical lymphatics to the apical pleura and thence into the lung. This hypothesis furnishes a satisfactory explanation for the frequency of apical lesions, the preponderance of right-sided lesions, of the pathogenesis of tuberculous pleurisy with effusion and other obscure features of this infection.

Janowski found symptoms suggesting exophthalmic goiter in 17 per cent of the 3,000 cases of pulmonary tuberculosis examined. In 10 per cent the symptoms of hyperthyroidism preceded the onset of tuberculosis from a few months to two years. In another 10 per cent the tuberculous lesions in the lung had long persisted in a latent phase until the onset of excessive thyroid function, and this had evidently accelerated the pulmonary process. He therefore concludes that in every suspected case of tuberculosis the thyroid should be investigated, and, in every case of hyperthyroidism, the lungs. Many of these patients are treated for hysteria, neurasthenia, or heart disease according as one symptom predominates.

Within the last few months we have seen one case of toxic goiter follow immediately an attack of follicular tonsillitis. In this case all the cardinal symptoms were present.

Blodgett, of Philadelphia, in a recent article reports 4 cases of diabetes of the acute pancreatic form due to an infection of the pancreas following an infection of the tonsil. In one case, acute pancreatic diabetes developed twelve days after severe infection of the tonsils. The appearance of sugar and lowered carbohydrate tolerance followed each of the three attacks of sore throat until finally death occurred.

The factors used in the treatment of tonsils and adenoids are as follows:

Seven in. spark gap, 5 ma., 10 in. distance, four minutes' time, filtered through 3 mm. of aluminum. This exposure is given at two-week-intervals, the number of exposures depending entirely on the progress of the case. So far, our experience has been that the average case requires from six to eight treatments, but to say that all cases require a fixed number of treatments is about as rational as advocating a fixed number of units for all cases of diphtheria. Careful observation and examination of the throat during treatment are as essential as the factors of the technique. On account of the sensitiveness of the skin, the dosage in children should be reduced proportionately according to the age.

The position of the patient is illustrated in Figure 1, with the target of the *x*-ray tube centered just behind the angle of the jaw, and the opening in the lead-foil extending over an area 2 inches wide from just above the external auditory meatus down to the hyoid bone.

In the treatment of goiter the same factors are used with an area of exposure extending from just above the external

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., September 27–30, 1921.

auditory meatus down to the lower level of the thyroid gland and transversely to the center of the middle lobe. As in the treatment of tonsils, each side is exposed for four minutes, thus giving crossfire treatment to the gland and at the same time including the tonsils and adenoids. An number of treatments varies in these cases and is regulated by the basal metabolism determinations.

The same dosage and technique may be used in the treatment of tuberculous glands of the neck. The area of exposure includes not only the tuberculous glands but also the

Fig. 1.

examination of the throat in these cases of exophthalmic goiter almost invariably reveals chronic infection of the mucous membrane and tonsils. It is therefore essential that the infected tonsil and mucous membrane should be included in the area exposed in order to rid the patient of an infection which may be indirectly the cause of the toxic symptoms. The tonsils and adenoids, for the reason that it is more than probable that the primary focus of infection is, or was, in the tonsil. The *x*-ray effect on the follicles and crypts of the infratonsillar nodule and the follicles throughout the mucous membrane of the pharynx is similar to that produced on the tonsillar tissue, namely, atrophy due to the destruction or absorption of the immature lymphatic cells in the follicles, thus lessening the depth and distortion of the crypt and at the same time causing an eversion and evacuation of its contents. In 30 out of 36 cases, hemolytic streptococci and staphylococci were eliminated from the crypts four weeks after one massive dose of *x*-ray.

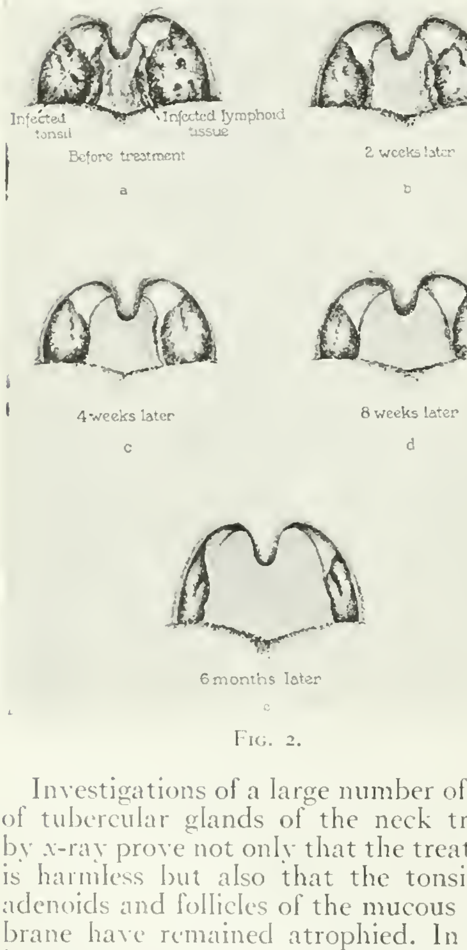

Fig. 2.

Investigations of a large number of cases of tubercular glands of the neck treated by *x*-ray prove not only that the treatment is harmless but also that the tonsil and adenoids and follicles of the mucous membrane have remained atrophied. In some instances three years have elapsed since the last *x*-ray treatment; in the more severe infections of the glands of the neck it has been necessary to give as many as forty treatments. This has been done without the slightest indication of any sign or symptom of the impairment of the functions of the normal thyroid, parathyroid, pituitary, and parotid gland. *X*-ray treatment of tubercular glands of the neck has been successfully carried out for the last ten years and a review of the literature on this subject does not, so far as I am aware, reveal a report of any case in which untoward effects have been recorded. The possibility of an *x*-ray burn is even more remote than injury to the adjacent glands, provided the technique is properly carried out.

In these chronically infected throats associated with exophthalmic goiter and tubercular glands of the neck, the infratonsillar nodule and lymphatics in the lateral and posterior walls may be markedly hypertrophied and contain numerous infected crypts. The operation of dissecting out these individual crypts after surgical removal of the tonsil and adenoids has proven inadequate is, necessarily, tedious and impractical from the standpoint of complete removal, although some cases of rheumatism have been temporarily relieved and benefited by this procedure. It is, therefore, essential in the treatment of goiter and tubercular glands of the neck that the tonsillar area be exposed, even though the adenoids and tonsils have previously been removed.

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CAPUT PUDDLING

BY ANTHONY BASSLER, M.D., AND J. RAYMOND LUTZ, M.D.

NEW YORK CITY

LITERATURE exists on cecal stasis, little of it being presented under that entity; most of it is bound up in the large subject of intestinal stasis, or that of the colon. This literature is some years old, much of it was offered by surgeons to advance surgical therapy, and but little that is worth while has come from the internists. Perhaps the best single article is that of Behan's* which draws attention to adventitious bands in connection with stasis of the cecum and chronic appendicitis, presenting the operative side of the subject.

Fig. 1. The left half of the colon and all of the transverse colon are empty of barium, puddling in the caput cecum being marked.

Fig. 2. In some cases there is some residue in the ascending colon, this being sparse and scattered (cecal stasis), but in which, nevertheless, marked puddling in the caput coli is distinct.

* Behan. Cecal stasis and its relationship to appendicitis. *Penn. M. J.*, Dec., 1920.

We desire concretely to draw attention to a form of stasis existent mainly in the caput coli, not because in the study of the cases an entity of importance can be attached to it, but because it does not always exist with so-called cecal stasis, may occur when the rest of the right colon drains practically well enough, and clinically it appears to be of more than casual roentgenological interest in symptomatic ways, although the symptoms cannot be sharply differentiated from colonic stasis in a general way.

Fig. 3. The cecum may be displaced downward well over the pelvic brim with torsion of the caput from weight of the barium. This is shown with general stasis in the colon, but puddling in the caput is distinctive.

Fig. 4. Another case in which a clysma had been given. It will be noted here that the transverse and right colon contain bismuth from the clysma, but the puddling of the barium of the day before is plainly visible (arrow pointing).

The easiest way to observe the condition is to follow the method employed at the Mayo clinic of having the patient take barium six hours before the first roentgen-ray observation, the second dose being given at that time. On the next day (thirty hours after the first dose and twenty-four hours after the second) the caput coli is observed before a clysma is given for colon study.

The suggestion is marked that this puddling occurs in the caput below the level of the ileocecal valve, and it is this limited residue collection with practically an empty colon distal to the valve that is the distinctive feature of the roentgenological diagnoses, which is the only way we know of to diagnose it accurately.

In the study of the histories of a number of such cases there are no distinctive features leading to a definite diagnosis of caput puddling. Chronic colitis is more frequent and a history of chronic digestive disturbances with its many and manifold symptoms with general body results, occurs most often. Not uncommonly there is tenderness on direct pressure over the caput with a diagnosis of chronic appendicitis having been made, sometimes with a normal appendix present, although logically it could easily become diseased from the condition, and often is. When there is no ptosis of the caput cecum and this in the erect posture is situated above the brim of the pelvis, it is our belief that the condition is significant of adventitious or embryonic bands and veils covering the lower cecum. An abnormally large cecum does not seem to give this finding, but a marked Jackson or Jonnesco membrane commonly does. On occasions, adhesions from the appendix attached to the cecum have produced the finding. In the vast majority of our cases embryonic bands and veils with thickened edges and abnormal anchorage of this section of the gut are no doubt the cause of this roentgen-ray finding.

CASE OF KÖHLER'S DISEASE

BY BENJAMIN M. BERNSTEIN, M.D.

BROOKLYN, NEW YORK

IN 1908, Köhler of Wiesbaden first described a condition affecting particularly the scaphoid bone of the feet. He also stated that there may be a coincident affection of the patella on the same side. Since then several other observers, amongst whom may be mentioned Fassett, Pfahler, McClure and others, have reported similar cases. Practically all the cases so reported, with the single exception of those in Köhler's original article, mentioned the scaphoid bone as the only one involved, leading to the condition being sometimes known as "isolated disease of the scaphoid." In view of the original description by Köhler and the findings of the case which I am here reporting, the latter designation of the disease is not quite applicable. It seems to me that we shall be obliged to adhere strictly, at least for the present, to the name "Köhler's Disease." Further findings in regard to the etiology and pathology of the condition may cause us to change our views relative to the name at some future date.

CASE I. Child, male, approximately five years of age; normal as for general inspection; no previous or family history of any consequence. Child complained of indefinite pains; sometimes in one leg, sometimes in the other, at irregular intervals, with no localization at any particular time. On examination, he had a mitral lesion; had no outward signs, swellings, or other marks which might lead one to a possible diagnosis of any disease affecting either leg. Due to the suspicion of possible tuberculous disease in the knees or hips, I was requested to radiograph him from hip-joint to foot. I found the following: neither hip-joint showed evidenee of disease; the right patella seemed rudimentary in size and form, being about one-fourth the size of the left. Both scaphoids were much smaller than they should have been at his age in comparison with the growth of the other tarsal bones. In addition, the right scaphoid showed a very definite hypercalcification. The remaining bones of both feet were of normal appearance, contour and calcium content.

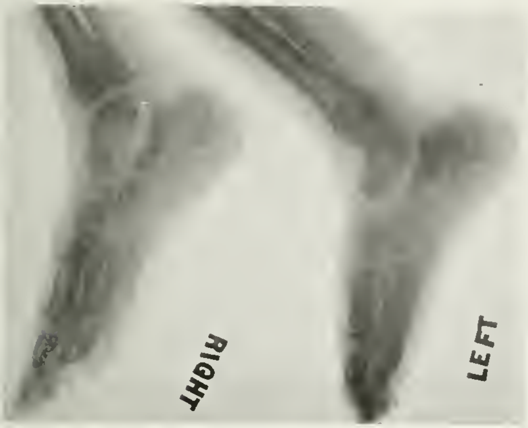

Fig. 1. Lateral view, both feet. Note hypercalcification of right scaphoid.

Fig. 2. Dorso-Plantar view, both feet.

I might also mention the fact that the child had a bilateral second degree flat foot.

Going into this child's history very thoroughly and carefully, I was unable to elicit that there had been any trauma, either direct or indirect. There was no tuberculosis or syphilis in the family. The child's brother was perfectly normal and healthy.

In Pfahler's report, he mentions the fact that one of his cases had a cardiac lesion, as has this child. He gives it as his opinion that the condition is an osteitis of traumatic or rheumatic origin. In my case, trauma can quite definitely be ruled out, as it has also been by various other observers who have reported similar cases. It seems to me that in view of the indefinite unlocalized pains, and the coincident cardiac lesion in Pfahler's, as in my case, the theory of a rheumatic etiology may well be kept in the foreground.

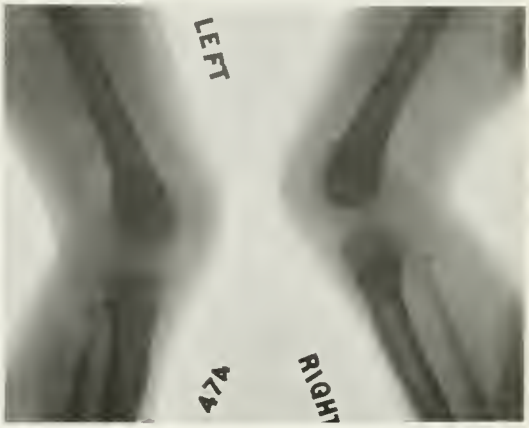

Fig. 3. Lateral view, both knees. Note rudimentary right patella.

Although the condition is a self-limited one, tending to spontaneous recovery, rest and massage with the possible administration of calcium, phosphates, and thyroid may be used as therapeutic measures. The condition is interesting because of its unusual character and manifestations, its inability of diagnosis by clinical means and its medico-legal importance in cases of injury to the foot or knee.

In conclusion, I wish to state that I have recently re-examined this child after a lapse of about six months and have found a tremendous improvement, particularly in the scaphoid, without definite therapeutic measures having been undertaken in its cure.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY
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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY
LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922
Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

PROFESSOR JOHN SANDFORD SHEARER: AN APPRECIATION

The death, on May 17, 1922, of Dr. John Sandford Shearer, Professor of Physics at Cornell University, removed from the world of science one who had gained an enviable and a well-deserved reputation, both here and abroad, by his unique work in that very important borderland between physics and medicine. His work in roentgenology, to which he devoted the last decade and a half of his life, I shall leave to others to describe. But I deem it an honor and a duty, sad though it be, to accept the invitation of the editor of this Journal, to write of the work of my friend and colleague in his connection with the Physics Department of Cornell.

Professor Shearer was born in New York City on October 20, 1865. His early years were spent in Homer, N. Y., where he taught in the Homer Academy before his entrance into Cornell University in September, 1889. He completed the four-year course leading to the degree of B. S. which degree he received in June, 1893. The degree of Ph. D. was conferred on him in 1901.

During his undergraduate work his proficiency in physics was such that, upon graduation, he was appointed assistant in the Physics Department. After one year he was promoted to an instructorship. In 1903 he was made assistant professor, and in 1910 was promoted to a professorship, which appointment he held until the time of his death. With the exception of a half-year on Sabbatic leave spent at Columbia, and something over two years in the Sanitary Corps of the U. S. Army, during the late war, first as Major and later as Lieutenant Colonel, he spent his entire career at Cornell University.

He is survived by three sons: Lee, of Argentina, South America, and Howard and Harold of Ithaca, N. Y. Mrs. Shearer, née Minnie Lee of Cuyler, N. Y., to whom he was married in 1888, died in January last, after an extended illness. The death of his wife was a blow from which he did not recover, and which, without doubt, made him less able to bear the operation that resulted in his death.

Professor Shearer's activities at Cornell naturally fall into three groups: Teaching, research and other scientific work, and administration.

His activities as teacher covered almost the entire work of the Physics Department. Shortly after his appointment as instructor, he was placed in charge of a large undergraduate laboratory course in General Physics given primarily to engineering students. Soon, however, the growth of the department demanded an additional lecturer in the elementary course. Shearer was the logical choice. To this work he devoted a very large amount of time and thought. He was particularly skilful as a demonstrator, and it is, without doubt, due to this long experience in lecturing that he acquired an unusual facility of expression and of explanation which later he used to such good advantage in presenting fundamental principles of physics to roentgenologists and to the medical profession in general.

His later work among undergraduates consisted in organizing and in giving courses in *x*-rays and general roentgenology, particularly to pre-medical students.

Among the courses, primarily for graduate students, which he offered, may be mentioned those on Geometrical and Physical Optics, and on Heat and Thermodynamics. These later gave way to advanced courses on *X*-rays and Radioactivity. He also directed a large amount of graduate research, particularly in low temperature work and later in *x*-rays.

The wide range of Professor Shearer's scientific work may be judged by the following partial list of papers:

Vibration of Tuning Forks (1893)
Behavior of Dielectrics when Subjected to High Potentials (1902)
The Heat of Vaporization of Air (1902)
Bibliography of Low Temperature Work (1902)
The Heat of Vaporization of Nitrogen (1902)
Heat of Vaporization of Oxygen, Nitrogen and Air (1903)
Coefficient of Expansion at Low Temperatures (1905)
Specific Heat of Air at Low Temperatures (1905)
The Thermal E.M.F. of the Nernst Filament (1912)
Factors Governing the Photographic Action of Roentgen Rays (1915)
Losses in High Tension Transmission (1915)
The Physical Aspect of Roentgen-Ray Measurement and Dosage (1916)
U. S. Army *X*-Ray Manual (1918)
The Physics of the Roentgen Ray (1920)
Le Tube Coolidge en Radiographie et en Radioscopie (1920)
X-Ray Dangers (1920)
X-Ray Dosage (1921)

During the decade 1905 to 1915, Professor Shearer carried a very heavy load of administrative and kindred work. It always happens, in a university, that a man who proves himself a capable organizer, a good committee worker, and a good administrator, is overloaded with such work, regardless of his value as a teacher or productive scholar. Not only was Professor Shearer very effective as a member of numerous committees of the University, of many of which he was chairman, but his advice and counsel were frequently sought in connection with the larger projects of the University, particularly where installations of new apparatus and equipment were involved. For example, in the Physics Department he planned and supervised the installation of the low-temperature equipment, and of the high-pressure storage tanks for oxygen and hydrogen. He was instrumental in perfecting and, for a long time, in supervising, the instrument shop. The entire list of appliances and conveniences which are directly due to his planning and good judgment would be a very long one.

Whatever his work, whether teaching, research, or administration, he always kept clearly in mind that one must give most careful consideration to that plan or procedure which is most expedient. In teaching, he emphasized, but not too strongly, the applications of the principles under discussion. In research, both his own and that of graduate students, he was constantly looking for the simplest, most direct method. In his work of administration he tried to evolve that plan or lay-out which would result in the greatest utility and convenience.

It was this practical turn of mind which, quite by accident, was responsible for his interest in *x*-rays. An *x*-ray outfit was suddenly and urgently needed at the University Infirmary for diagnosis of a very serious case. As no outfit then in use in Ithaca was adequate, it was decided to get one, with all possible speed. Accordingly, Professor Shearer, because of his proven ability in emergencies of this kind, was commissioned to go to New York, select an outfit, bring it back to Ithaca, and set it up for operation. He was so successful in this mission that he was given permanent charge of the outfit. And it was from this small beginning that his interest in x-rays grew.

He very early saw the importance of coordinating the physical principles of x-rays with medical practice. But he realized that if one were to enter this middle ground between physics and medicine, one must have a sufficient knowledge of the latter to get the medical point of view. Accordingly, he devoted himself to a study of anatomy and medical practice generally, so as to be able to advise with medical authorities on problems of roentgenology. One need only point to his international reputation, his war medals from the French Government, and the general esteem and respect in which he was held by the roentgenologists of the country, to appreciate the success which he made of this work, to which he gave the last and the best years of his life.

Not only have his associates lost a trusted friend and a respected colleague, and the world of science, both in physics and medicine, a tireless worker, but his death cuts off the development of many plans and projects which he had in mind, which, when completed, would have been of permanent value to applied science.

Few men have had the courage, in these days when each science is a small universe unto itself, to take up the much neglected, but highly important, middle ground work, such as is found between physics and medicine. Professor Shearer's place among his fellowmen would have been assured, had he done nothing more than point out, as by actual work he did point out, the importance of this general field, and what could be accomplished by work therein.

The following concluding paragraph extracted from the resolutions adopted by the faculty of Cornell University in appreciation of their late colleague sums up the feeling of respect in which Professor Shearer was held by the University community:

"There is reason to believe that Professor Shearer's early death was due to his exertions in war service, and that he is to be counted among those who gave their lives for the country. In him this faculty has lost a valued colleague, the community a public-spirited citizen and the sciences of physics and radiology a worker of eminence and renown."

F. K. Richtmyer,
Cornell University,
Ithaca, N. Y.

PROFESSOR JOHN S. SHEARER

He was to us a friend, a companion, a wise counselor. He was to the world a zealous, consistent, effective worker in humanity's cause.

His contribution to roentgenology was very great. It was creative, inspirational and educational. His interest in the subject was intense, and his zeal never flagging. He brought to his work in this field a firm grasp of essentials, and an eye which was always fixed on the goal. There are few, if any, who combine his understanding of the underlying physical principles with his knowledge of the art of roentgenology. In this respect, he occupied a unique position among us.

A task that he once set his hand to, he finished, and his high ideals and thoroughness show in everything that he undertook. They are seen in the development of the x-ray apparatus which was so useful to the United States Army during the Great War, and in the subsequent redesign of such apparatus, incorporating the lessons learned during active war service. The same painstaking care is seen in his still later work on an apparatus for high voltage deep therapy, which he carried out as consultant to the General Memorial Hospital of New York.

His unusual conscientiousness was shown by his work as Chairman of the Safety Committee of the Society. In this connection, he was not content with the formulation of recommendations based upon his rich past experience, but must first investigate as thoroughly as possible all reported accidents and must then try quantitative experiments to determine the exact degree of safety afforded by various schemes.

Although he had strong convictions, his attitude was invariably truly scientific. He was always willing and anxious to review a situation upon the appearance of new evidence.

His mind was exceptionally well balanced. He was progressive, in the sense that by reading and by experiment he kept abreast of scientific progress in his chosen field and was always eager to apply new knowledge to useful ends. He was, at the same time, helpfully conservative, giving frequent timely warnings against the blind following of fads and fancies, and, at the same time, pointing to other paths leading upward and onward over firm ground.

To know him was to appreciate him, and it was, therefore, only natural that roentgenologists and other members of the medical profession should individually and collectively turn to him for advice and make heavy demands upon his time and energy. He gave as freely as they asked. He was never satisfied with the selfish pleasure of knowing something, but was always eager to pass his knowledge on to others.

He was an unusually effective teacher, marshalling his facts in logical order, making his points clear by homely pertinent illustrations, and leavening the whole with a rich vein of humor.

It is hard for those familiar with the extent of his labors in roentgenology to realize that, in addition to this, he was an active teacher of general physics as well.

Through the indelible impression which he made upon the science and art of roentgenology, he will always be with us.

May his memory serve as an inspiration to others to try and devote themselves as faithfully, as unselfishly and as helpfully to the service of mankind.

May 31, 1922.

W. D. Coolidge, Ph. D.,
Research Laboratory,
General Electric Co.,
Schenectady, N. Y.

PROFESSOR SHEARER'S SERVICES TO THE ARMY

Professor Shearer was among the earliest to volunteer his services to the Medical Department of the Army at our entrance into the World War, although he was at that time long past the age when such a course would be expected.

He secured leave of absence from Cornell University, and even before he was commissioned in the Army he began instruction work in the Army School for Instruction of Roentgenologists in New York City.

He was later commissioned as Major, and continued his work in the school until the spring of 1918. During this time he organized a course for the thorough instruction of roentgenologists in the technique of roentgenology as applied to military medicine and surgery.

The work of Professor Shearer during the first year of the war contributed more than can be calculated to the success of the *x*-ray work among the sick and wounded in the American Army. He so organized the course of instruction as to make it possible to give physicians with little or no previous training a practical working knowledge of *x*-ray technique, in a comparatively short time. At the same time that he was engaged in this instruction work, he devised various types of apparatus subsequently used in our army. Among these was the Army Bedside Unit, which proved of such immense value in every type of military hospital. In addition to all this, his energy and enthusiasm enabled him to act as the constant advisor in all technical matters of the *X*-Ray Division in the Surgeon-General's Office.

When, in the spring of 1918, he was asked if he would be willing to go to France to remain as long as his services were necessary, he replied within the hour in the affirmative.

Arriving in France, he went to work with characteristic energy to assist the Red Cross in its *x*-ray and electrical problems, and soon after, was again at work for the Medical Department of the Army, establishing a general repair shop for *x*-ray apparatus in Paris. From then until the end of the war, and for eight months after its close, he remained on duty in France, supervising the repair of apparatus, and the modification of machines to suit the various types of electrical current encountered in different parts of the country, and finally making settlement with French manufacturers and the French Government for apparatus purchased from them in the early days of our activities in the war.

He returned to this country in the summer of 1919, having been promoted to the grade of Lieutenant Colonel upon special recommendation of the Chief Surgeon of the American Expeditionary Forces. The stress of his work in France had greatly impaired his health, and he never recovered his former strength and energy. In spite of this, upon the request of the Surgeon-General, he undertook to devise an Army portable apparatus based upon the experience of the World War. After more than a year of exacting work he finished this task, and produced a complete *x*-ray apparatus which was immediately adopted by the Medical Department of the Army. This apparatus was, in most essential particulars, that devised and used by our Army during the war, but it contained numerous modifications and improvements that render it much more durable, more highly efficient, and more readily portable than any *x*-ray apparatus ever before constructed for military service.

If Professor Shearer had done nothing in all his life except what he accomplished during the world war, the entire nation would owe him an eternal debt. He gave without stint or thought of reward out of his great fund of experience and knowledge.

Today those who came in close contact with him during the war not only mourn the loss of a friend, but wish to offer this little tribute of words, however inadequate, to a man whose well-poised judgment and ripe experience carried them safely through many trying experiences, and contributed incalculably to the success of the *x*-ray work in the American Army.

Arthur C. Christie, M.D.,
1621 Connecticut Ave., N.W.,
Washington, D. C.

CORRESPONDENCE

To the Editor:

On page 113 of the February issue of the Journal of Roentgenology, Dr. Levin is quoted as stating that he uses a 9 in. gap, 7 ma., 8 in. distance, time forty-five minutes, no filter, in the treatment of frogs, to determine the blood changes.

In replying to my letter of inquiry to him he states that he actually gives this treatment, and that the frogs recover in four days. The last sentence of his letter, however, states that he is using German induction coil.

I wonder if you do not see the necessity of calling attention in an editorial to the desirability of having experimenters make accurate statements with reference to technique. The facts are, of course, that Dr. Levin is not using more than a 5 in. gap, and probably not more than 4½ in.; and it is apparent to anyone that the dosages indicated in this article would kill any frog or anything else.

The vital point of this communication is that inasmuch as he has fallen down in the matter of *x*-ray dosage, or rather has failed to give a technique which is in common use, the whole experiment is well-nigh worthless.

This error is not an uncommon one, and it seems to me highly important that any statement with reference to *x*-ray technique should be so accurate and so carefully done that it could be duplicated anywhere in the world by any other investigator.

Very truly yours,
E. A. Merritt.

Washington, D. C., April 13, 1922.

To the Editor:

In his letter to you, dated April 13th last, Dr. E. A. Merritt makes a statement that what I consider to be a 9 in. gap is in reality only a 5 or 4½ in. gap. The reason for his assertion is apparently the fact that I use an induction coil instead of a step-up transformer.

Dr. Merritt seemingly is not familiar with the construction of the therapeutic coils used in Germany and England. The inverse current is reduced in them to a very small fraction, and the length of the parallel spark gap indicates at least as many kilovolts on the secondary as in a transformer. Furthermore the secondary voltage on the coil is constantly controlled by Bauer's Qualimeter, which acts very well up to a 10 in. spark gap. In accordance with Merritt's notions, the latest model of a therapeutic coil, the "Symmetrie" machine which delivers a 20 in. (50 cm.) spark gap, really gives only a 10 in. gap, or, in other words, does not give *x*-rays of any shorter wavelength than an old Snook machine. When Dr. Merritt talks of a "technique which is in common use," he does not seem to realize that on the continent of Europe and in England, for *x*-ray therapy, 10 induction coils are being used as against 1 transformer.

I fully agree with Dr. R. Knox and the majority of German clinicians, that even with a Coolidge tube the coil is superior to a transformer for therapy. My latest high voltage installation is, nevertheless, a transformer; but the reason for it is the lack of repair stations in this country for induction coils.

Now as regards the sentence in Dr. Merritt's letter, "The whole experiment is well-nigh worthless." As I have shown above, his premises are wrong. There is, however, a more important matter connected with it. In my thirty odd years of experimental work in medicine, I have never attempted to condemn another worker's results without first repeating his experiments. Roentgenologists must learn to use similar scientific methods in radiobiology and radiotherapeutics, and not use loose methods of disparaging criticisms.

Very sincerely yours,

I. Levin.

New York, May 27, 1922.

DR. EDWIN R. RASELY

We regret to announce the death of Dr. Edwin R. Rasely, which occurred at his home in Uniontown, Pa., on Wednesday, July 12th. His death was due to accidental electrocution. He was developing kodak films in his dark-room when the accident occurred. It is believed that he touched a wire with his arm, making a short circuit with the metallic sink, as evidenced by a burn at the point of contact. Dr. Rasely was one of the earlier workers in roentgenology, and was favorably known by a large cortege of friends throughout the country. His reputation in the community in which he served was not only that of a roentgenologist, but also that of a public-spirited citizen.

THE PHILADELPHIA ROENTGEN RAY SOCIETY

OFFICERS FOR 1922–23

President: F. F. Borzell, 1119 Harrison Street, Philadelphia, Pa.

Vice-President: W. C. Westcott, Pacific and Delaware Avenues, Atlantic City, N. J.

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THE NEW YORK ROENTGEN RAY SOCIETY

OFFICERS FOR 1922–23

President: Charles Eastmond, 483 Washington Avenue, Brooklyn, N. Y.

Secretary-Treasurer: Fred. M. Law, 576 Fifth Avenue, N. Y.

Executive Committee: George S. Dixon, Chairman, 218 Second Avenue, N. Y.

PACIFIC SECTION OF THE AMERICAN ROENTGEN RAY SOCIETY

At the spring meeting of the Pacific Section of The American Roentgen Ray Society, held May 18th in Yosemite National Park, the following were elected to office for the coming year:

President: M. P. Burnham, San Francisco, Calif., Vice-President: F. C. Swearingen, Pomona, Calif., Secretary: Roy A. Payne, Portland, Ore.

A CORRECTION

In the article by Frank Rieber on Standardization of the Measurement of Tube Potential, published in the June, 1922, issue of the Journal, Mr. Reiber is announced to have read his paper in January, 1922. This date should have been January, 1921.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page viii of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to Roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

TRANSLATIONS & ABSTRACTS

PINCH, A. E. HAYWARD. Annual Report London Radium Institute. (*J. Am. M. Assn.*, April 1, 1922, lxxviii, No. 13, 985.)

In the annual report of the Radium Institute, the medical superintendent, Mr. A. E. Hayward Pinch, reviews the work done since its foundation, which covers a period of rather more than ten years. He is thus able to furnish an estimate of the therapeutic value of radium based on wide experience. During the period, 7,750 patients have been dealt with and nearly 100,000 treatments administered. He divides the cases into four classes: (1) Those in which cure, either complete in the case of the non-malignant, or apparent in the case of malignant disease, may be confidently expected. This class includes chronic eczema, seborrheic eczema, lichenification, cavernous nevi, keloids, papillomas, keratomas, corns, rodent ulcer, lymphosarcoma, and sarcoma of the nasopharynx. (2) Those in which great benefit may be expected: psoriasis, xanthelasma, xeroderma pigmentosum, Fordyce's disease, leukoplakia, capillary nevi, spring catarrh, lupus erythematosus and vulgaris, tuberculosis adenitis, vicious cicatrices, Dupuytren's contraction (early), exophthalmic goiter, parenthymatous goiter, splenic and lymphatic leukocythemia, lymphadenoma, mediastinal tumors, epithelioma of the skin, cornea, vagina and urethra (female), carcinoma of the breast, uterus, bladder, prostate and thyroid, sarcoma (excluding endosteal), endothelioma, angioneurotic edema, and arthritis deformans (early infective cases). (3) Those in which the result is doubtful, some cases responding very well while similar ones fail to show any improvement: Pruritus, neuralgia, neuritis, epithelioma of tongue, mouth, fauces, larynx and esophagus, carcinoma of the stomach, intestine and rectum, myeloma, melanoma and glycosuria. (4) Those in which radium is practically useless: Dupuytren's contraction (late), kraurosis vulvæ, adenomatous goiter, osteitis deformans, acromegaly, cysts, lipomas, enchondromas, osteomas, endosteal sarcomas, syphilis, locomotor ataxia, disseminated sclerosis, pyomyelitis and paralysis agitans.

By far the greater number of patients applying to the Radium Institute suffer from malignant disease, which usually is advanced and inoperable or has recurred after operation with no possibility of further surgical interference. To use the term "cure" when discussing the radium treatment of such cases would be unwarrantable; but results have been obtained in the arrest of the progress of the disease which improve the general health and comfort to a degree that cannot be excelled, and is rarely equaled, by any known medical or surgical measures. At present the institute has records of many patients suffering from recurrent inoperable malignant disease, who first presented themselves for treatment seven or ten years ago, and who now lead useful, comparatively healthy lives, the disease having been rendered quiescent by the treatment.

With increasing experience it has been possible to augment the dosage greatly. In the early days of the institute, a dose of 3,000 mg. hours was considered large; now it is common to give from 20,000 to 30,000 mg. hours, and, if judiciously administered, this entails little systemic disturbance. Considerable advances have been made in the treatment of such conditions as carcinoma of the prostate, bladder and uterus, mediastinal tumors, splenic and lymphatic leukocythemia, lymphadenoma and tuberculous adenitis. Results are now obtained far more striking than were at first anticipated. The chief problem to be solved is the treatment of deep-seated growths to which there is no adequate approach by the natural channels; but improvements in technique are being devised from time to time which are slowly but steadily lessening the difficulty. For widespread conditions, roentgen rays are considered preferable to radium, as in generalized psoriasis, the early stages of cancer encuirasse, generalized infection of the peritoneum, and cystic disease of the ovaries. For these conditions an enormous amount of radium, mounted on numerous applicators, would be necessary to irradiate the whole area, while it can be easily done with a roentgen-ray tube. On the other hand, to give an intense dose over a small area, as in rodent ulcer, small superficial epitheliomas or recurrent nodules after excision of the breast for carcinoma, radium should be used, as by means of emanation applicators a powerful dose may be given to a very small area. In certain situations, such as the cavity of the uterus, bladder, larynx, esophagus, stomach and rectum, it is almost impossible to give an adequate dose of roentgen rays, but radium can be effectively used. Though physicists consider the gamma rays of radium analogous to the hardest cathodal rays of a roentgen-ray tube, clinical experience tends to show that there must be some difference, as frequently cases of lichenification, rodent ulcer and lupus vulgaris do not respond to roentgen rays but yield promptly to radium. James T. Case.

William H. Stewart

PRESIDENT OF THE AMERICAN ROENTGEN RAY SOCIETY
1922-1923

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THE ROENTGENOLOGICAL ASPECTS OF ACHYLIA GASTRICA*

BY A. W. CRANE, M.D.

KALAMAZOO, MICHIGAN

EVERY form of alimentary tract pathology must ultimately be considered in its relations to roentgenological signs. Gastric and duodenal ulcers which are usually associated with an increased secretion of hydrochloric acid are the most studied and the best understood roentgenologically of all gastrointestinal diseases. We have now to consider the roentgen-ray interpretation of an opposite secretory condition, namely, a total absence of free hydrochloric acid which is associated with a wide range of diseases and with signs and symptoms which may lead easily to diagnostic confusion. We shall in achylia encounter six-hour residues without gastric ulcer; or we may find vigorous, bisecting peristalsis and rapid expulsion of stomach contents without ulcer of the duodenum. The patient may complain of recurring epigastric hunger pain as in ulcer, or right hypogastric pain as in cholecystitis, or a deep vague abdominal pain as in cancer, and yet no roentgenological sign of any gastrointestinal pathology may be discoverable. Especially in achylia the complaint may be a persistent pain below the left costal margin, which is the despair of the diagnostician. A study of the laboratory analyses may thus furnish the roentgenologist with the deciding factor in the interpretation of the *x*-ray findings and prevent unduly radical conclusions from indecisive signs.

The term achylia gastrica, although originally introduced by Einhorn to mean a total absence of the gastric juice, is now commonly used in medical literature to mean a total absence of free hydrochloric acid. Barker ("Monographic Medicine," iii, 516) states that in the early stages of achylia the gastric ferments are still present. He also says that the use of the term achylia to mean the absence of free acid is growing. Many authors shun the word achylia and use achlorhydria to mean the absence of free acid. But the continued use of the term achylia gastrica indicates a real need. This term implies an organic change and constitutes a diagnosis, whereas achlorhydria implies a purely functional alteration of gastric secretion, and is never a diagnosis. Hyperacidity is an example of a functional change which may disappear under treatment with a return to the normal; but achylia gastrica once established is, with surprisingly few exceptions, a permanent condition, with organic changes in the stomach walls. In this respect it is on a par as a diagnostic concept with a valvular disease of the heart in the course of a goiter, a nephritis following a focal infection, or an arteriosclerosis resulting from luetic disease. Achylia gastrica similarly results from, or is associated with pernicious anemia, cancer, dental sepsis, gall-stones, intestinal toxemias and a number of other apparently unrelated diseases. In this paper, therefore, the term achylia gastrica is used

* Read at the Midwinter Meeting of the Central Section of The American Roentgen Ray Society, Chicago, Ill., February 22, 1922.

to mean an established chronic disease of the stomach characterized by the persistent absence of free hydrochloric acid in the stomach contents during the whole of the digestive cycle.

The material which forms the basis of this study consists of approximately 1,000 cases in which, with few exceptions, the stomach contents were obtained in 5 or 6 fractions at fifteen-minute intervals, beginning one-half hour after the Ewald test meal. These cases were examined in collaboration with my partner, Dr. John B. Jackson, and with the help of several very capable assistants. The case records contain the histories, physical examinations, laboratory analyses of the blood, urine, stomach contents and other material when available, in addition to the *x*-ray examinations, excepting in a few cases where these were considered unnecessary.

The importance of achylia to the roentgenologist lies in the following points:

1. Its frequency in gastrointestinal cases.
2. Its association with abdominal pain.
3. Its association with intestinal disturbances.
4. The difference in the interpretation of the same roentgen-ray signs according to whether or not achylia is present.

The frequency of achylia is surprising and increases rapidly with increasing age. Lockwood, in a careful analysis of 500 cases in his personal practice, found that in patients over fifty years of age 60 per cent showed achylia. He quotes Stockton as finding 37 per cent and Seidelin 40 per cent under similar conditions and criticises their figures as too low. For patients between twenty and seventy years of age Lockwood's figures show 17.4 per cent of achylia. In the 1,000 cases which comprise our own series 12.6 per cent of achylia was found for all ages. It is, therefore, an almost daily problem in gastrointestinal diagnosis.

It is, however, less frequent in our series than hyperacidity. Of our 1,000 cases, 158 showed achylia compared with 393 showing hyperacidity. Of these 393 cases, 117 showed duodenal ulcer and 25 gastric ulcer, but of the 158 cases of achylia not a single case of ulcer was diagnosticated or found later by subsequent examination, operation or autopsy. In some of the reported cases of peptic ulcer in achylia the diagnosis of achylia has been based upon a single sample of the stomach contents. This may give false conclusions, as many writers have pointed out. In our series a total absence of hydrochloric acid may be found in several of the first samples, and yet an hyperacidity develop in the final samples obtained by the Rehfuss fractional tube. Granting, however, that peptic ulcer does occur in achylia gastrica we may emphasize the conclusion that the occurrence is exceedingly rare.

The association of pain with achylia arrests attention. In all, 102 out of the 158 cases complained of pain which, in 69 cases, was abdominal. The source of this pain was often difficult to find and sometimes inexplicable. The pains of hyperacidity are, with few exceptions, attributable directly to peptic ulcer or pylorospasm; but the pain associated with achylia in our series was in no case due to either of these causes. Only in 26 cases of gastric cancer and the one of gastric syphilis was the pain due to any demonstrable condition within the stomach. In 17 cases the pain was traced to the gall-bladder, in 9 cases to the appendix and in 8 cases to pericolic adhesions. Mucous colitis was present in two cases. Spondylitis deformans, which is a possible cause of abdominal pain, was demonstrated in 11 cases, 5 of which complained of pain in the abdomen. The explanation of the pain is often questionable even when the examination is sufficiently thorough. The diversity of causes and the number of achylias without pain make it doubtful if the achylia itself is often accountable for it. The useful conclusion is, if achylia is present and gastric cancer or syphilis can be excluded, then look elsewhere than to the stomach for the cause of the pain.

The association of achylia with diarrhea has been emphasized by various authors. In our series of 158, 12 cases complained of diarrhea. Mucous colitis was present twice only. Stockton ("Oxford Medicine," iii, 240) may be quoted as follows:

"Diarrhea is often induced in achylia gastrica, in which disease the stomach frequently empties itself in a precipitate manner, and the undue peristalsis in the small intestine which follows this is carried over into the large intestine, sometimes as a true peristaltic rush, giving rise to the postprandial diarrhea with lienteric stools. For the reason that constipation occurs in a proportion of cases of achylia gastrica, the frequency with which diarrhea exists is overlooked by many writers. Dudley Roberts, in a careful study of the subject, thinks that in achylia gastrica there is usually to be found some especial reason for the occurrence of the diarrhea. It must be admitted that such special reasons do exist in cases of achylia gastrica, as in other individuals, but I must hold to the position taken that there is something in achylia gastrica which predisposes to diarrhea."

The rapid expulsion of the barium meal with intestinal hypermotility may thus find a rational explanation if the roentgenologist is enabled to interpret his *x*-ray finding in conjunction with the laboratory sheet.

The association of syphilis with achylia is seen when this disease attacks the stomach. Here syphilis and cancer are indistinguishable by clinical, laboratory or roentgen-ray methods. Exploratory laparotomy is equally helpless as a diagnostic measure. The four-plus Wassermann does not exclude cancer. The therapeutic test should, we believe, be applied in all cases which are not proven to be carcinoma by the pathological examination of material removed at operation.

When achylia is present the roentgenologist will do well to include the chest in his examination. In our series, 22 showed disease of the circulatory system and 8 revealed tuberculosis. The teeth also should be rayed in all achylias. In 25 of our series dental sepsis was recorded, but in many of the other cases the teeth had previously received attention, so that the incident of dental sepsis is not well shown in this analysis.

Weakness is a prominent symptom which was present in 45 of our cases, and in all of the 17 cases of pernicious anemia which are included in our series of achylia gastrica. A case of pernicious anemia with abdominal pain presents not infrequently a clinical picture of gastric cancer. The blood findings of cancer may sometimes show a striking similarity to those of pernicious anemia. For this reason the roentgenologist is often called upon to differentiate between these two diseases. If the achylia type of gastric peristalsis has been studied, it will very effectively confirm the absence of a filling defect, and give added assurance to the roentgenray interpretation.

Gastroptosis is frequently present with a general loss of muscular vigor. In such cases six-hour residues cannot be interpreted as evidence of gastric ulcer. Gastroenteroptosis is so frequent without symptoms in the average run of all kinds of cases that we have ceased to record them excepting in very aggravated cases, and cannot therefore give figures.

One of the most important aspects of achylia in roentgenological practice is its mimicry of the behavior of the stomach in duodenal ulcer. The duodenal and the achylia type of gastric peristalsis may often be indistinguishable. Very commonly four or five peristaltic contractions may be seen to be simultaneous. The acid control of the pylorus is of course in abeyance in achylia. This, in connection with the rapid expulsion of stomach contents and the often incomplete filling of the duodenal bulb due to the rapid passage of the barium, may appear to give the symptom-complex and the bulbar deformity of ulcer of the duodenum. It is here that the constancy of the deformity and the necessity of serial plates are most to be emphasized. But Carman and others have shown that bulbar deformity is not always necessary for the diagnosis of duodenal ulcer.

If in a given case the history of epigastric hunger pain relieved by eating is found, then a diagnosis of duodenal ulcer would seem reasonable. But in the presence of achylia gastrica, beware of such a diagnosis. If the stomach contents show a total absence of free hydrochloric acid, then the roentgenologist should never make the diagnosis of duodenal ulcer without doubly proving the persistence of a characteristic deformity of the duodenal bulb, and then excluding adhesions, pressure or reflex spasm as a cause of the deformity. In our series, as already stated, no case of gastric or duodenal ulcer was demonstrated.

Without exhausting the subject, we hope that enough has been said to show the advantage of recognizing achylia gastrica in roentgen-ray interpretations of gastrointestinal findings. Another series of cases would likely give different figures. Achylia is associated with such an extraordinary range of pathological states that only very large series of cases could give anything like uniform footings. The frequency of achylia in patients over fifty must result in the inclusion of many pathological conditions that have no necessary relation whatever with the achylia itself. We claim nothing therefore, for our figures excepting to show in a general way from personal experience the roentgenological aspects of this interesting secretory disorder of the stomach.

DISCUSSION

Dr. Murphy. I would like to ask Dr. Crane if he has ever considered achylia gastrica as the first stage of pernicious anemia, and, if he has followed his cases, how many cases of achylia gastrica so diagnosed have been found later to be pernicious anemia.

Dr. Hickey. I would like to ask if he found any difference in the observations between duodenal ulcer and achylia gastrica. He said the differentiation could be made.

Dr. Crane (closing discussion). I think that pernicious anemia is invariably associated with achylia. So far as I know there is a uniformity of opinion among authorities on that point, but that all cases of achylia gastrica ultimately become cases of pernicious anemia I am sure is not true.

Dr. Hickey's question is important for roentgenologists. I do not believe there is sufficient distinction between the hyperperistalsis seen in achylia and the hyperperistalsis seen in duodenal ulcer, so that one could base a conclusion on this point. That is one of the most disturbing features of roentgenological diagnosis of duodenal ulcer. If the roentgenologist does not know whether there is a hyperacidity or an achylia present, he is greatly hampered.

TECHNICAL AND CLINICAL ASPECTS OF THE NEW DEEP ROENTGENOTHERAPY*

BY JAMES T. CASE, M.D., F.A.C.S.

From the Surgical Department of the Battle Creek Sanitarium

BATTLE CREEK, MICHIGAN

ONCE again we find ourselves discussing the "new" roentgenotherapy! How many times those of us older in this *x*-ray work recall discussions of so-called new treatment methods! On each occasion the appellation "new" has been more or less justified by the introduction of some new phase in the technique, such as new filter material, new ideas of crossfire or multiple field irradiation, shorter target-skin distance, or increase of voltage. On this occasion we believe the term "new" is more than ever justified, for we have been equipped with a wealth of new information concerning the physical and biological factors underlying the principles of therapeutic *x*-ray applications, especially regarding the behavior of scattered radiation, which for the first time in the history of roentgenology enables us to feel the assurance of a reasonable degree of precision in dosage.

The various factors referred to have been discussed by the other speakers in this symposium. Permit a word of emphasis on the necessity of *knowing* the approximate wave-length of the rays available, of understanding the rationale of filtration, choice of size, and number of fields, and the target-skin distance from which the application is to be made. It is very encouraging to realize the vast extent of the experimental, physical and biological investigations which have been successfully and accurately carried out by Coolidge, Duane, Shearer, Bovee, Wood, Kroenig,

* Read at the Midwinter Meeting of the Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 28, 1922.

Christen, Dessauer, Friedrich, Seitz, Wintz, and especially by a group of French investigators, including Regaud, Nogier, Béclère, Ledoux-Lebard and their associates. We are further spurred on to renewed effort by the reports coming to us of the practical results secured in the clinics of Europe, especially in Germany, France, and Scandinavia. A number of us have journeyed across the sea to ascertain for ourselves whether or not these reports have been trustworthy; and we find that even though some of them are undoubtedly highly tinged with overenthusiasm, there remain enough cold facts—indisputable tangible results,—to shake the reserve of the most skeptical. Your essayist went to Germany in the fall of 1921, not entirely unacquainted with the immediate results to be obtained with the therapeutic application of *x*-rays produced at 180 to 200 kv., having been provided for nearly a year with equipment to work at this tension. He was prepared to find what he did find, namely, that the new method of deep therapy gives more constant and more pronounced immediate palliation in a larger percentage of cancer cases, and, with some, complete disappearance of signs and symptoms of the disease, concerning which more will be said later. New fields have been opened up in the treatment of a number of benign pathological states which have hitherto not been attacked.

In our discussion we will assume that all are agreed as to the rationality of employing a combination of radium and roentgen-ray therapy wherever the situation of the pathological lesion permits. In this hour's discussion we will be more especially interested in the treatment of malignancy.

SELECTION AND PREPARATION OF CASES

Selection may be made according to the pathological classification of malignancy, but in our present stage we should not stick to this. It is probably wise to exclude from this new deep therapy, at least for the present, those patients whose malignancy has progressed to the stage of advanced cachexia and utter hopelessness, with extensive metastases in bone, liver or lung. In such, the application of the massive doses involved in the new method will very likely hasten the inevitable, and will thus tend to bring unfair discredit upon the radiologist. We may well follow the plan of classifying our cancer cases as (1) early operable (2) fairly well advanced, yet operable (3) inoperable (4) hopeless.

Your essayist is not yet prepared to agree with the pronouncement of some of the German authorities (Seitz and Wintz, Opitz and others) who have abandoned entirely the operative treatment of uterine cancer, still holding with the majority that we should continue to operate distinctly operable cases, combining with our surgery such radiation treatment as may seem appropriate. In our estimation, the pre-operative treatment is of even greater importance than the postoperative, the irradiated cells being in such degree and manner influenced by the treatment that there is certainly less danger of transplantation during the surgical interference.

Just as there is apparently a favorable time for the surgical intervention, there is probably a favorable phase in the development of malignant disease in which application of a massive dose of short wave-length rays will exert a maximum beneficial influence. We must look to the workers in the biological field for selecting the time of application unless we continue to begin as early as possible.

We do, however, have an opportunity for aiding the patient by establishing a plan of preparation for the deep therapy. We look upon the administration of the complete massive dose planned for a given case, given, as we recommend, as nearly as possible in one sèance, as a procedure quite analogous to a surgical operation; and we prepare our patient just as for a major surgical procedure, this preparation involving preliminary rest in bed, attention to eliminative processes, dietary regulation, blood and urine examination, and even a blood transfusion, if it is the type of case in which such a procedure would be considered if the patient were going through a surgical operation. Plenty of fluid should be introduced by the mouth, and if necessary, by retained enemas or by intravenous injection. Lactose or glucose with alkalies may be added to the liquid with advantage.

The patient should come to the treatment room with an empty stomach. It is our custom to administer hypodermically a quarter grain dose of morphine just before starting the treatment; we thereby seem to decrease materially the tendency to nausea and vomiting, and we enable the patient to remain tranquil during the tedious and often uncomfortable treatment.

PLAN OF ATTACK

No two cases are quite alike, either in the distribution of the existing lesion or in the probable line of extension. They differ also in the position and physical dimensions of the zone to which we wish to deliver what we believe to be 10 or 20 per cent more than a definite skin erythema dose of homogeneous and widely but evenly distributed radiation. By careful examination, and by applying our knowledge of the paths along which the lesion is likely to spread, we may prepare a sort of military map and determine in advance with reasonable accuracy what percentage of a definite skin erythema dose to apply through a certain number of definitely defined ports of entry having certain dimensions.

We recognize that there are probably numerous errors in the charts prepared by Dessauer and by Holfelder; yet, in the absence of anything better, we feel that these charts present the best available means of planning our fields and the percentage of the skin erythema dose to be administered through each one. We further recognize the probable great danger in talking of a "carcinoma" or "sarcoma dose," but until we have been furnished with a better basis, we are working on the principles laid down by Seitz and Wintz.

The object of our attack is to deliver to the zone under fire approximately 120 per cent of a skin erythema dose for carcinoma, and 70 per cent of the skin dose for sarcoma, this dose to consist of homogeneous radiation equally distributed to all the pathological or suspected tissues at one sitting. There is considerable discussion as to the necessity of getting this dosage into the tissues at one séance, and as to just what is meant by one séance. In our practice, we seldom deliver the dose in one day, but more often within two or three consecutive days, with an added day for the radium application. Regaud and his associates at the Radium Institute in Paris believe it preferable to consume from four to eight days for the administration.

TECHNIQUE OF APPLICATION

In the treatment of uterine carcinoma we employ four areas of *x*-ray application in addition to the intrauterine and vaginal radium treatment. The proportion of the skin erythema dose given through each of the four portals of *x*-ray treatment depends upon the distribution of the lesion and the external measurements of the pelvis. The anterior and posterior areas are large, measuring 16 to 20 cm. square; the lateral areas are smaller. A filter of 1 mm. of copper is used, though it seems likely that less is sufficient, and permits considerable saving in time. We use a target-skin distance of 50 cm. in our pelvic work. For the treatment of breast, neck, jaw and face malignancy we hold that a target-skin distance of 75 cm. is preferable to a shorter distance. Only the question of undue prolongation of time required to administer the necessary dosage deters us from employing a still greater target-skin distance, for these relatively superficial lesions. At present, 8 ma. is the maximum our tubes are thought to be able to stand, and even this intensity keeps the target at what seems at first glance a disconcerting heat. We eagerly await the perfection of some cooling device which will permit the employment of more current, thus shortening the treatments which are no less tedious to the operator than to the patient. Under our working conditions we require 800 ma. minutes, working at 200 kv., with 8 ma. through the tube, at 50 cm. target-skin distance, with the filter and size fields above named, to produce a mild erythema on the skin of the neck; namely, immediately after the treatment a reddening of the skin, followed in about three weeks by a definite light brown discoloration, which later becomes more marked. It is generally recognized that the skin of various portions of the body differs somewhat in its sensitivity to the irradiation, the most sensitive being the skin of the neck, while the abdomen, thigh, back and face are more resistant in the order named.

In our estimation, it is important to complete the introduction of the entire dose within the shortest reasonable time, for thus does the procedure seem most nearly to approach the surgical ideal. Certainly one has little likelihood of accomplishing anything like as much toward the destruction of the disease at any subsequent attack as at the first one. This does not mean that we do not re-ray our cases; we frequently do. But if the first grand attack has not produced results within six or eight weeks, it is not likely that any subsequent offensive will prove effective. Gaylord has mentioned the period of latency which some patients seem to show before manifesting the good results of treatment, and he feels that three months should elapse before repeating a dose which really merits the term "massive."

It is only fair to describe the technique of others. The Freiburg school lays greatest stress on the single massive dose plan, employing through each of two large fields, one suprapubic and one sacral, at 50 cm. distance, a dose which in thin patients is just short of the skin erythema dose, and considerably exceeds this measurement in fat patients. Here too, radium is used internally to supplement the treatment with *x*-rays. The available statistics from the carefully worked-up material of the Freiburg Frauenklinik indicates that at least a third of the inoperable but not yet cachectic cases of uterine carcinoma are alive and symptom-free after two years.

Just as encouraging statistics are furnished from Erlangen, where an essentially different technique is employed. Here the pelvis is divided into three zones: The first concerns the uterus itself, which is treated at 35 cm. through six (in fat patients, seven) 6×8 cm. portals, three (or four) anteriorly and three posteriorly, all aimed at the seat of the primary tumor, in the belief that about 20 per cent of the skin dose reaches a point 10 cm. below the skin; thus delivering at the site of the disease a total of 120 per cent of the skin erythema dose. After six weeks, during which the skin and the blood picture have recovered, the right parametrium is attacked, again through the six small portals, all laid out to the right of the midline, three anterior and three posterior. After a further six or eight weeks the left parametrium is attacked in a similar manner. The left side is left to the last on account of the high degree of sensitivity of the rectosigmoidal mucosa. By thus planning the treatment, the rectum and lower sigmoid, which usually lie more to the left than to the right side of the pelvis, are allowed twelve to fourteen weeks to recover from the irritation following the treatment of the primary tumor, before receiving the second irritating dose to which they are subjected during the treatment of the left side of the pelvis. If the left parametrium is more involved than the right, then the danger of overirritating the rectal mucosa must be faced.

The Erlangen school also recommends the employment of the large field, longer distance technique when there is widespread diffusion of the disease throughout the pelvis, especially in dealing with sarcoma. Since Professor Seitz has moved to Frankfort, he has introduced the above technique into the Frankfort Frauenklinik, where it is faithfully carried out.

It is of the utmost importance to assure the presence of the filter. In the past, with the treatment methods usually in vogue throughout the United States, the omission of the 3 or 4 mm. of aluminum used as filter has resulted in acute lesions exceedingly distressing alike to patient and operator; it is not difficult to picture the unfortunate result if an omission of filter occurs in the course of treatment with the new technique. Various methods of assuring the presence of the filter have been devised. The use of some one of the ionometers will betray at once the omission of the filter by the rapid discharge of the electroscope. The plan carried out in our clinic seems worthy of recommendation. The operator of the treatment instrument has strict instruction not to turn on the current until the voltage, the target-skin distance, the protective coverings and the filter have been verified by one of the physicians of the department who is required to sign his initials personally in the blank provided for that purpose.

DOSAGE

As above intimated, the dosage administered is intended to approximate as accurately as possible, 120 per cent of the skin erythema dose for carcinoma, and 80 to 85 per cent of this dose for sarcoma. Whether the skin dose is estimated by some method of ionometry, it transpires sooner or later that the individual installation under the peculiar working conditions of each laboratory will become standardized, and the chief dependence will be placed on the reproduction of the six physical factors (voltage, milliampèrage through the tube, time of application, filter, target-skin distance, and size of field of entry) rather than upon the electroscopic readings. For the present at least, the use of the ionometer in the average American's practice will be greatest for the instruction of the physician and his office personnel, and for experimental investigations.

PROTECTION OF THE PATIENT

Our tube enclosure is not at all satisfactory; therefore we feel bound to cover the patient with protective material, except for the opening through which he is being treated. Lead or lead-rubber protective material, grounded to the steam or water pipes, is supported on hoops or other frame work to relieve the patient of unnecessary weight. The protection for the head and face may be so arranged as to permit the freedom of the patient's arms to hold a book or magazine. Enough blankets are provided to keep the patient warm, thus permitting free ventilation of the room with fresh air even in the coldest weather. In some instances a retention catheter is placed in the bladder to avoid the necessity of disarranging the protective material before the conclusion of the treatment. Only a physician is permitted to arrange the area under treatment and the protective material, and to verify the presence of the filter, the correctness of the voltage and other treatment factors, and in our clinic he is required to certify to the performance of this duty by initialing the book.

IMMEDIATE EFFECTS

During the treatment the patients frequently become nauseated, and many of them vomit. Morphine minimizes this tendency and lessens complaint as to discomfort. When treating the glands of the neck, the axilla or the groin, the application is promptly followed by an immediate swelling and reddening of the area treated, so marked that unless the patients are warned in advance, they are apt to call for the attending physician six to twelve hours after the application, alarmed by the occurrence. In another twelve to twenty-four hours the visible swelling has disappeared, but the discomfort continues for several days to a greater or less extent. In general, there is a primary blush or reddening noted on the skin lasting one or two days, followed in a week or ten days by the deeper reddening of the erythema, marking a full erythema dose. The reddening gradually fades and is later replaced by a brown discoloration of the skin. If the treatment has been given in a very much larger dose, it is possible to observe a final whitening of the skin owing to destruction of the function of the pigment cells.

Following treatment in full dose for malignancy of the lip, tongue, tonsil, thyroid, supraclavicular or mediastinal glands, or any type of malignance involving intensive radiation to the chest or neck, patients frequently complain of temporary dysphagia, dyspnea, dry cough, disturbance of voice at times approaching aphonia, pharyngeal irritation simulating pharyngitis or tonsillitis, edematous reddening of the uvula, pillars and pharynx—all, however, without the constitutional symptoms of an acute infection. These symptoms usually pass away in four to ten days.

Much has been said in this country regarding blood changes of a serious nature following the new deep therapy. We have been given to understand that it is not infrequently necessary to administer a blood transfusion to counteract the depressant effect of the treatment on the blood-forming functions. Our experience and observation do not confirm this impression. In very marked cases of leucopenia it is true, such transfusions may become justifiable, but experience has shown that when the patient is already cachectic, the prospect of help from the irradiation is remote, if, indeed, the contrary result is not substituted. The immediate effect of a heavy treatment is a transitory rise of the white count of, say, from 7,000 to 10,000 or 12,000, within a few hours, followed by a gradual rise in the white count, until at the end of from four to eight weeks it has returned to about normal. There is very little change in the number of erythrocytes, a fall of 4 or 5 per cent being the maximum change noted in any of our cases. Abnormal cell elements are not especially numerous. In going over the protocols of a number of cases observed, we may note the following with reference to three typical cases:

	Case A	Case B	Case C
Before..........	4,312,000	4,630,000	3,508,000
At once after....	210,000	4,400,000	3,220,000
6 hours.........	4,120,000	4,300,000	3,110,000
3 days..........	4,100,000	4,500,000	3,400,000
6 weeks.........	4,280,000	4,580,000	3,600,000

and the following with reference to white cells in the same cases:

Before..........	5,300	4,300	5.800
Im. after........	5,100	3,800	4,600
6 hours.........	5,000	3,400	4,000
3 days..........	4,900	3,300	4,700
6 weeks.........	5,200	4,000	5,500

In none of the above patients was the hemoglobin lower at the end of the six weeks of observation than at the beginning.

In other words, there appears to be no permanent deleterious effect upon the blood-count resulting from the massive doses. In a limited number of observations the blood-sugar has been moderately lowered and the blood-nitrogen slightly elevated. We have not marked any constant change in the coagulation time of the blood. The diminished blood-sugar could easily be explained by the lessened alimentary intake during and immediately following the treatment.

Rectal and bladder tenesmus are fairly constant sequels to pelvic irradiation in massive doses. This seems best relieved by radiant heat applied locally, warm sitz baths, and sedative drugs. In one of the German clinics we saw a special device for the application of incandescent light treatment within the vagina. The daily bowel movements begin to increase in number on about the third day reaching ten to fifteen in twenty-four hours by the eighth or ninth day, then gradually returning to normal at about the same rate.

"Roentgen intoxication" is one of the less serious complications of the newer deep therapy, though it stands out as one of the most disturbing to the patient. Headache, nausea, vomiting and weakness are fairly common in a greater or less degree, but fortunately the symptoms are transient and usually disappear with forty-eight hours. Many patients suffer during the first application of the series when the areas are treated on successive days, and are not at all inconvenienced during the remaining two or more days constituting the session. It is impossible to foretell who will be sick. Some go through the whole session without inconvenience, while others, appearing equally able to withstand minor symptoms are wofully upset for a day or two. Occasionally (especially after long-distance irradiation in breast cases) the roentgen sickness lasts for weeks and is very disturbing to the patient, though, after all, of minor consequence compared to the malady for which we treat. Various theories have been advanced to explain the intoxication, for such it seems to be,—disturbance of the internal secretion of the ovaries, the adrenals, or other glands of internal secretion; toxins developed in the intestine, especially the small intestine; disturbance of the sympathetics; acidosis; vitiation of the air of the room; absorption of products of disintegration of the tissue under radiation; changes in the blood (Heinecke). To all of these suggestions one immediately thinks of exceptions; attention to any one fails to do more than slightly lessen the discomfort.

One naturally chooses for treatment work a room with a high ceiling, well ventilated; he adopts a system of high tension wiring which minimizes corona; he puts his current-generating apparatus in another room; he encourages the patient's eliminative processes in every possible manner; sedative drugs are employed to minimize the nervous or psychic factors (and these latter are of no mean importance); certain endocrine therapy may prove useful. The ordinary tests for acidosis (estimation of the CO_2 tension of the aveolar air, study of the urine and the chemical analysis of the blood) in our clinic have failed to show evidence of acidosis even in cases subjected to the largest doses we have dared to administer, or in patients exhibiting the most distressing symptoms of irradiation sickness.

RESULTS

The immediate reaction upon the disease is very encouraging. In a given series of consecutive cases (excluding the cachectics) one sees a larger number of more prompt improvements. Pain is usually relieved; bloody and purulent discharges lessen or disappear; the general condition of the patient is improved in a considerable proportion of cases. Some have responded no better than before, but the sum total of our conclusion is that palliative results have appeared more promptly than ever in a larger percentage of cases, while in a few, the visible evidences of the disease have disappeared. We have no right yet to talk of permanent results, but we do feel justified, from our own experience, in expressing the encouragement we feel in going earnestly ahead with our work.

Personal investigation of the good reports of apparent cures from Germany revealed a somewhat modified tone of optimism. Reports published in American medical journals give figures of apparent cure after two or three years approximating 60 or 70 per cent. Actual investigation of the figures given today in the leading clinics showed the most optimistic to claim only 30 to 35 per cent. The most bitter critics of the overenthusiastic admitted perhaps 15 per cent of apparent cures in inoperable cases! Our German colleagues have been carrying out this treatment for four or five years, and they have small series of cases now alive three years after massive treatment with what they consider nearly ideal technique. Several well-known gynecologists have abandoned the operative treatment of cancer of the uterus in any stage, submitting even their earliest cases to the combined radium and *x*-ray treatment. Everywhere was found a reluctance to talk with much enthusiasm until another two years or more have passed by. We shall do well to follow this example.

REPETITION OF TREATMENT

We believe an interval of from six to twelve weeks should elapse between treatments given in the manner earlier described in this paper. In some cases where the first series of treatments failed to produce a definite reddening of the skin, the urgency of the situation has led us to give a supplementary dose within two weeks. We have been fearful of late-appearing damage to the skin, but in none of our own cases have we ever seen this. A herpetiform skin eruption has followed within a week or two in a rather striking number of cases; in half a dozen breast cases, this rash has seemed to be a true herpes zoster. In one patient, it appeared twice, each time following a treatment. In no instance have we continued the treatment after the third massive application. In the European clinics we saw a few instances of the so-called chronic indurative edema which occasionally appears in the treated area several weeks after repeated application. The appearance of this induration should be a warning to discontinue the roentgen therapy through the area involved, for it seems that it is in just this kind of situation that the late skin injuries have appeared. Even so, the number of recorded cases of late skin damage is very small. Seitz admitted only two such cases, and in one of them it is likely that the late damage would not have appeared had not the area been subjected to chemical irritation due to the patient's occupation.

CONCLUSIONS

We should accept with considerable reserve the reports of clinical results from the work of our European colleagues, but we should welcome gratefully the enormous fund of information concerning the physical and biological basis of deep therapy furnished by them and by our American investigators which will enable us to make most intelligent use of the shorter wavelength roentgen radiation. A definite advance has been made in deep radiotherapy. Unprecedented good results (of at least temporary duration) are being secured in a more constant fashion in a larger percentage of patients presented for therapy. I believe we should discard our old methods just as rapidly as we are equipped, not only with apparatus, but especially by a familiarity with the principles underlying the new method. Radium therapy will be more than ever successful in gynecological malignancies when combined with the intelligent application of the new, more penetrating *x*-rays, which by their adaptability to conversion into practically homogeneous radiation, will supplement the internal use of radium in a manner best calculated to reach the lymphatic lines along which extension of the malignant disease occurs. For benign lesions of the pelvis, for which radiation is indicated, it cannot be stated that the newer, high voltage apparatus is a necessity; but it is certainly a great convenience.

X-RAY AND CLINICAL FINDINGS IN THE NORMAL CHEST (CHILDREN SIX TO TEN YEARS OF AGE)

NATIONAL TUBERCULOSIS ASSOCIATION

MEDICAL RESEARCH

THE National Tuberculosis Association some time ago began a new and important phase of its work in an attempt to increase the quantity and character of research work in problems related to its own field in the United States. For this purpose it appropriated $20,000.00 and appointed a small committee composed of Dr. Wm. Charles White, Medical Director of the Tuberculosis League of Pittsburgh, Dr. Paul A. Lewis, Director of Laboratories of the Phipps Institute, Philadelphia, and Dr. Allen K. Krause, Director of Kenneth Dows Research Fund, Johns Hopkins Hospital, to expend these funds to the greatest advantage.

This committee decided that the best use of these funds would be in assisting researches already under way that held the greatest promise of increasing the practical knowledge of physicians dealing with tuberculosis. This, they considered, would bring the greatest help to those suffering from tuberculosis and the greatest boon to the public from whom the funds were collected. This plan has been carried out in cooperation with the universities.

One of the researches was an effort to establish the *x*-ray and clinical findings in the chest of a normal child up to ten years of age. For this problem the National Tuberculosis Association nominated the following groups of roentgenologists and clinicians.

Dr. H. K. Pancoast and Dr. H. R. M. Landis—University of Pennsylvania.

Dr. F. H. Baetjer and Dr. C. R. Austrian—Johns Hopkins University.

Dr. H. K. Dunham and Dr. K. D. Blackfan—University of Cincinnati.

The signed reports of these physicians are here presented in two sections with the hope that they may promote a discussion which will be fruitful in establishing the truth in these two fields.

THE X-RAY AND CLINICAL FINDINGS IN THE NORMAL CHEST OF THE CHILD

Report of the Clinical Division of the Committee on Medical Research of the National Tuberculosis Association.

The value of roentgenography in determining the presence of pulmonary disease has long been recognized. Studies to determine the roentgenograms of various pathological lesions of the lung have been almost without number, yet much difference of opinion exists in the interpretation of findings, largely because no satisfactory observations have been made establishing the variations that may occur in the normal. To one observer, shadows noted are indicative of disease; to another, they are not evidence of a pathological process. To one, they represent lesions of clinical significance; to another, they suggest changes of no moment. The realization of this unsatisfactory state of affairs was widespread, but it remained for the Research Committee of the National Tuberculosis Association seriously to consider it and to set about to correct the shortcomings.

In the spring of 1920, that Committee called together the collaborators in this work and instructed them to set about in ways of their own choosing to solve the problem, extended to them a financial grant, and, in order that the problem might be a very definite one, asked that the immediate study be limited to a consideration of the chests of normal children between the ages of 6 and 10 years. The work was begun promptly and a preliminary report was made at the annual meeting of the Association in May, 1921. The findings at that time were incomplete, and because of the then limited observations, no very definite conclusions were drawn. However, the practical need of a solution of the problem was apparent. Study was continued throughout 1921 and the first four months of 1922, and the data independently assembled were jointly discussed to evaluate them. Although each pair of workers carried on its investigations without inter-group consultation, although each approached the subject from a different angle and when first met held views apparently not altogether in accord, it was agreeable to find that an exchange of conclusions disclosed almost an unanimity of opinion. The findings of these six observers—three clinicians and three roentgenologists—are presented to you for consideration:

Theoretically, the normal child is one of ideal height, weight and development for his age, without subjective or objective evidences of deformity or of disease, and without residual changes due to antecedent pathological processes. Practically, a normal child is one of average height, weight and development for his age, symptom-free and without signs of disease. Each such individual, in more or less relation to his age, will have been ill more or less often, and as a consequence may be expected to show variations from the ideal, not because of present disease, but as a result of residual changes that persist. An appreciation of these facts makes it apparent that the findings, clinical and roentgenographic, in normal children as we meet them will vary greatly from any fixed standards, and still must be considered as variants of normal.

The clinical data dealt with in this report were obtained by careful examination of apparently healthy children between the ages of 6 and 10 years. All children who showed signs of disease were excluded from the series. Individuals from various strata of society, foreign and native born, residents of urban and of rural communities, school children and children residing in institutions, children exposed to tuberculosis and some without a history of such exposure, children with and without a history of previous infectious diseases, all symptom-free, and of an approximately normal height and weight for their ages, were studied. A history of each individual was recorded, and in making the examinations of the chest, care was always observed to have the child relaxed and to see that no cramped or unnatural posture was assumed, for, as is well known, faulty position may lead to findings that cause confusion in interpretation. In addition, a tuberculin test was made on every child. The clinical data were then assembled and after the roentgenologist had interpreted his plate independently, the clinical and roentgenographic findings were correlated.

In all, over 500 children were thus studied, and as a result some definite conclusions seem warranted.

As in the adult, so in the child, vocal fremitus is more marked over the right upper chest than over the left.

It is generally stated that the percussion note elicited over the lungs of normal children within the age limits under consideration is fuller, more tympanitic, of higher pitch and more resilient than that noted over those of adults, and that frequently the tympanitic quality is quite outspoken, especially over the lower lobe of the left lung. Although in general our observations confirmed this view, we have been impressed by the fact that in an appreciable number of such children, the note obtained on percussion over the lungs is indistinguishable in quality from that elicited over the lungs of normal adults and that the usual resilience of the note is lacking. These findings in many instances have an analogue in shadows noted in the *x*-ray films, shadows indicative of increased density along the bronchial tree, similar to those seen in the plates of normal adults. This correlation of the findings on physical examination and on *x*-ray study is more constantly possible in studies of the upper half of the chest. When minor changes, similar to those discovered by *x*-ray examination of the upper lobes, occur in the bases, they usually escape detection on physical examination. In those instances in which no shadow is found to explain the deviation of the note from the generally accepted one, it is our belief that the lack of resilient quality may be due to a decreased elasticity of the chest wall.

The so-called tympanitic quality of the percussion note over the left base may be increased, decreased or be entirely lacking, depending upon the degree of distention of the stomach or colon, and the curvature of the spine, and may likewise vary with the position of the diaphragm or with the posture of the child during the examination. The note over the upper thorax is often the same on the two sides. Kronig's Isthmus averages 5 to 6.5 cm. in width. The lower margins of the lungs posteriorly are at the level of the 10th or 11th rib and descend from 1.5 to 3.5 cm. during forced inspiration.

A just detectable diminution of resonance over the apical regions is of no significance unless associated with a modification of the breath sounds in those areas, or with other abnormal ausculatory findings.

It is generally accepted that normally in childhood, the breath sounds have a harsh, sharp character, with expiration longer and better heard than in the normal adult. This so-called puerile breathing is physiological, and though it may seem trite, let it be emphasized that this exaggerated vesiculo bronchial respiratory murmur, especially well heard in the areas overlying the great bronchi (i.e. anteriorly at the level of the first interspace and the second rib just lateral from the sternal margins, and posteriorly, particularly on the right side, at the level of the second to the fourth spine) is often incorrectly interpreted as evidence of pulmonary disease. An auscultatory finding that has not been pointed out, or, at least, has not been emphasized, has come forcibly to our attention in carrying out this study. Just as the full, deep note or higher pitch characteristically elicited by percussion of the child's chest is often replaced in health by a note more like that produced when one percusses the normal chest of an adult, so, on auscultation of a child's normal lungs, the exaggerated or puerile breath sounds may be lacking, and instead, the so-called vesicular respiratory murmur characteristically present in adult life is heard. This finding, regarded by us as a physiological variation, has been noted as early as the age of four years and may perhaps occur in younger children. It is more readily appreciated and more often found than the variation in the percussion note just described. In more than 50 per cent of the children in which this type of breathing was heard, examination with the *x*-rays gave findings like those obtained by a study of normal adult chests. In fact, the agreement of clinician and roentgenologist was so constant that we have come on the basis of these variations to designate the chest of normal children as of "puerile" or of "adult" type. The essential fact to be stressed is that so-called vesicular respiration is heard with great frequency in normal children, and is to be regarded as a variation of normal and not necessarily as an indication of disease.

These variations and those of the percussion note are more generally found in children with a history of infections of the respiratory tract. No satisfactory explanation for this finding is offered. It may be due in part to altered resilience of the chest wall, a suggestion supported by the fact that in some instances in which it was noted, diminished elasticity of the thoracic wall was apparent on percussion. It may stand in relation to variations of elasticity of the parenchyma of the lung. It may be due to a relative narrowing of the lumen of the bronchial tree. It is hardly to be considered evidence of increased density of respiratory tissue, for, theoretically, at least, that should lead to a modification towards bronchial breathing.

Concerning the whispered voice sounds, little comment needs to be made other than to emphasize their loud transmission often with syllabation over the region of the major bronchi. Auscultation of these sounds over the upper thoracic spine of the children has led to the conclusion that D'Espine's sign as indicative of enlarged tracheobronchial lymph-nodes is, to say the least, of doubtful value. In 23 of the children, this sign was elicited without other signs of a mediastinal mass and without any corroborative evidence on *x*-ray examination. In 3, the sign could not be elicited, although from the *x*-ray plate it might have been inferred that it should be. Eustace-Smith's sign is so generally present in normal children that it is of little or no practical diagnostic worth. The presence of these two signs together with impairment of resonance in the interscapular region is all too frequently made the premise for a diagnosis of tuberculosis of the tracheobronchial lymph-nodes. This is unwarranted, for, as indicated, these signs are unreliable evidence of a pathological condition, and the determination of a diminution of resonance in the interscapular region requires such a nicety of technique that even masters of percussion disagree as to the presence or absence of significant findings in this region of the chest.

A year ago, in the preliminary communication to this Association, we stressed the importance of the rôle that antecedent infections might play in the production of areas of increased density within the respiratory tract (bronchial tree, parenchyma of the lungs, etc.). This fact is re-emphasized, for further study has established the importance of it. Not only may recognized or remembered infections of the bronchi and lungs be responsible for alterations in these tissues, but other diseases not ordinarily considered of significance in this regard may be causal of such changes. For example, our observations indicate that after measles, pertussis or tonsillar infections, areas of increased density radiating from the hilum into the bases especially, occur with great frequency. Such lesions generally are not discoverable on physical examination and would be unsuspected but for the use of the *x*-ray. They are referred to in the clinical part of our joint report in order to point out the need of a careful history as well as examination in all individuals, before proceeding finally to interpret the findings of the roentgenologist. By way of digression, it may be interesting to point out the fact that though measles and pertussis have been known to produce lesions in the upper air passages, involvement of the lower tract has been considered a complication and was thought to occur only when evidence of bronchitis or of bronchopneumonia was discovered. Our observations indicate that there may be a mild inflammatory process throughout the respiratory passages in a large percentage of the so-called uncomplicated cases of these diseases. This suggestion warrants further study in relation not only to the infections under consideration but also other infectious diseases. That such shadows, mediastinal and basal, noted in children who give a history of uncomplicated measles and pertussis are evidences of healed processes is evidenced by the experience that similar shadows of like origin have remained unchanged and without the development of clinical symptoms in a series of children observed from three to five years. Such changes must be properly evaluated as indices, not of present disease, but of lesions past and healed, not as warrant, for the diagnosis of present illness and the institution of treatment, but as scars of infections met and overcome.

Most of the children included in this study were tested with tuberculin—some were given a cutaneous test with old tuberculin (Pirquet) others were tested by the intracutaneous method (Craig).

The foregoing facts have been detailed at some length to establish the major thesis that, clinically, the ideal, normal child is a hypothetical impossibility. Children, apparently healthy, symptom-free and active, show, on careful examination, many deviations from fixed standards, variations that must be interpreted as within physiological limits. Standards of height and weight must be elastic, measures of resonance and of resilience of the chest must not be rigid, and estimates of acoustic phenomena must permit of a range of difference from the ideal. These facts, clinical experience establishes beyond peradventure; and they suggest a corollary, namely, that *x*-ray examination of the chests of such children may be expected to show comparable deviations from a fixed ideal roentgenogram.

The studies reported, fortified by past experience, warrant the following conclusions:

1. The data obtained on percussion and auscultation of the lungs of normal children show wide variations from a fixed standard. These variations are usual and are considered to be within normal limits.

2. Inasmuch as the changes referred to are dependent often upon alterations that persist as the residua of past infections of the respiratory tract, it is obvious that a careful anamnesis, with special reference to all infections, is necessary if diagnostic errors are to be avoided. Even a history carefully taken is often unreliable, as minimal infections are soon forgotten by many and among the unintelligent classes even more significant indispositions are not readily recalled.

3. Failure properly to evaluate these deviations from a fixed standard will often lead to the unwarranted diagnosis of disease and to even less justifiable treatment.

4. With a proper appreciation of the widest variations that the normal may present from the ideal, the informed clinician is better able correctly to understand the findings of the roentgenologist, and each, cooperating with the other, is less liable to error.

5. D'Espine's sign as indicative of enlarged tracheobronchial lymph-nodes is of little value.

6. Recognition of and familiarity with the foregoing data is of cardinal and practical importance to every patient, potential and established. Without a proper appreciation of the facts set forth, no intelligent differentiation between a normal and an abnormal respiratory tract can be made.

In brief, to establish the presence or absence of disease, it is imperative that all data—clinical, laboratory and roentgenographic—must be evaluated and correlated, and that no one fraction of the evidence be stressed to the exclusion of the others.

(Signed) C. R. Austrian
H. R. M. Landis
K. D. Blackfan

May 6, 1922.

THE X-RAY AND CLINICAL FINDINGS IN THE NORMAL CHEST OF THE CHILD

Report of the X-Ray Division of the Committee on Medical Research of the National Tuberculosis Association

It is generally conceded that one of the most important factors in accurate interpretation of the appearance of morbid processes in the roentgenogram of the thorax is a thorough familiarity with the normal, and variations therefrom, within normal limits. With a full realization of this in view, the National Tuberculosis Association, in 1920, appointed a committee comprising three roentgenologists and three internists to make a study of the normal chest of the child between the ages of six and ten years. This group was instructed to work in cooperation, and to make a report of their investigations before the Association when their studies were completed and their conclusions reached. The members selected for the committee were Dr. H. Kennon Dunham of Cincinnati, Dr. Frederick H. Baetjer of Baltimore and Dr. Henry K. Pancoast of Philadelphia, to act in the capacity of roentgenologists and to work in cooperation with the respective internists in the same cities, Dr. Kenneth Blackfan, Dr. Charles R. Austrian and Dr. H. R. M. Landis. Each group of two was to work independently until a satisfactory number of individuals were examined and the entire committee was then to meet and draw their conclusions for presentation. It was to be the duty of the internist in each group by careful clinical study to select as nearly normal children as possible for examination by the roentgenologist. The entire procedure was to be carried out with strict cooperation between the two members of each group.

It was soon realized by the *x*-ray members of the groups that an attempt to describe a normal chest was practically impossible. Their endeavors soon began to centre around the description of a theoretical normal with wide variations that would serve as a basis for the interpretation of abnormal appearances, and tend to preclude the possibility of erroneous diagnoses being based upon faulty interpretations of hilum shadows, trunk shadows and linear markings, more or less altered in appearance by the frequent respiratory infections of children. They realized that herein had existed the greatest source of error in interpretation; and no doubt the Association had this same thought in mind when the committee was appointed to take up these investigations. Errors in interpretation have been made chiefly in connection with the diagnosis of pulmonary tuberculosis.

It was the consensus of opinion that children are probably more apt than adults to show definite *x*-ray evidences in the hilum and trunk shadows of simple as well as serious respiratory infections. Practically all children of the ages of those examined have had at one time or another one or more respiratory infections, especially measles and whooping-cough, that are likely to produce very apparent changes in the shadows mentioned and which will remain distinctly visible for a variable period of time. These apparent deviations from the normal are not necessarily abnormal when observed, but may be the harmless results of one or more infections. No doubt such appearances have many times been misinterpreted as evidences of tuberculosis. In the conclusions reached by the committee, the attempt has been made to preclude this possibility.

Many of the general observations made have not been included in the conclusions. One of those perhaps worth mentioning is the fact that the heart of the child is found to extend relatively further to the right than that of the adult.

The thoroughness with which the studies were carried out may be in part realized from the number of individuals examined. Over five hundred children were selected from all strata of life, as stated in the clinical report of the committee.

The groups comprising the committee met at the Phipps Institute, Philadelphia, March 3, 1922. Prior to this meeting, there were misgivings as to the possibility of an agreement upon any very definite conclusions, but, much to the satisfaction of all the members, a definite agreement was reached, and the conclusions were completed, after a few hours' careful deliberation.

To assist in a better understanding of the conclusions of the committee, a composite diagrammatic reproduction of several roentgenograms was made. It must be remembered that the three zones, like the chest, have thickness as well as length and breadth. Thus the zones extend anteriorly and posteriorly as well as laterally, from the lung root.

CONCLUSIONS OF THE X-RAY DIVISION OF THE COMMITTEE

1. *The Normal Chest.* The normal chest of the child from the roentgenologic standpoint is subject to such wide variations within normal limits as to be beyond the possibility of exact description.

2. *Hilum Shadow.* The conglomerate shadow commonly called the hilum shadow, when found lying entirely within the inner third or zone of the lung area can be disregarded (or regarded as normal) except where it is made up of a solid mass of homogeneous shadow giving undoubted evidence that it represents a growth or mediastinal pleurisy.

3. *Calcified Nodes.* Calcified nodes at the root of the lung, without evidence of lung disease, are of no significance except as a possible evidence of some healed inflammatory condition, possibly,

but not necessarily, tuberculous. They are a common finding in normal chests.

4. *Density and Thickness of Trunk Shadows.* In the normal lung, the bronchial trunk shadows are not visible in the extreme apical regions. For convenience of description, the remainder of the lung is divided into three vertical zones, extending outward from the lateral border of the spinal shadow to the lateral chest border.

The inner zone contains the root shadows.

The mid-zone contains the trunk shadows, gradually fading out into their final subdivisions.

The peripheral zone contains radiating lines from these, fading off before the periphery is reached.

Where in the mid-zone or peripheral zone, these shadows do not disappear in the characteristic fashion described, the appearance may be evidence of a variety of conditions, past or present, of an inflammatory nature or otherwise. It may accompany a tuberculous process, but is not necessarily indicative of tuberculosis.

5. *Improper or Misleading Terms.* The use of the terms "peribronchial tuberculosis" and "parenchyma tuberculosis" is not to be recommended in the interpretation of roentgenograms of the chest. Until corroborated by laboratory or clinical findings, the use of the terms "active" and "quiescent" should not be definitely applied to evident lesions demonstrated on plates.

(Signed) Henry K. Pancoast
Kennon Dunham
F. H. Baetjer

May 6, 1922.

ROENTGENOGRAPHY OF INTRACRANIAL PASSAGES FOLLOWING SPINAL AIR INJECTIONS

BY CHARLES L. MARTIN, M.D., AND CLAUDE UHLER, M.D.

From the Laboratories of the Baylor Medical School

DALLAS, TEXAS

Any new procedure related to the brain or spinal cord is approached by most physicians with great caution, and this is undoubtedly as it should be. However, the need of more accurate diagnostic methods in studying intracranial disease is so urgent that every reasonably safe procedure should be given a fair trial.

It may not be out of place to set down some operative statistics in an effort to emphasize this point. Bailey[1] states that out of 118 consecutive cases diagnosed as brain tumor at the Peter Bent Brigham Hospital, 55 were not verified and 31 were found to be suffering from other conditions such as cerebral thrombosis, embolism, syphilitic meningitis, cerebral hemorrhage, meningo-encephalitis, multiple sclerosis and post-traumatic psychoses. Ransohoff[2] claims that only about 8 per cent of all brain tumors can be successfully removed at the time of recognition. Heuer and Dandy,[3] in a series of 45 suspected tumors of the cerebral hemispheres, failed to locate the tumors at operation in 44 per cent of the cases. Bruns[4] states that only 3 to 4 per cent of brain-tumor operations are surgical successes. The mortality for such operations done under Victor Horsely at the National Hospital was given by Tooth[5] as 32 per cent. Krause[6] gives the mortality as 50 per cent in 109 operations at the Berlin Clinic. Harvey Cushing[7] states that in 350 operations, the immediate mortality was 10 per cent and the permanent cures 5 per cent. It seems only fair to assume that these figures might be improved materially by the introduction of an efficient method of diagnosis.

The use of air as injection material for the subarachnoid space and ventricular system as advocated by Dandy[8] offers wonderful possibilities. His system of investigation will undoubtedly soon be accepted by the profession as a fit companion for the barium meal and the pyelogram. Many roentgenologists will remember his original article entitled "Ventriculography following the injection of air into the cerebral ventricles" which appeared in the AMERICAN JOURNAL OF ROENTGENOLOGY in January, 1919. In October, 1919, a second article dealing with the roentgenography of the brain following the injection of air into the spinal canal appeared in the *Annals of Surgery*. It has been our good fortune to have the opportunity of examining a series of 14 cases by this latter method at the Baylor Hospital during the past year. Our results have been, on the whole, very satisfactory and we have had no mishaps.

The technique used has been essentially that recommended by Dandy. The lumbar punctures were done in the roentgen-ray laboratory following the administration of full doses of morphine. The adult patients were required to sit up with the head bent slightly forward during this procedure, and it would seem that this is the ideal position for filling the ventricular system. The children were given a general anesthetic and placed in the right lateral position on a table with the head elevated so that the table top made an angle of about 15° with the floor. A 10 c.c. syringe was fitted to the lumbar puncture needle after its insertion into the spinal canal. Following the removal of each 10 c.c. of spinal fluid, about 9 c.c. of air were forced into the spinal canal. This procedure was continued until no more fluid could be obtained or until at least 40 c.c. of air had been injected. The needle was then removed and a small dressing placed over the puncture. At this point the children were held upright with the heads tipped slightly forward for four or five minutes. All roentgenograms were taken on the inclined table used in doing the punctures on anesthetized patients. Two lateral views, a posteroanterior and an anteroposterior view, were taken in each case. It was also found advisable to take a lateral view before beginning the procedure. This made the identification of suture lines and blood-vessel grooves much easier.

From the patient's point of view the investigation is not altogether pleasant, but the information obtained often far outweighs the importance of the symptoms produced. These symptoms have been quite temporary in our cases. Headache has appeared with each injection, and at times it has been quite severe but all unpleasant symptoms have disappeared within twenty-four hours. In a few cases pain has appeared in the back or in a

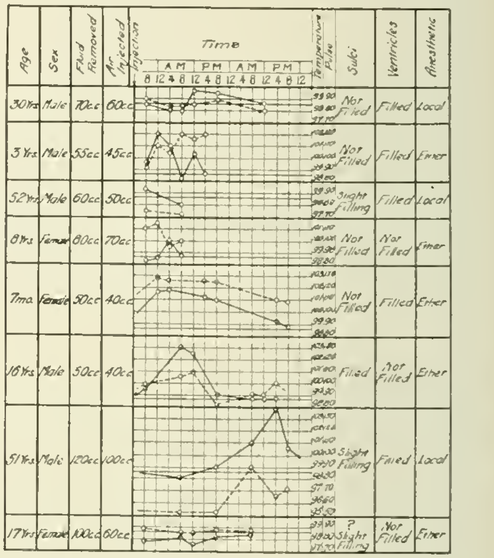

FIG. 1. Chart showing reactions following injections. The solid lines represent temperature and the broken lines the pulse.

leg during the injection; possibly because nerve filaments got caught in the needle. This pain is usually transient. Eight of our patients remained in the hospital for twenty-four hours or longer, and Figure 1 shows the temperature and pulse variations. The solid lines represent temperature and the dotted lines, pulse variations.

No good explanation of the temperature rise can be offered at the present time, but it doubtless has some relation to a disturbance in pressure on the heat center. Since all the patients did not show a marked rise, we feel quite certain that no infectious organisms were introduced with the air. No attempt was made to study the absorption of the injected air except in one case. At the end of six days there was a small amount in the lateral ventricles, although none of the other injected structures could be made out.

A word should be interposed here regarding the selection of cases for this type of injection. The most important contraindication is a brain tumor in the posterior fossa. It is a well-known fact that removal of the spinal fluid in such cases may cause death. The brain stem is pushed into the foramen magnum by the pressure from above, when the pressure in the spinal canal is lowered. Where there is any question of such a condition being present, a ventricular puncture should be done first through a small trephine to equalize the pressure on the two sides of the medulla. Infections and hemorrhagic conditions have also been mentioned as contraindications. The method appears to be of the greatest value in studying cases of hydrocephalus where it is of importance to locate definitely the point of obstruction.

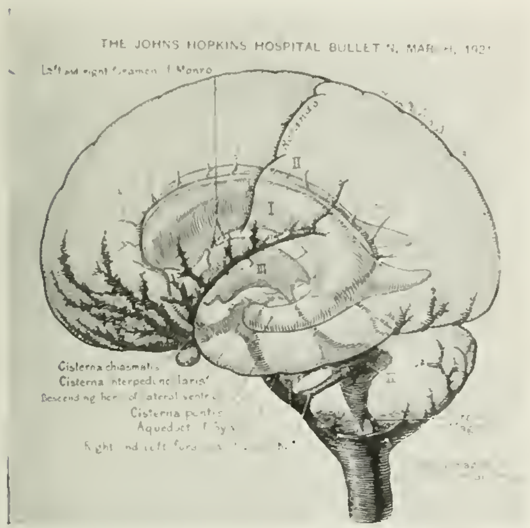

Fig. 2. Drawing made by Max Brodel to show the arrangement of the intracranial spaces.

In attempting to study the details of the intracranial passages we found the standard textbooks rather unsatisfactory. Since others may experience the same difficulty, a few roentgenograms of normal brains may be worthy of discussion. Figure 2 shows a drawing which appeared in one of Dandy's recent articles. This drawing gives the most graphic representation of the cerebrospinal fluid circulatory system which has come to our attention. According to our present conception, the spinal fluid is formed in the lateral ventricles labelled I and II in the sketch. It passes through the foramen of Monro on each side into the third ventricle and from there down through the long narrow aqueduct of Sylvius into the triangular-shaped fourth ventricle. Three passages, the foramina of Luschka and the foramen of Magendie, carry the fluid into the cisterna magna and the cisterna pontis, both of which communicate with the subarachnoid space of the spinal cord.

Fig. 3. Lateral view of a normal baby's skull made following the injection of air through lumbar puncture. The sulci are not injected. None of the roentgenograms shown are retouched.

The cisterna pontis is continued forward as the cisterna interpeduncularis and the cisterna chiasmatica, and the spinal fluid after having traversed these passages is distributed over the surfaces of the cerebral hemispheres through the branches of the cerebral sulci and is here absorbed. Should an obstruction occur in one of the narrow passages, that is, in the aqueduct of Sylvius, or the foramina of Luschka and Magendie, a dilatation of the third and lateral ventricles will result from back pressure. This condition is called internal hydrocephalus. Should the obstruction occur in the basilar cisterns or in the branches of the cerebral sulci, as often happens following meningitis, a dilatation of all the ventricles is likely to occur, and this condition is designated as communicating hydrocephalus.

Figures 3 and 4 are lateral and posterior-anterior views which show the normal basilar cisterns and ventricular system very clearly. It is a rather interesting fact that none of the sulci were filled in this case, although we had no reason to believe that the baby had ever had meningitis. The fourth ventricle is much more distinct in infants than in adults because of the absence of large mastoids and because the basilar portion of a baby's skull is not

Fig. 4. A posterior anterior view of the case shown in Figure 3.

very thick. The anterior edges of both lateral ventricles are sharply defined.

It is Dandy's opinion that normal sulci should always fill, and that the absence of such filling indicates a blocking of either the basilar cisterns or the sulci themselves. In our series of 14 cases, the sulci were well filled only four times, whereas the ventricles were filled ten times. In 4 cases there was some questionable filling of a few of the sulci. Since the ventricles appeared normal in most of the cases in which the sulci did not fill, there probably was no hydrocephalus present. We do not feel, therefore, that a failure of the sulci to fill always indicates a blocking of these structures. It is at present impossible for us to offer a reasonable explanation of this finding.

Several cases in our series were considered definitely pathological and three of them will be cited briefly.

Case I. A male child aged three years, was brought to the hospital because of mental sluggishness and inability to talk. He had shown tardy development. The first teeth appeared at the age of two. He began to walk quite late. He had been very apathetic. He never cried nor drooled and made no attempt to talk.

At the time of the examination, the pulse was 90 and the temperature 98.8°F. The

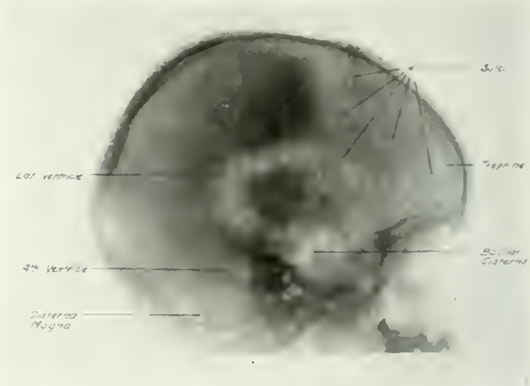

Fig. 5. A lateral view of the skull which shows the configuration of the cerebral sulci. The injection was done through lumbar puncture and not through the trephine shown in the frontal region.

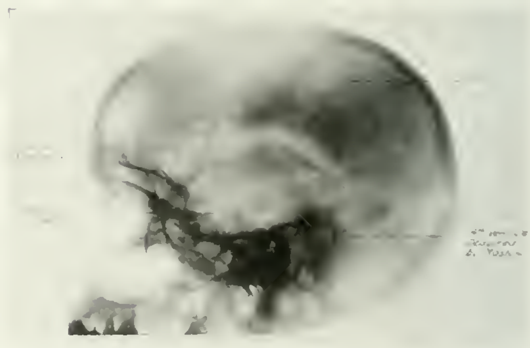

Fig. 6. A lateral view of the skull of an adult made following spinal injection. The sulci are very well shown and appear to fill normally.

child showed normal development and normal weight. The features were somewhat suggestive of Mongolian idiocy. The pupils were equal and reacted well. The eye grounds were essentially negative except that the right was pale and indistinctly outlined. The brain segment areas were normal. There was a general diminution of strength. The reflexes were slightly active.

Figures 7 and 8 show posteriorlanterior and lateral views of the head. The first, second and third ventricles are clearly outlined and are moderately dilated. For some reason the fourth ventricle cannot be made out. An irregularly shaped passage is made out in the region of the chiasmatic cistern, but no sulci can be detected. It seems possible that there may be a blocking present in the basilar cisterns; possibly as a result of meningitis. The diagnosis of hydrocephalus is certainly justified on the basis of the findings and it must of necessity be the communicating type since the lateral ventricles were filled by spinal injection.

Fig. 7. A lateral view of the skull of a patient having a communicating hydrocephalus.

Fig. 8. A posterior anterior view of the skull shown in Figure 7.

Case II. A male patient aged thirty-one came to the hospital because of paralysis of both legs.

He had always been subject to sore throats. About six weeks before the onset of his present illness he stepped on a nail and developed an abscess at the point of injury followed by abscess formation, tenosynovitis and lymphangitis.

His present illness began with a sudden severe pain in the left hip-joint six months ago. There was a rapid loss of the use of the left leg. By midnight both legs were completely paralyzed and he developed loss of sphincter control, intense headache and a fever of 103°F. The loss of sphincter control lasted thirty-six days and was followed by precipitate action. Following the subsidence of the acute symptoms, he noticed a dulling of both touch and pain sensation over both legs, most marked on the right. He also had intense headaches at intervals.

On examination he was found to have a temperature of 98°F. a pulse of 72 and a blood pressure of 148 80. His muscular development was normal except for a hypotonic and atrophic condition of both legs. His pupils were widely dilated but contracted readily to light and accommodation. The brain segment areas were normal. There was anesthesia to touch and temperature over the right leg as far up as the level of the trochanter. The pain sense was dull over the same area except for a strip along the lateral and posterior borders of the thigh in the upper two thirds. The medial portions of both buttocks showed insensibility to touch, pain and temperature. Over the left leg, heat and temperature sensibility were lost up as high as the level of the trochanter and there was an impairment of touch sensibility as high as the crest of the ileum. The deep reflexes and the cremasterics could not be elicited. Slight adduction of the left thigh could be accomplished and feeble movements at the left knee joint could be brought out. There was a complete paralysis of the right leg. The Wassermann was negative for both the blood and the spinal fluid.

A lateral view of the head, made following injection is shown in Figure 9. There is a moderate dilatation of the lateral ventricles made out and a slight filling of a few of the sulci can be observed. Much of the detail is obscured by the thickness of the base of the skull. The headaches were, in all probability, due to the hydrocephalus, which was the communicating type and probably appeared as a result of meningitis, which caused an occlusion of a large number of the sulci. The paralysis was due to a spinal cord condition; probably a meningomyelitis.

Case III. A female child aged nine, was brought in complaining of headaches, blindness, one-sided deafness and paralysis. She had an enlarged head at birth, but appeared at that time to be healthy and normally developed. At the age of three she developed sick headaches and vomiting attacks. At about the same time she stopped using her right hand and began to limp. Two years ago deviation of the eyes to the right and dimness of vision appeared. Five months later she became deaf on the left side. During the past year she has been unable to walk and has become totally blind.

At the time of examination, her temperature was 99° F. and her pulse 72. The head was enlarged and showed special prominence of the parietal bosses. The occipitofrontal circumference measured 59.0 cm. The eyes were held in conjugate deviation to the right with nystagmus. The pupils were widely dilated, the left being larger than the right. Both pupils reacted sluggishly to light. The eye grounds showed extreme pallor of both discs with an obscuring of the outlines. Voluntary movements of the eyes were limited in all directions. There was slight facial weakness on the right side and total deafness on the left. There was spastic paresis of all extremities; more marked on the right. The deep reflexes were hyperactive. No abdominal reflex was obtained on the right. Ankle-clonus and the Babinski were obtained on both sides. Gordon and Oppenheim reflexes were elicited. There was generalized weakness of the right arm and the movements of the lower extremities were not coordinated. The muscle sense and touch, pain and temperature sensibility appeared to be normal. The Wassermann was reported negative for both the blood and the spinal fluid.

Fig. 9. A lateral view of the skull of an adult suffering from communicating hydrocephalus.

Fig. 10. A lateral view of the skull of a patient suffering from an internal hydrocephalus probably caused by a midbrain tumor.

A lateral view of the head, made following injection is shown in Figure 10. The skull is definitely enlarged and shows in the posterior parietal region, the convolutional atrophy which is usually a result of long-continued intracranial pressure. The cisterna magna, the fourth ventricle and the basilar cisterns are filled with air. The remaining ventricles and the sulci are not filled. This suggests an obstruction in the aqueduct of Sylvius. The fourth ventricle appears unusually large, and we are at a loss to explain this finding. It has occurred to us that in such cases the filling of the sulci is prevented by the increased intracranial pressure. In order to diagnose this case more definitely a ventricular puncture should be done through a trephine so that the lateral ventricles might be studied. They should show a marked dilatation. A clinical diagnosis of midbrain tumor probably arising in the quadrigeminal bodies was made.

SUMMARY

Injection of the subarachnoid space with air appears to be a relatively safe procedure where the cases are properly selected. The after-effects of the injection are not serious. The proper interpretation of roentgenograms of the skull made following such injections should aid materially in improving the mortality statistics now credited to brain surgery.

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TUBERCULAR EPIPHYSITIS OF THE GREATER TROCHANTER*

BY D. Y. KEITH, M.D.

LOUISVILLE, KENTUCKY

THE case reported in this paper aroused interest when we began to search the literature for a description of this particular lesion. Only two of six recent textbooks of orthopedic surgery, used in our search, mentioned this type of infection, and then only very briefly. One showed a poor reproduction of the condition with no description of it.

In Peabody's report† he states that the index of all diagnoses made in the wards in the Massachusetts General Hospital since 1870 showed tuberculosis of the greater trochanter occurring only 5 times. During the past ten years the diagnosis of bone or joint tuberculosis had been made 3,062 times, and in that period only 3 times did the diagnosis of tuberculosis of the greater trochanter appear. None of these was operated on in the early stage, all developing abscesses and breaking down spontaneously; secondary infection, sinuses, recurring abscesses, etc., following.

The case reported by Peabody is the only one found in the medical literature at our command, and he states that in the current medical literature for the past ten years he has found no case reported.

Case Report. Male, aged twelve. No history of tuberculosis in the family or associates.

Personal History. Boy has had the diseases of childhood. No other serious illness. Has no local adenopathy. At age of two years drank a small quantity of kerosene and was said to have shown sugar in his urine for a period of nearly two years subsequently. (Mother's statement.)

Present History. In November, 1920, during a rest period at a football game, his feet were forcibly knocked from under him by a larger boy. This caused him to

* Read at the Midwinter Meeting of the Central Section of The American Roentgen Ray Society, Chicago, Ill., February 22, 1922.
† *Boston M. and S. J.*, June, 1921.

fall, striking directly on the greater trochanter of the right femur. He suffered considerable pain and it was with difficulty he was able to walk to his home. He did not complain during the following few days, though he says he felt quite sore; and his mother insists that for several weeks following the accident he had a decided limp. For several weeks he was under the care of a physician, and on January 13, 1921, he was x-rayed by Drs. Hickey and Evans. The report follows.

"Plate made of the pelvis shows normal appearance of the head of the femur. The right trochanter in its epiphyseal development shows marked irregularity and quite a change from the normal appearance, as indicated by the trochanter of the left side. We think there has been a localized injury here which has resulted in irregular bone proliferation. There is also a slight change in the angle of the neck. We see no change, however, in the epiphyseal line of the head of the femur, which we would expect if this were to be regarded as a case of adolescent rickets. Plate was made of the femur which shows no evidence of injury to the shaft."

FIG. 1. Examination April 7, 1921. Note the bony irregularity on the diaphysis. Note the irregularity and destruction of the epiphysis for the greater trochanter. Note the infiltration in the soft structure above the epiphysis.

Patient was first seen by us on April 7, 1921. He was a well-developed boy of the washed-out blond type, presenting a tumor over the right hip posteriorly and laterally, with enlargement of the superficial veins. Motion in all directions was restricted and painful.

On aspiration of the tumor by the surgeon, a few drops of turbid fluid were obtained, which, on microscopic examination, revealed no information.

Roentgen-ray examination of the pelvis showed the left hip and trochanter normal. The epiphysis for the trochanter on the right side showed a definite area of bone destruction on the superior and external aspects, extending down to the external portion of the adjacent diaphysis. There were bone proliferation and islands of bone in the surrounding soft structures, definitely separated from the diaphysis of the femur and the epiphysis of the greater trochanter. The bone destruction from the epiphyseal line of the trochanter extended on the diaphysis for approximately 1 cm., ending in a spur of elevated bone 1 cm. in height. There was no change in the acetabelum or head of the femur. The epiphyseal line for the head of the femur was normal.

FIG. 2. Examination Jan. 13, 1922. Note the smooth contour of the epiphysis of the greater trochanter as well as the area on the diaphysis, and the lessened density of the soft structures.

In the soft structures above the right trochanteric epiphysis there is a shadow the size and shape of a normal kidney ($2\frac{1}{2}$ by 5 inches), which is much more dense than the surrounding soft structures, though more radiable than the normal bone; this shadow is probably a thickening of the dense fascia lata from infection.

Roentgen Ray Diagnosis. 1. Neoplasm, destructive sarcomata. 2. Osteomyelitis, probably tuberculous.

Operation by Dr. B. F. Zimmerman on April 22, 1921. The mass was incised and the macroscopic appearance was that of a degenerated tumor. There was a thin turbid fluid in the fascial planes, which was removed, and a piece of the tissue was excised for microscopical study. The wound was left open for the purpose of radium application, should it prove malignant. The tumor mass was disturbed as little as possible.

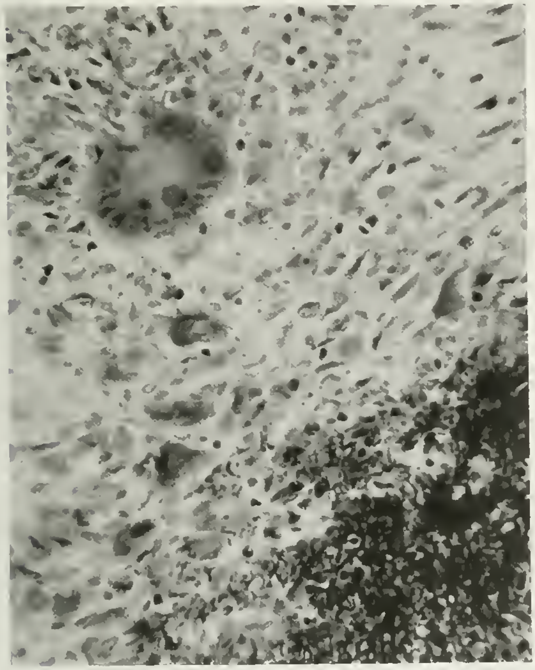


Fig. 3. Photomicrograph of greater trochanter of the epiphysis showing typical tubercles. (Signed) Stuart Graves, pathologist.

Clinical and Surgical Diagnosis. Degenerated sarcomata.

Microscopical examination by Drs. Stewart Graves and J. D. Allen showed a number of tubercles in almost all the sections.

Diagnosis. Tuberculosis.

On April 29, 1921, the boy was again subjected to operation. The incision was enlarged and all the fungoid material removed. The bone was curetted and the wound packed with iodoform gauze. The recovery was entirely satisfactory, the wound healing completely in three months' time, there being very little discharge at any period. The pathologist's report follows.

"Gross description: Specimen consists of several bits of pinkish gray, soft tissue, the largest 20 × 8 mm. Microscopical diagnosis: 1. Tuberculosis. 2. No evidence of neoplasm."

Roentgen-ray examination on Aug. 16, 1921, showed a definite spur on the diaphysis of the right femur near the trochanteric epiphyseal line. The epiphysis of the right greater trochanter was quite irregular, though of the same density throughout. There was very little infiltration of the soft structures.

Patient was last seen January 13, 1922, and presented over the greater trochanter a thick though flexible scar, $5\frac{1}{2}$ inches in length and $2\frac{1}{2}$ inches in breadth, with a decided depression over the upper portion of the greater trochanter. There was a tendency to keloid formation in the scar.

Roentgen-ray examination (January 13, 1922) showed that the irregular bone which has been described was smooth both on the femoral diaphysis and the epiphysis of the trochanter. There are, however, a few islands of bone in the soft structures but with very little infiltration.

CONCLUSION

The clinical history, physical and roentgen-ray examinations pointed toward a neoplasm. There was a definite history of trauma, followed by a limp, and formation of a tumor in the soft structures with marked enlargement of the superficial blood supply. The definite hypertrophy of superficial blood-vessels is quite characteristic of sarcomata. The amount of bone destruction without bone production seen upon the roentgenogram, according to Baetjer, would correspond to a bone tuberculosis, as he definitely states that there is never any new bone produced in a tuberculous bone infection unless a mixed infection is introduced after operation with a resulting sinus tract.*

With the amount of destruction of bone of the trochanteric epiphysis with extension on to the diaphysis, and increase in density of the adjacent soft structures with a definite tumor shadow, which we now know was the wall of the abscess cavity, a diagnosis of infection should have been positive.

The epiphysis of the greater trochanter is not different from the epiphyses in other locations and is probably more frequently infected with tuberculous bacilli than has been reported in the literature. Bone infection is certainly more frequent than new growth.

In this case bony changes were noted by roentgen-ray examination sixty days after injury, though no diagnosis was made by roentgenologists of unquestioned ability and very wide experience.†

If we have from our original plates, lantern slides and reproductions given information contributing to better diagnoses by roentgenologists, our purpose in presenting this paper will have been accomplished.

DISCUSSION

Dr. Hickey. The presentation of this case is certainly very interesting and I think Dr. Keith is to be complimented on the way he has worked it out. At the time we saw the patient his appearance was such that we did not think he had a sarcoma, and we did not feel like making a diagnosis from the plate. The patient disappeared from our observation and we were very glad to hear from Dr. Keith regarding him. I must confess that I still have a lurking suspicion that it might be sarcoma. I would like to know whether any cultural inoculations in animals were made with pieces of tissue or whether the tissue was stained for tubercle bacilli. Between a pathologist and a clinical surgeon of good experience I think I would take my choice with the diagnosis that the surgeon makes against the microscopic diagnosis. My reason is that often the diagnosis based on microscopic tissue is made from very small pieces which are not always characteristic of the entire lesion, whereas the surgeon has a chance to see the lesion in its entirety.

Dr. LeWald. My mind seems to run along the same lines as Dr. Hickey's. I would like to have absolute proof that the tuberculous nature was established beyond doubt. We did the same thing in our first case of syphilis of the stomach. The pathologist reported that it was tuberculous. We immediately asked for a revision of his study and whether he could demonstrate tubercle bacilli. He went so far as to state that he could not prove that this was a tuberculosis, and he was willing to admit that the opinion of the surgeon was correct—that this case was syphilis of the stomach. As time went on, it was proved beyond doubt that it was. I think if one wants absolute proof of tuberculosis, inoculation of animals with the tissues should be made.

We had a case in which an extraneous shadow proved to be a bursitis of the trochanteric bursa. That case was clinically diagnosed as probably a sarcoma involving the trochanter. It was the bursa overlapping the trochanter, and at operation it was found that the trochanter was filled with broken-down material; but there was every indication that it was a bursitis. That was an older patient, an adult case. I think Dr. Keith's case is of great interest.

Dr. Evans. I believe the figures are misleading and that there are more of these cases. I cannot give the figures available but I am sure that we have seen more than a dozen cases of infection of the greater trochanter, not only infected with tuberculosis but with acute infections. I believe the primary lesion is a bursitis and the general involvement is secondary to the involvement of the bursa. I believe it is very common and that this is a rather favorable location for the infection.

Dr. Keith (closing discussion). I want to thank the gentlemen for the discussion. My mind runs very much like Dr. LeWald's and Dr. Hickey's—I was sure this was a sarcoma and I stated this in the report. That was the clinical diagnosis and also the operative diagnosis, but the tissue was submitted to two pathologists, one of whom is known to be very accurate as far as technique is concerned, who will not express himself unless he is very positive. He reported on both examinations that it was tuberculosis. The other man said that the mere fact that there were tubercles present was evidence that it was an old healed area, but that there was no absolute proof that it was not malignant.

As for inoculations in animals, I am sure there were none made. It was not in the report. The fluid obtained on aspiration showed nothing on cultures; it was absolutely sterile. As to whether there were any cultures made at the time of operation, I do not know.

In Peabody's report he mentioned several

* Baetjer, F. H. and Waters, C. A. Injuries and Diseases of the Bones and Joints. New York, 1921.

† Note. June 15th, 1922. To date the patient remains well, which we believe should verify [illegible] the diagnosis of a tubercular epiphysitis instead of sarcoma.

cases of bursitis which he had seen. He reports two cases, one of sarcoma and one of tuberculosis, in both of which they missed the diagnosis. The cases were operated on at the same time and were in the wards together.

Whether the figures are misleading, I cannot say, as we are simply reporting the figures in the literature. I think it is a very difficult thing to tell whether we were dealing with sarcoma or infection.

THE EFFECT OF RADIUM ON THE NORMAL TISSUES OF THE BRAIN AND SPINAL CORD OF DOGS, AND ITS THERAPEUTIC APPLICATION*

BY EUGENE P. PENDERGRASS, M.D., J. M. HAYMAN, JR., K. M. HOUSER AND V. C. RAMBO

Departments of Roentgenology and Surgical Research

University of Pennsylvania

PHILADELPHIA, PENNSYLVANIA

THE discovery of the selective action of radium upon tumor cells together with the daily crying need for tumor therapy has created a somewhat unusual condition in modern medicine. A large amount of interest centers around the action which radiation has upon malignant cells, and some of the most detailed studies have been made by investigators in this connection. This, however, is but one aspect of the effect of the rays upon the living cell, and we believe that an increased knowledge of the reactions exhibited by normal tissues is necessary before the real nature of the processes set up by radiation can be revealed. To treat properly any malignant tumor, one must know, if possible, the effect of radium upon the normal as well as the malignant cells. There has been comparatively little work done to show the effect of radiation on the brain; then, too, there is some discrepancy in the dosage due to the impure salt used, and the doses given have been so small that they would be of little value in therapeutic application.

Such a situation makes it necessary to discover and emphasize not only the possibilities, but also the limitations and the dangers which are inherent in a substance which possesses the powers for good or evil that are characteristic of radium.

In this paper we wish, therefore, to present the results of an experimental study of the effects of radium radiations upon the normal tissues of the brain and spinal cord of dogs, both by surface application and implantation. This work was begun with the purpose of determining the safe limit of dosage for work on these tissues in the human being, but certain findings have made it advisable to consider the subject from a broader standpoint, and to bring together and weigh the results of the work, which can be found in the literature. We will consider the clinical symptoms, gross effects, and microscopical pictures produced by various doses applied to the brain and spinal cord. For our present purposes the microscopical study must of necessity be limited to the practical consideration of the matter of the distance to which the rays penetrate, as shown in the sections. A more intensive study of the extremely interesting sections must be reserved until time and opportunity permit a study which shall give a comparison of our findings with known lesions of the brain and cord. We will have to consider the general effects of radium, the manifest toxemia, and finally, certain findings which may throw some light on the nature of the general effects which we have observed.

Danysz[1] was the first worker to study the effects of radium upon the tissues of the central nervous system. He placed a tube containing one centigram of a "very

*A Leonard Prize Paper

active" radium salt over the spine and part of the skull of a mouse one month old, the tube being placed beneath the skin. The mouse developed paralysis and ataxia in three hours, convulsions in seven hours, and died in eighteen hours. Mice one year old treated the same way did not die for six to ten days. Three guinea pigs, eight to twelve days old, which had had the same tube beneath the skin over the lumbar cord for twenty-four to forty-eight hours, developed a complete paralysis of the posterior part of the body in one to three days, and died with convulsions a few days later. Adult guinea-pigs and rabbits, similarly treated, showed no nervous lesions. They succumbed some weeks after operation, probably as the result of infection due to the destruction of the skin. An adult rabbit which had had the tube on its dura for eight hours, a trephine opening having been made, showed no symptoms for two days, but developed a hemiplegia on the third day.

In a later paper[2] Danysz records the results of exposing mice, confined in small wooden cages to 23 and 50 mgm. of radium bromide, which was fastened in a hole in the lid of the cage. The duration of exposure varied from four hours to twenty days. The reactions consisted in alopecia, dermatitis, paralysis and death, the latter occurring in from ten to forty-four days, depending on the age of the animal and the length of exposure. Microscopic examination showed, especially, vascular disturbances, broken capillaries and the nervous substance "swimming" in the blood. No changes were found in the nerve cells.

Schotz,[3] after fastening 25 mgm. of a radium salt on the heads of rabbits for one to three hours, found a peculiar intense injection of the meninges. He found similar changes in mice, exposed in small chambers, but no gross areas of softening. No microscopic report is given.

London[4] exposed young mice in a small glass cage to 30 mgm. of radium bromide fastened upon the cover. They all died in four to five days. The first symptoms were reddening of the ears, blinking, sleepiness, and weakness, followed by paralysis, coma and death. The reflexes were increased during the coma. At post morten he found hemorrhages into the subcutaneous tissue and dura, and the greatest microscopical changes in the skin and cerebral cortex. In another paper[5] he reports the finding of atrophic nerve cells in the cords of three rabbits exposed for a long time to a small amount of radium.

Heineke[6] found deep hemorrhagic areas of softening, spreading from the site of application in a rabbit which had carried 20 mgm. of radium bromide on its head for fourteen days, the dosage being 6,720 mgm. hours. The rabbit was well until the third week, when it died with general spastic symptoms.

Obersteiner,[7] working with mice, found that a diffuse radiation of the head produced large and small hemorrhages into the cerebrum, cerebellum, and medulla, with some round cell infiltration around the vessels. The nerve cells were for the most part unaltered, some of the anterior horn cells in the cord, however, showing changes in the granules. He notes that while the severity of the symptoms depends on the age of the animal, the duration of exposure, and the amount of radium used, there seems also to be a variable factor of resistance in different individuals. The different symptoms after exposure are, for the most part, directly or indirectly, the expression of the circulatory and metabolic changes produced by the radium, and the impressive symptoms referable to the nervous system are accounted for by the fact that this system responds most easily to the influences mentioned.

Alquier and Faure-Beulien[8] found only minute hemorrhages, without discoverable change in the nerve elements, after therapeutic applications of radium, applied externally to the heads and cords of rabbits. There was no disturbance of the general health.

In the above experiments, except those of Danysz, the radium was placed either on the scalp or some distance above in the roof of the cages, and radiation was with unfiltered rays.

Horsley and Finzi[9] placed 55 mgm. of radium bromide on the pre- and post-central gyri of monkeys for two and a half to four hours. The rays were filtered through 0.5 mm. of platinum and 1 mm.

of rubber. No animals showed any symptoms up to the time they were killed, after twenty-six to forty-five days. Examination of the brains showed thickening of the dura with an infiltration of the pia and arachnoid by erythrocytes and leucocytes. There was an endothelial proliferation in the blood-vessel walls, in some places, even occluding the lumen. There were punctate hemorrhages in the first two layers of the cortex. No changes in the nerve-cells were found, except where hemorrhage had taken place.

In comparison with this, the results of Wago[10] obtained by exposing the surface of the brain of rabbits to the radiations from a Krommayer mercury quartz lamp, are interesting. He found chromotalysis, kariolysis, karyorrhexis and other changes in the nerve-cells, most intense in the superficial layers of the cortex. He could not recognize any change in the neuro-fibrils even when the cells were well degenerated. Young rabbits were much less resistant than full-grown ones.

Williamson, Brown and Butler[11] reported the effect of doses of 200 to 900 mgm. hours on the normal brain tissue of the dog, the tubes being placed beneath the dura on the surface of the brain. None of the dogs showed any clinical symptoms up to the time they were killed three weeks after operation. Two dogs which were not killed showed no symptoms up to seven weeks. At autopsy the surface of the brain showed an area of hyperemia down the center of which was a black necrotic strip. Microscopically the great majority of the cells in this area were completely destroyed, the blood-vessel walls were three or four times their normal thickness, hyalinized, and congested, but their walls were intact. Marking the area of necrosis was a circle of hemorrhage, where the vessels were not thickened, but had ruptured. Beyond this area the vessels were congested but their walls and the nerve-cells in this region appeared normal.

Halkin,[12] after exposing small areas of the skin to a small amount of radium salt for one to two hours, could discover no histological change after twenty-four hours. The first change, seen on the third day, was a widening of the capillaries, followed in a few days by a slight perivascular infiltration, followed by swelling and vacuolization of the endothelial cells. Still later, the capillaries had become broad blood spaces, with small hemorrhages around them. This was regarded as a paralysis rather than an inflammation, for the infiltration was slight. This early and pronounced effect of radium on the small blood vessels has been noticed by many later observers, and is often looked upon as a primary and perhaps essential effect, upon which all other findings are to be based.

We have applied doses of 1,000–2,600 mgm. hours well-filtered radium to the brain cortex, doses of 450–1,000 mgm. hours unfiltered radium implanted into the brain substance, by means of radium needles, and doses of 300–1,200 mgm. hours well-filtered radium applied to the dorsal cord. For all operations the dogs were under surgical anesthesia with ether. The side of the head was shaved and painted with iodine. An incision was made from above and behind the eye to above and in front of the ear, extending down to the temporal muscle. The muscle was cut downward and forward, in the direction of its fibers, retracted laterally, and a trephine opening 1 cm. in diameter made in the skull. This was enlarged with rongeur forceps, as was necessary to accommodate the radium tube, or to allow the insertion of the needles. On account of the size of the tube and needles used, it was necessary to make the opening over the parietal lobe. Radiation of the motor area alone, which might have given results of some interest, was impracticable on account of the size of the tube, the shape of the dog's skull, and the forward position of the motor area in the dog's brain. When a tube was used, the dura was not opened, the tube being placed on the dura. The dura is not thick enough to have any appreciable effect on the rays, and the removal of the radium was greatly facilitated, and the danger of mechanical injury to the brain lessened, by this method. In the first operation when the tube was inserted beneath the dura the mechanical injury gave rise to a hernia cerebrae, and consequently this method was abandoned. The muscle was sutured, and the subcutaneous tissue and skin sutured separately. A silk thread was attached to the tube, (or needle), brought out through the muscle and subcutaneous tissue, and folded under the skin, which was sutured over it. When the radium was to be removed, this silk thread was caught on a blunt dissector, and the tube gently drawn out. Another stitch was then put in the subcutaneous tissue where the thread had been, and the skin wound closed. Attempts were made to protect the muscle from the rays by placing a small piece of lead over the tube, but so much difficulty was experienced in removing it, that it was not done routinely. The tubes used for the surface application measured 2–2.8 cm. long, .3–.5 cm. in diameter, and were .4–.5 mm. thick. They were made of platinum or silver.

With the exception of one dog (22) all dogs receiving a dose of 1,150 mgm. hours or below gave no symptoms until necropsy was performed. Dog 22 was a dog which had been operated on before, a gastroenterostomy having been done with a low loop of bowel. At autopsy no gross lesion could be found in the brain. To what degree death was due to the previous operation, or whether the radium had a much more severe effect upon this dog in his weakened condition than it would have had on a normal dog, is problematical.

All dogs, except one, receiving a dose of 1,400 mgm. hours or above, died. The exception (dog 20, Table I) is supposed to have received a dose of 2,500 mgm. hours, which should have caused death in about fourteen days. There is a possibility that the dog only received 1,250 mgm. hours, due to the fact that the radium might not have been placed in one of the silver capsules inserted into the cranial cavity. Another possibility of error is that the radium capsule might have slipped out of the cranial cavity into the muscle flap. This seems improbable, however, as there was no necrosis of the muscle flap. The only other explanation we have is the possibility that we may be dealing with an increased individual resistance in this particular dog.

The gross lesions of the brain found at autopsy varied greatly, the variation depending upon the time that had elapsed

Table I

EXPERIMENTS ON SURFACE APPLICATION

Dog No.	Dose in Mgm. Hrs.	History	Result
29	360	No symptoms for 2 months. For a while seemed blind and showed peculiar circus movements. Seemed to recover.	Killed after 10 months
30	900	No symptoms for 2 months. Occasional convulsions during the summer, but none for 4 months before death.	Killed after 9 months.
22	500	Gradually grew weaker after operation. See below.	Died in 7 days.
28	542.5	....	....
19	1,000	No symptoms.	Killed the 14th day.
17	1,150	No symptoms for 7 weeks.	Killed the 49th day.
1	1,400	No symptoms for 3 weeks. Then restlessness, followed by gradually increasing weakness.	Died 28th day.
9	1,800	....	Died 17th day.
5	2,100	No symptoms for 1 week. Then vomited some. Developed weakness of the hind legs during 2d week. Superficial infection in skin incision.	Died 14th day.
27	2,200	No symptoms for 1 week. Eighth day sick, gradually grew weaker. Fourteenth day lay quietly on side, could not be aroused. No localizing symptoms. Killed. Viscera negative.	Killed 14th day.
16	2,300	Well 1 week. Eighth day slight weakness right side. Eleventh day very weak. Unable to stand. Lay helplessly on side; could not be aroused.	Killed 11th day.
14	2,400	Well 1 week. Ninth day languid and a little weak. Tenth morning very sick; could not be aroused. Died about noon.	Died 10th day.
20	2,500	No symptoms for 4 weeks.	Killed 29th day.
18	2,600	Well 4 days. Weak and sick on the 5th.	Died 6th day.

since the radium application. Thus a dog which died one week after receiving a dose of 500 mgm. hours showed no gross lesion, as mentioned above. Dogs with doses of 2,300–2,600 mgm. hours and living eleven days or less presented a dark reddish-brown, apparently sharply circumscribed, oval area on the surface of the brain, studded with bright red dots. This area averaged 20 × 10 mm., and extended inward 10 mm. from the surface of the brain at its deepest point. In two dogs with smaller doses, 1,800 and 2,100 mgm. hours, which lived slightly longer, seventeen and fifteen days respectively, the color of this apparently sharply circumscribed area had changed to a dull grey, and was surrounded by a darker grey halo. On cross section, the area still appeared sharply circumscribed. In these dogs there was no disturbance of the contour of the brain surface. A dog killed on the forty-ninth day, after having survived a dose of 1,150 mgm. hours, and showing no clinical symptoms, presented a similar area, but of a decided yellow color, measuring 15 × 23 mm. In the center of this area was an excavation, with irregular jagged base and margins, 12 × 16 × 3 mm. Cross section showed that the necrotic area extended into the brain 12 mm. from the surface. Beyond this area were small punctate hemorrhages as far as the internal capsule. These small punctate hemorrhages were also seen in a dog dying twenty-eight days after a dose of 1,400 mgm. hours.

A dog killed ten months after an exposure to 360 mgm. hours of radium, and showing the clinical symptoms mentioned above, presented at autopsy a healed scar on the surface of the brain in the parieto temporal region. This area was greyish in color and slightly depressed. The area measured 15 × 8 mm. Cross section showed a dark brown, irregular area extending 8 mm. beneath the cortex. While the outline of this area was irregular, its margin appeared very sharp and distinct from the grossly normal brain tissue beyond.

Another dog which was killed nine months after an exposure to 900 mgm. hours showed at autopsy a large, fairly well defined, irregular, crater-like excavation on the left parieto temporal region. The edges of the crater were rough and jagged, with shreds of necrotic tissue hanging from them. This crater measured 20 × 10 mm. Lying loose in this cavity at autopsy was a shrunken laminated blood clot, covered on the outside with yellow hemosiderin pigment. On cross section the blackened homorrhagic and necrotic area extended into the brain substance 10 mm. from the edge of the crater, which was 15 mm. deep at its deepest point. Grossly this area of necrosis and hemorrhage, while irregular, was sharply circumscribed.

One of the questions of vital importance is the extent of the effect of the radium. This problem might be approached in two ways, both of which methods we have followed to a certain extent.

The first method would be to expose the brain to small doses of radium, and then compare the area of destruction of the brain after the animal had lived a long period of time with the lesions produced by similar doses at earlier stages. The purpose of such a procedure would be to determine whether the area involved is greater in dogs living for a long period than appears in dogs living a shorter time. From this standpoint, the extent of the destruction in the dogs allowed to live a year is found to be considerably greater than that seen after three weeks. From this finding it is evident that the effect of radium is more insidious and far-reaching than could be concluded from short-time experiments, and its full effect can only be seen after a long time.

The second method of study of this particular problem is by the application of refined histological methods. This is manifestly a special part of the work, and will require a comparison with known pathological conditions of the nerve cells, and therefore a detailed description of these results does not belong in a general discussion of the problem.

At the present time we are amply justified in stating that far-reaching effects upon the cells are demonstrable in sections. These findings fully explain the gross lesions seen in the long-time experiments just described; definite conclusions as to the nature of these cell changes can only be reached by comparison with recognized changes in nerve-cells due to causes other than radiation, a study manifestly exceeding the scope of this paper.

The sections show distinct evidence of involvement of the various tissues of the brain, at least as far again as the areas of necrosis and hemorrhage seen grossly. The salient changes are endothelial proliferation of the intima of the blood-vessels, perivascular infiltration, and degenerations of the nerve-cells and fibers.

In this connection it is interesting to bear in mind the work of Hertwig,[13] who found that radiated spermatozoa still possessed their general cellular function of penetrating the ovum, thus starting the process of fertilization, but had lost their specific nuclear function whereby the nucleus of the spermatazoon takes an equal part with the nucleus of the ovum in development. From the standpoint of the nuclei the egg developed parthenogenically. In other words, the radium has exerted an effect upon the nucleus of the spermatozoa, too delicate to affect the function of the cell as a whole, but which could be clearly demonstrated by loss of specific nuclear function. Therefore, in judging the effect of radiation, the possibility of delicate nuclear changes far beyond extent of gross lesion and even beyond the extent of histological demonstration should be borne in mind.

The radium needles used for implantation measured 2.8 cm. long and 1.5 mm. wide, and contained 10 and 12½ mgm. of radium. They were made of thin non-corrosive steel, which, being very thin, does not act as a good filter; thus allowing the penetration of a large percentage of beta rays. The needles were sterilized in 10 per cent formalin solution for fifteen minutes and in 95 per cent alcohol for forty-five minutes. Two needles were used in each dog. A small opening was made in the dura, over the parietal lobe, one needle inserted in a forward direction, toward the motor area, keeping it nearly parallel with the surface of the brain, at a depth of about 7 mm., in order to avoid striking the internal nuclei: the other implanted vertically in a similar maner, running toward the temporal lobe.

The first striking result of these implantation experiments compared with surface application is the much more rapid development of a general toxic condition, as shown by dogs 23 and 24. The development of a general peritonitis in two of the others, without local signs of infection, would point to a general lowering of resistance by the radium, and even the fifth dog, in spite of the meningitis, showed a generalized infection not usually associated with post-operative meningitis.

Table II
IMPLANTATION EXPERIMENTS

Dog No.	Dose in Mgm. Hrs.	History	Result
23	360	No symptoms for 2 days. Then began to be sick, general weakness, especially in the hind legs. Sixth day very sick, could hardly be roused, rapid difficult breathing. No local or general infection.	Killed 6th day.
2	450	No symptoms for 5 days, then restless, and gradually increasing weakness. Post mortem, meningitis, pleuritis, peritonitis, pericarditis, multiple abscesses in liver, hemorrhagic pancreatitis.	Died 7th day.
8	450	No symptoms for 5 days. Very weak by eighth day. Eleventh day general clonic convulsions. Post mortem peritonitis, viscera negative except congested kidneys.	Killed 11th day.
4	900	Dog sick and languid all the time. Post mortem, generalized peritonitis, viscera negative.	Died 5th day.
25	Control	Glass rods size and shape of needles used. No symptoms up to 17 days. Post mortem, viscera showed nothing abnormal.	Killed 17th day.

It seems almost unnecessary to point to the fact here that radium is not very effective on bacteria, and that therefore radium needles must be carefully sterilized and inserted under the most strict aseptic precautions. But even then, we believe, the strange results we have here recorded can only be explained on the hypothesis of the lowering of the resistance of the entire body to invading micro-organisms.

More intense reactions would naturally be expected from implantation of the radium into the brain substance than from the surface application of an equivalent dose, as, in the former instance, the brain is receiving the entire radiation, whereas in the latter, approximately half of the radiation is lost. However, the results from implantation seem to point to an effect not observed at all with surface application. This, we feel, is due to the fact that in the implantation experiments, radium needles were used. The thin steel surrounding the radium was a poor filter and the brain substance received a large quantity of beta ray radiation. This in addition to the gamma ray radiation, caused the intense reaction, and subsequent toxemia.

In the application of radium to the spinal cord, an incision was made over the spinous processes corresponding with the segments of the cord noted below; the muscle masses were separated on either side from the lamina. Three spinous processes were cut off with bone forceps and the lamina removed with rongeur forceps until there was sufficient room to place the radium tube on the dura over the cord. The wound was closed by the same method as that used in the head operations, and the same method of removing the tube was employed.

Table III

EXPERIMENTS ON SURFACE APPLICATION TO THE SPINAL CORD

Dog No.	Dose in Mgm. Hrs.	History	Result
13	300	No clinical symptoms.	Killed 48th day.
11	600	Developed weakness in the hind legs followed by spasticity in 6 weeks. This went on to a spastic paralysis in the 7th week. Complete paraplegia. Moderate spasticity of thigh muscles, virtually none in lower leg. Flexion and crossed extension, reflexes feeble. Scratch and stepping reflex and extensor thrust could not be elicited. Patellar reflex brisk.	Killed in 10th week.
10	900	Eighth thoracic segment. Marked spasticity of hind legs in 2 weeks. Spastic paraplegia in 3d week.	Killed end 4th week.
12	1,200	Twelfth thoracic segment. Spastic paralysis of hind legs before end 2d week.	Killed end 2d week.

In none of these dogs was there any involvement of the sphincters. There was no paralysis of the forelegs. Attempts to test for loss of sensation were unsatisfactory.

Grossly a slight discoloration at the level of the lesion in dogs 10 and 12 was all that could be seen. Histologically dogs 11, 10 and 12 showed tract degeneration and various degrees of changes in the nerve-cells for two segments above and below the lesion. Dog 13 showed an appreciable amount of tract degeneration and abnormal nerve cells at the level of the lesion. The fact that marked clinical symptoms are produced by an exposure of 600 mgm. hours, a dose which produces only a very insignificant gross lesion, indicates the probability of extensive and serious physiological changes in the brain far beyond the extent of the gross lesion. This is borne out in the histological sections. Hence great caution must be used in estimating the effect of a dose of radium by the size of the gross lesion produced.

The local tissue destruction is by no means the only effect of the application of radium to the surface of the brain.

There is a considerable increase in the weight of the radiated hemisphere, ranging from 12.6 to 42.8 per cent. This fact was stumbled on by accident when a number of experiments had already been completed; so that the list of weighed brains does not include the entire series.

The weights of the two hemispheres of 9 normal dogs which had been obtained after pharmacological experiments showed an average difference in weight of 0.63 per cent, and a maximum difference of 1.8 per cent (Table IV). This small difference in the two hemispheres of the brain is rather striking when the normal variations in the weights of the other paired organs of the body are considered. A similar correspondence in the weights of the two hemispheres in sheep has been found by Donaldson.[14]

He found an average difference of 1 per cent in a series of 53 cases.

The weights of 6 treated brains are seen in the accompanying table (Table V). The brain of dog 22 which died one week after operation, showed a difference of only 1.1 per cent, which is within the normal limits.

It will be noticed that the increase in weight of the treated hemisphere seems to bear more relation to the time the dog lived after operation than it does to the doses of radium. Thus dogs 16 and 19 with doses of 1,000 and 2,300 mgm. hours respectively, showed practically the same increase of weight. On the other hand, dog 20, which received a dose of 2,500 mgm. hours, but lived until killed on the twenty-ninth day, showed the greatest increase. In this brain the difference was easily appreciable to the eye. The whole hemisphere looked bigger, the convolutions were flattened, the sulci less prominent, and on section the tracts of white matter appeared much broader in the treated than in the untreated hemisphere.

Table IV

WEIGHTS OF NORMAL BRAINS

Dog No.	Left Hemisphere, Gm.	Right Hemisphere, Gm.	Left Heavier, Gm.	Per Cent	Right Heavier, Gm.	Per Cent
1	30.84	30.96	0.12	0.3	....	...
2	22.35	22.28	0.07	0.3	....	...
3	40.51	40.69	....	...	0.18	0.4
4	29.99	30.21	....	...	0.22	0.7
5	22.95	23.01	....	...	0.06	0.2
6	33.78	33.26	0.52	1.6	....	...
7	27.78	27.81	....	...	0.03	0.1
8	29.94	30.49	....	...	0.55	1.8
9	32.75	32.85	....	...	0.10	0.3

Average difference 0.63 per cent. Maximum difference 1.8 per cent.

Table V

WEIGHTS OF TREATED BRAINS

Dog No.	Dose in Mgm. Hrs.	Treated Hemisphere, Gm.	Untreated Hemisphere, Gm.	Difference, Gm.	Per Cent Increase
22	500	30.44	30.10	0.34	1.1
19	1,000	36.28	31.11	5.17	16.5
27	2,200	38.85	30.42	8.43	27.7
16	2,300	35.45	30.45	5.00	16.4
20	2,400	39.08	27.35	11.72	42.8
18	2,600	36.40	32.30	4.10	12.6

An attempt was made to determine, if possible, whether this increase of weight in the radiated hemisphere was due to edema. The brain of a dog killed two weeks after an exposure to 1,000 mgm. hours of radium was carefully removed, separated from the cerebellum, and the brain stem divided just above the corpora quadrigemina. The forebrain was then cut into three pieces by a transverse cut, and then into six parts by a longitudinal cut. Each piece was then placed in a separate glass desiccating jar and weighed. They were then frozen by placing the jars in the refrigerating apparatus used for storing cadavers, for twenty-four hours. Next the jars were put into a desiccating oven and dried in vacuo at a temperature of 48°C. to constant weight. From these weights the total wet and dry weights of each hemisphere were calculated. A second brain, that of the dog which survived the dose of 2,500 mgm. hours, was treated in a similar way, except that the temperature of the oven was increased to 98°C. The weights of these two brains are seen in Table VI.

Table VI

TOTAL SOLIDS IN RADIATED AND NORMAL HEMISPHERES

Dog 19. Dose 1,000 mgm. hrs.

	Radiated Hemisphere	*Unradiated Hemisphere*
Wet weight	36.26	31.11
Dry weight	7.15	6.86
Per cent solids	19.7	22.0
Per cent water	80.3	78.0
Radiated side heavier.. Wet weight, per cent		16.5
Dry weight, per cent		4.3

Dog 20. Dose 2,500 mgm hrs.

Wet weight	39.08	27.35
Dry weight	6.24	5.42
Per cent solids	15.9	19.8
Per cent water	84.1	80.2
Radiated side heavier.. Wet weight, per cent		48.2
Dry weight, per cent		15.1

The increase in the dry weights of the radiated hemispheres, and the consequent rather close agreement of the percentages of solids and water in the two hemispheres is rather difficult to explain. There would seem to be three possibilities; first, that there had been a cellular increase in the radiated hemisphere, due to the action of the radium. The second possibility is that the radium has given rise, directly or indirectly, to a process of hydrolysis, so that some of the water is held in chemical combination and is not lost by desiccation at the temperature used. The third possibility is that the increase in dry weight is due to the solid matter derived from lymphatic fluid which had previously occupied the hemispheres giving rise to an edematous condition of the treated side.

The first proposition is responsible for this increase in dry weight only in a very small degree, if at all, because histological study shows no such extensive cellular infiltration or proliferation.

In attempting to prove or disprove the second idea, the total nitrogen of the treated and untreated hemispheres of dog 27 was determined by the method of Stehle.[15] The increase of the total nitrogen on the treated side is sufficient to disprove the second theory.

This difference, however, is not inconsistent with the third view, but, on the other hand, rather supports it. For if we assume that the difference in weight of the two hemispheres, 8.43 gms., is due to edema—distention of the lymph spaces and flooding of the tissues with a lymph-like fluid—we can come to the following conclusion: We know that lymph contains approximately 5 per cent protein,[65] therefore in an increase of 8.43 gm., 0.4215 gm. must have been due to protein substances. This would contain 0.067 gm. nitrogen, since 6.25 gm. protein contain 1 gm. of nitrogen. The difference in the two analysed hemispheres was 0.075 gm. of nitrogen. The discrepancy of 0.008 gm. is within the limit of error of the experiment.

Hence we are inclined to assume that the observed increase in the weight of the treated hemisphere can be accounted for entirely by an existing edema.

We have already noted the fact that an exposure of greater than 1,400 mgm. hours was followed by death, with a single exception (dog 20). With this single exception the animals have responded so uniformly that the results follow, when plotted with doses in mgm. hours as abscissae, and length of life after operation as ordinates, almost a straight line (Fig. 1). In fact, following this graph, it was possible to predict within one or two days the time of death of an animal. This result shows very clearly that the cause of death must be sought in some other factor than the loss of function of the destroyed area.

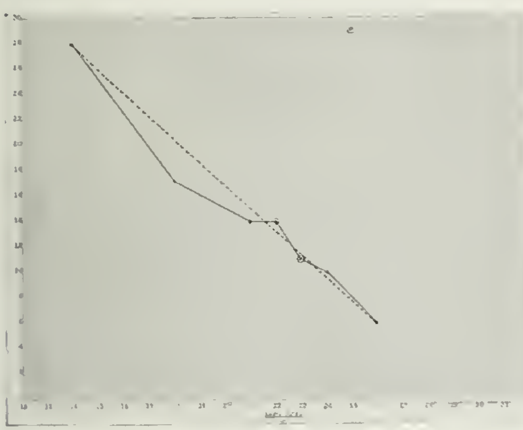


Fig. 1. $\frac{\text{mgm. hrs.}}{100}$

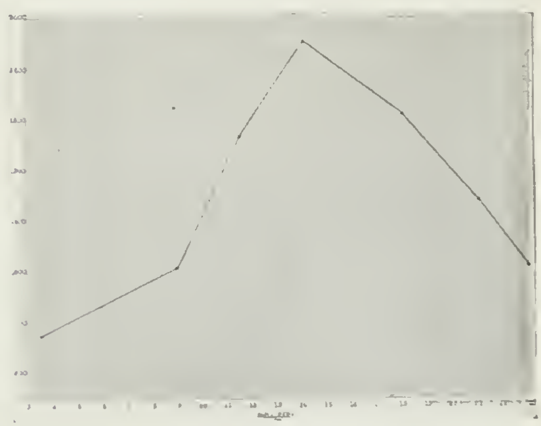
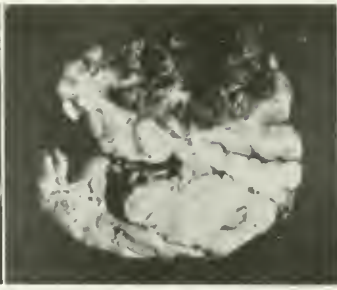


Fig. 2. $\frac{\text{mgm. hrs.}}{100}$

In the first place the animals did not show symptoms of loss of cerebral function. They were apparently in the best of health, with no localizing signs, as paralysis. The only symptom noted at all was a possible weakness in the hind legs. Then possibly twenty-four or forty-eight hours before the calculated time of death the animals became very ill with general weakness and prostration, but with still no paralysis, and died apparently from increasing weakness. Symptoms derived from the gastrointestinal tract were not in evidence, a point to be borne in mind in the later discussion of roentgen-ray toxemia.

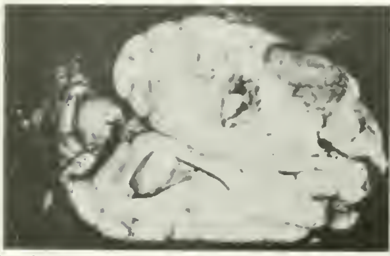
A second reason for considering that the fatal result is not due to the loss of function of the injured brain is found in Figure 2, in which the total volume of destruction seen grossly, calculated as half an ellipsoid of revolution by the formula

Brain No. 1. Received 1400 mgm. hrs. surface application.

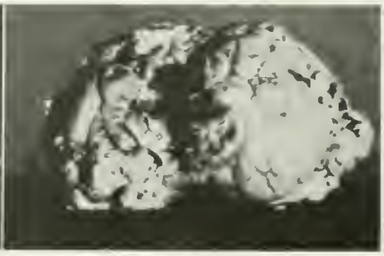


Brain No. 1. Cross section shows extensive destruction of brain tissue. Dog lived twenty-eight days.

Brain No. 4. Received 900 mgm. hrs. implanted into brain substance.



Brain No. 4. Cross section shows comparatively little destruction of brain tissue. Dog died fifth day.



Brain No. 5. Received 2100 mgm. hrs. (surface application) also had infection of wound. Photograph shows extensive necrosis. Dog died fourteenth day.

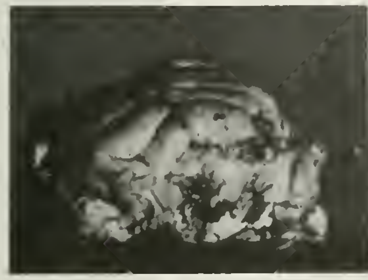
Brain No. 9. Received 1800 mgm. hrs. surface application. Photograph shows that there was very little destruction of brain tissue. Dog dled in seventeen days.

$V = \int_0^a y^2 dx$, where x and y are given by the equation of the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, are plotted as ordinates, and the dose in mgm. hours as abscissae. It is seen that the total volume of gross destruction, in spite of increasing dosage, falls rapidly after the dose has reached a size which results, as seen in graph Figure 1, in the death of the dog at an earlier time. It might be argued that the gross area of destruction is no criterion of the total effect of the radium; and this is no doubt true, as shown in our microscopic studies of the brain and from the experiments just recorded on the cord, and also from the gross findings in the brains of the two animals that had lived for almost a year after small doses. In these two animals the size of the lesions was far in excess of that seen in the animals autopsied a short time after equivalent doses. Nevertheless the two factors taken together indicate clearly that the cause of death is not due to local effect, but to some general condition of toxemia.

The existence of a toxemia after exposure to either *x*-rays or radium was early recognized both by clinicians and experimental workers, and considerable literature has been produced in the discussion of the possible source of this toxemia. The results of different observers have been somewhat at variance, and different theories have from time to time controlled the opinions of investigators. In order to show these fluctuations in opinion, we will review the more important papers in chronological order, rather than attempt to group them with respect to the principal point stressed.

Walsch,[16] in 1897, reported that an *x*-ray demonstrator, who had been under his care, suffered from headaches and dizziness for two months, after he had been exposed to the x-rays for some time.

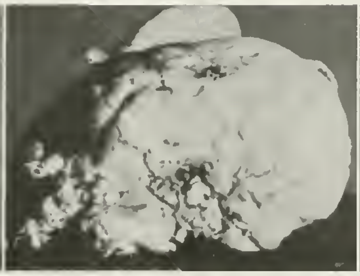
Schwarz,[17] in 1903, advanced the first definite theory of the modus operandi of the radium radiations. After placing 20 mgm. of radium on the shells of hens' eggs for one hundred and forty-four hours, he found only insignificant changes in the shell and albumen, while that part of the yolk exposed to the full effect of the radium was of a greenish color, stiff, and could easily be lifted out from the rest of the yolk. It had the strong unpleasant taste of spoiled cod liver oil. He believed that these changes were determined chiefly by a decomposition of lecithin, in which embryonal cells are particularly rich.



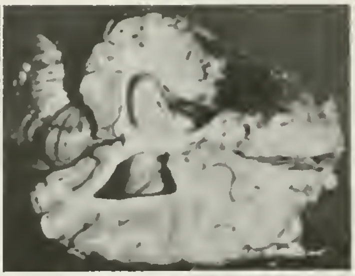
Brain No. 8. Received 450 mgm. hrs. implanted into brain substance.

Brain No. 8. Cross section shows the destruction of tissue. Dog was killed eleventh day.

Brain No. 18. Received 2600 mgm. hrs. (surface application). There is some necrosis of brain tissue and the area of hemorrhage surrounding necrosis can be seen.



Brain No. 30. Received 900 mgm. hrs. Photograph shows extensive destruction of tissue.



Brain No. 30. Cross section shows extensive destruction of brain tissue. Dog killed after living nine months.

The same year, Bohn[18] came to the conclusion that radium acts chiefly on the chromatin of the nucleus, augmenting its activity or destroying it, according to the duration of the exposure.

The next year, in discussing the action of radium on the tissues, Schaper[19] took his stand with Schwarz.

Neuberg,[20] however, did not agree with Schwarz. He explains the effect of radiation as due to the destruction of all the cellular ferments except the autolytic ones, so that in tumor tissue after exposure there is (*a*) a loss of the vital ferments, and (*b*) an increased activity of the autolytic ferments.

Heile,[21] on the other hand, finding an increased metabolic rate after exposure to x-rays, and particularly an increase in the excretion of uric acid and the purines, was inclined to assume that by these rays one can produce an increase in the autolytic processes in the living body, and in such fashion that not only the cells of the tissues themselves are destroyed, but that the leukocytes which have wandered in and later gone to pieces, give an increased amount of enzymes. He compares the process to the autolysis of dead organs in the absence of bacteria, resulting in products similar to those of tryptic digestion, and quotes the work of Hoppe-Seyler and others to support this view. The increased excretion of the purines he accounts for by the autolysis of the nucleo-proteins.

Henri and Mayer[22] note that beta rays of radium will precipitate positive colloids, but are without effect on the negative colloids. The oxyhemoglobin of the dog and frog was changed to methemoglobin and slowly precipitated, while carbonmonoxyhemoglobin was unchanged. The red blood-cells were rendered less resistant to hypertonic salt and sugar solutions by exposure to radium. They compare their results with those of Schwarz, and conclude that the action of the radium is on the lecithin, which is known to be one of the constituents of red blood-cells.

Darier[23] claimed that low intensity radium radiations over the peripheral nerves produced an analgesic effect.

Baermann and Linsen[24] maintained that the chief effect of the *x*-rays was on blood-vessels. Thies[25] repeated Schwarz's experiments, but could detect no change when he exposed lecithin itself to radiations. He claims that change in the lecithin cannot be responsible for the tissue changes, and thinks it more likely that the primary effect is on some cell substance which plays a rôle in the cell division, giving rise to the irregular division seen in radiated cells.

Lange,[26] writing in 1905 on the constitutional symptoms seen clinically after *x*-ray treatment, concluded that the reaction was due to an acidosis produced by the breaking down of the cells under the treatment.

Edsall[27] at this time noted an increased excretion of urea, uric acid, and the purine bases, and a general stimulation of metabolism after *x*-ray and radium treatment, and believed this due to stimulation of autolysis. In another paper[28] he found the greatest destruction in the bone marrow, spleen, and lymphoid tissue, and concluded that the destruction was most marked in the tissues rich in nucleoproteins.

Linser and Helber[29] and Rosenstern[30] claimed that long exposure to the *x*-rays produced nephritis. Buschke and Schmidt,[31] and Krause and Ziegler,[32] on the other hand, held that any renal changes were slight and transitory.

In 1906, Bouchard and Balliazard,[33] in a most interesting paper, reported the distribution of radium emanation in the different tissues of the body after placing radioactive barium sulphate contained in collodion sacs in the peritoneal cavity of guinea-pigs. They measured the amount of emanation by estimating the electrical conductivity communicated to the gases extracted from the organs by a mercury pump, the increased conductivity of the gases being due to the presence of the emanation. One gm. of suprarenal tissue contained 4.7 times as much emanation as 1 gm. of spleen; 11.4 times as much as an equal amount of lung tissue; and 15, 60, and 100 times as much as skin, liver, and kidney tissue respectively. This is interesting when the relatively considerable percentage of lecithin and neurine in the suprarenal capsule is considered.

Work on enzymes of various kinds was being pushed by various writers: thus Wilcox[34] stated that exposure to radium was without effect on tyrosinase, Lowenthal and Edelstein[35] that the autolysis of tissues in vitro was accelerated by the presence of radium emanations in the water added to the tissue, while Richter and Gerhartz[36] claimed that *x*-rays were without effect on enzymes and that the results recorded by other workers were due to experimental errors. It remained for Richards to coordinate these results.

Werner, in a number of papers,[37–43] reported his observations on the effect of radiation on lipoids, and on the effect of injection of lecithin and cholin. He found that lipoids are made more labile and favorable to autolysis by radiation. By subcutaneous injection of lecithin he duplicated the effect of radiation on the skin. Cholin injections produce the same effect on the white blood cells as does *x*-ray exposure, and also the same degeneration of the epithelium of the testicle. Injections of cholin in human beings produced diarrhea, vomiting, sweats and pain.

Opitz and Meyer,[44] in 1906, noted a rise in blood pressure, followed by slowing of the heart and a fall in blood pressure after intravenous injection of radium bromide in dogs.

Berg and Welker[45] found that exposure to radium was without material effect on protein metabolism.

Edsall and Pemberton[46] maintained that the toxic reaction seen in leukemia after x-ray treatment was due to the sudden demand on the organism for the complete disintegration and excretion of the many products of tissue breakdown. With an inability to accomplish this, there is a halting of the normal metabolism, and intoxication results.

Working on the theory that roentgen rays act as a ferment accelerator, thus speeding up metabolism, these workers record some success in treating unresolved pneumonia by roentgen rays.

Warthin[47] found that roentgen radiation over the kidney region produced swelling of the epithelium of the renal tubules, with changes in the chromatin and some loss of the staining powers of the cells. The cells recovered shortly, secondly developing cloudy swelling.

Engel[48] reported a study of the constitutional effects following roentgen-ray treatment. He noted nausea, vomiting, pain, followed by depression and accompanied at times by palpitation or tachycardia.

By exposure of pregnant bitches to x-rays, with the abdomen protected by a lead plate, Hippel and Pagenstecher[49] produced either cataracts in the eyes of the young, or abortion, or death of the embryo, the latter in about the same frequency as after direct exposure of the abdomen. Choline injections gave identical results, without giving rise to any symptoms in the mother.

Werner and Lichtenberg[50] found that injections of choline would interrupt pregnancy in rabbits, and they also call attention to the close imitation of roentgen-ray effects that can be produced in a chemical way.

Regaud, Nogier, and Lacassagne,[51] 1912, after some experiments on dogs in which exposure to roentgen rays led to abortion, anorrhexia, diarrhea, cachexia, and in some instances death, conclude that the roentgen rays exercise a powerful cytolytic effect on the stomach and gastrointestinal tract, with remarkable atrophy of the glands, especially those of Lieberkuhn, if the animal lives long enough.

Packard[52] suggests that radium radiations act indirectly on the chromatin and protoplasm of the cell by activating the autolytic enzymes which bring about a degeneration of the complex proteids and probably affect the other protoplasmic substances in the same manner.

Richards,[53–56] in a number of papers, 1914–1917, on the effect of exposure of enzymes to x-rays and radium, showed that a short exposure accelerated the enzyme action, while longer exposure inhibited, or destroyed it altogether. Between these there was a point where exposure was without effect. He suggests that the effect of radiation on the enzymes is due to hydrolysis of the zymogen; hence its more complete transference into active enzyme. With longer exposures the dissociation of the electrolyte may be supposed to occur in amounts sufficient to precipitate the colloid enzyme particles, and thus remove them from solution. When these two processes balance, radiation is non-effective.

Pfahler,[57] in a paper in 1916, discussing the cause of the nausea, vomiting, and prostration seen after roentgen-ray treatment, says they are probably due in great part to the gases generated in the neighborhood of the high tension currents, and to hypersensitiveness on the part of the patient.

Millet and Miller[58] reported in 1918 the post-mortem examination of a patient who had been treated for cancer with large doses of radium. No trace of the carcinoma could be found, nor any morbid process that could explain death. No blood studies were made. They conclude that in addition to the local action of radium there is "evidence of a more general effect whose nature we do not at all understand."

Luden[59] found that exposure to radium reduces the cholesterol content of the blood, and reduces the high cholesterol values commonly found in carcinoma.

Hall and Whipple,[60] in an excellent discussion of the toxemia following x-ray exposure, call attention to the similarity of the effects that can be produced in dogs by proteose injection, and regard both as true non-specific intoxications, associated with much destruction of body protein. If there is any renal trouble, it is slight and not constant. They conclude that after a lethal dose of x-rays to dogs there is a latent period of twenty-four hours or more followed by vomiting and diarrhea until death, which is generally on the fourth day. A greater dose does not change the clinical picture. The non-protein nitrogen of the blood is greatly increased the day before death, the urinary nitrogen is increased on the day after exposure and remains high until death. Post mortem they found mottling of the intestinal mucosa and destruction of the epithelium. They think the injury to these cells may account for the intoxication associated with the vomiting and diarrhea.

Denis and Mortin,[61] from their work on rabbits, believe that constitutional symptoms of intoxication follow exposure to the *x*-rays only when some part of the intestinal tract is radiated.

Gudernatsch and Bagg[62] by subcutaneous and intravenous injection of radium emanation in pregnant rats produced death of the embryo with areas of hemorrhage in the subcutaneous connective tissue and along the meningeal vessels. They conclude that the effect of radium on endothelium may be selective.

That the effects of radium are insidious, and that its power is little understood and not fully appreciated is evidenced by the recent report,[63] of three deaths from aplastic anemia at the London Radium Institute, in spite of the great care used for the protection of the workers. This is particularly significant, coming as it did only four weeks after the report of the death of Dr. William I. Bruce from the same condition.[64]

It is evident from the review of the literature that many minds have engaged themselves with a study of the problems of the general toxemia following radiation by *x*-ray and radium. The theories offered may be divided into three groups.

The oldest theory, and one which from some points of view still remains attractive, is that advanced by Schwarz.[17] This theory would explain the specific effect of radiation upon the young cells and other cells rich in lecithin by the production of choline from the breakdown of the lecithin. This theory has been severely attacked by numerous writers, but two facts nevertheless remain, in spite of the criticism; first, choline injections can reproduce certain of the so-called specific effects of radiation, namely, the destructive effect upon spermatogenesia, the causation of foetal cataracts, and even the sensitization of the skin to the *x*-ray; secondly, injections of choline can apparently reproduce the general symptoms noted by Hall and Whipple in their study of *x*-ray toxemia.

The second theory looks for the explanation in the effect upon the chromatin of the nuclei of the cells. This theory finds convincing support in the work of Hertwig who found the striking effect upon spermatozoa referred to above, namely, the loss of nuclear activity in a cell which still retains its cellular functions.

The third theory seeks the explanation in the increased autolytic activity of the radiated tissue, or, as some would express it, the inhibition of the other processes of cell death. This theory would explain the general symptoms of toxemia on the same basis as the theory now accepted for the cause of death in high obstruction of the intestinal tract (Whipple) or acute pancreatitis (Sweet,[66]) in both of which conditions the cause of the general toxemia is found in the activity of the proteolytic ferments of the body; since these ferments are in all cells, an autolysis of any tissue might set free the same series of toxic processes.

Now we must note that the symptoms which characterize our observations are not at all like those noted by Hall and Whipple in *x*-ray toxemia. The symptoms which they observed pointed to an involvement of the gastrointestinal tract, while in our animals these symptoms were not present. Furthermore, it should be noted that the clinical symptoms of a general nature seen after the use of radium in the uterus, for example, point to a primary effect on the gastrointestinal tract.

These three theories are reducible to two, and the apparent discrepancy between the toxemia seen in our work and that described as *x*-ray toxemia, as well as the toxic symptoms seen clinically after using radium in the uterus, can be cleared away. First we have an effect upon the nucleus, perhaps the primary and essential effect, as we might conclude from the work of Hertwig. The histological study of our sections, a study which will be reported later, shows an effect upon the cells far beyond the zone of vascular and gross injury. After the death of the nucleus, or coincident therewith, the cell dies, and the tissue becomes subject to autolysis. The direction of this autolysis will depend upon the predominating material of which the cell is composed. It is stated that "those cells which are most actively engaged in the synthesis of a given compound seem to be equipped with more of the necessary enzyme than are other cells less actively engaged in this particular type of metabolism." (Bradley [67]).

The only change in the original theory of Schultz is that the breakdown of the lecithin in living tissue is not due to the direct, chemical action of the radiation, but to a stimulation of the lipase found in connection with cells rich in lipoids; the first and the third theory are one and the same.

The stimulation of autolysis, or the creation of conditions favoring autolysis, as a result of the radiation, produces a picture dominated by the type of substrate chiefly present in the tissue; most of the tissues, being largely composed of protein, would show the influence of the proteolytic ferments, with a resultant picture of intoxication due to the products of proteolysis, as seen in the work of Hall and Whipple, and in the clinical picture after using radium in the uterus.

In our work, however, the lipase of the brain (Pagenstecher,[68]) breaks down the lecithin-lipoid compounds which are present in the brain in larger amounts than in other tissues, with the setting free of choline and neurine. Neurine may be set free directly, since some authors claim that it is found in brain tissue; it is also formed chemically by the simple dehydration of choline, in fact, the literature on choline and neurine is much confused, because of the close chemical relationship of the two substances. Neurine exercises an effect upon the voluntary muscles similar to curare[69] which would explain the symptoms of marked asthenia exhibited in our experiments.

We offer as a working hypothesis of the action of radiation upon living tissue that it is due to a primary effect upon the nucleus and the resultant death of the cell under conditions favoring autolysis. The direction of the autolysis will depend upon the predominating material of which the tissue is composed; and we will have as a result a toxemia in the one case due to proteolysis, in the case of the experiments here reported, a toxemia due to the products of lipolysis.

CONCLUSIONS

1. An exposure of the normal brain tissue up to 1,150 mgm. hours is compatible with life (surface application).

2. The results on the cord, however, would indicate that exposure of vital areas of the brain as well as exposure of the cord should never be made by surface application or implantation.

3. Microscopic studies indicate that considerable changes are to be found with exposures that give no clinical symptoms.

4. The brain after exposure of 1,000 mgm. hours shows a general swelling throughout the entire radiated hemisphere, which, from our studies, must be ascribed to the production of an edema which is not limited to the radiated area, but extends throughout the entire hemisphere.

5. Radiation of the brain by radium (surface application and implantation) can produce severe general symptoms which indicate that a powerful toxin has been produced from the radiated tissue.

6. The effect of radium is due to a twofold action; first, an effect upon the nucleus and cytoplasm of the cell, which causes, secondly, the death of the cell under conditions favoring autolysis. The direction of this autolysis is determined by the chief component of the radiated cells. If this be protein the toxic products of proteolysis may exhibit their general effect. If the chief component be lipoid compounds, we believe that the resultant autolysis may free the toxic components of lecithin, and produce their characteristic reactions.

7. The use of radium as a therapeutic agent in the treatment of brain tumors is recommended, but should be undertaken

only after one is thoroughly familiar with the dangers that may come from improper use thereof.

8. We believe our experiments on the dogs are applicable to human beings, because it is not the destruction of brain tissue that causes death, but some toxemia, and in the application of radium in the treatment of malignant tumors of the brain of humans the normal brain tissue should not receive more than 1,150 mgm. hours.

THERAPEUTIC APPLICATIONS

Malignant tumors[70] of the brain are somewhat different from malignant tumors found elsewhere, in several characteristics: they are usually very slow in growth; the cardinal symptoms, such as visual disturbances, headache, nausea and vomiting usually appear late; they usually do not metastasize. Very often the tumors are unlocalizable, even after exploratory craniotomy, and, finally, they are sometimes inoperable.

Thus one can see that there is a field for some physical agency such as radium, which will not only arrest the growth of a malignant lesion, but even lead to a process of retrogression.

In the treatment of brain tumors by radium there are a number of problems one must consider. In this paper we do not wish to go into the technique of application but only the types of brain tumor in which radiation should be employed.[71]

1. When a brain tumor is exposed after craniotomy and is considered inoperable, provided this tumor is localized and not of the infiltrative variety, direct implantation of radium into the growth is recommended. It is not safe to give dosage sufficient to destroy the entire growth, as this might entail too much exposure of normal brain tissue at a given location. To supplement the implantation, crossfire radiation by radium should be employed over as much of the scalp surrounding the tumor as is deemed necessary and of value. By this procedure the likelihood of causing considerable destruction of normal brain tissue and a possible toxemia is lessened. By clinical observations crossfire radiations of radium cause fewer general symptoms than does implantation. In the implantation of radium, one should be careful to insert it far enough below the surface of the lesion, so as to prevent a possible necrosis of the muscle flaps.

Direct implantation is only recommended in the growths easily accessible, and should the tumor be near vital centers of the brain, the dosage given should be governed by this, so as to prevent a possible loss of function of a given center. This danger is a real one, as evidenced from our spinal cord experiments wherein marked clinical symptoms were present even after small dosages.

2. In brain tumors partially removed, well-filtered radium should be packed in the center of the cavity made by the partial removal of the tumor. The dosage should depend on the amount of tumor tissue left, and as above should be supplemented by crossfire radiation through the scalp.

3. In brain tumors which are not localizable even after exploratory craniotomy, crossfire radiation by radium through the scalp should be given a thorough trial.

4. There are a number of brain tumors which infiltrate the brain substance. Crossfire radiation alone should be employed in this type of growth.

5. In the treatment of spinal-cord tumors we feel that one should not attempt to apply radium to the surface of the lesion, or implant radium into it. A large number of spinal-cord tumors give clinical manifestations early, are localizable, and can be removed surgically. In the cases where the cord tumors are removed, post-operative radiation by radium or *x*-ray is recommended.

6. Careful sterilization of all radium tubes or needles used in surface application or implantation, is very important, our method being to place the radium tubes and needles in 40 per cent formalin for thirty minutes and 95 per cent alcohol for forty-five minutes.

From our experiments we have drawn the following conclusions in regard to radiation in the treatment of brain tumors and from them a safe technique has been arrived at. Radium is recommended:

1. As a prophylactic against recurrence after removal of brain tumors.

2. As a prophylactic against recurrence after sella decompression.

3. As an active agent in the treatment of cases of recurrent visual disturbances after sella decompression has been performed.

4. As an active agent by direct implantation into inoperable tumors supplemented by crossfire radiation through the scalp (external application).

5. As an active agent in cases where brain tumors are only partially removed, by implantation of radium into the center of the cavity, and supplemented by crossfire radiation externally.

6. As an active agent by crossfire radiation (external application) in brain tumors which cannot be localized or discovered by operation.

7. Treatment of spinal-cord tumors should be restricted to crossfire radiation by the roentgen ray or radium, as in surface application there is a great possibility of causing paralysis.

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ULTRAVIOLET AND X-RAY AS PHYSIOLOGIC COMPLEMENTS IN THERAPEUSIS: A NEWLY ESTABLISHED CLINICAL TREATMENT*

BY C. M. SAMPSON, M.D.

United States Public Health Service Hospital No. 61

STAPLETON, NEW YORK

INTRODUCTION

IN provinces other than the province of medicine the method of scientific advancement is preeminently that of deductive sequel.

When the method of the scientific laboratory is applied to the study of the human organism, it is sometimes observed that the physically deduced laws either do not obtain, or obtain in so modified a form contrary to expectation, that the results are no longer recognized as born from the parent observation.

A critical survey of accomplishment in medicine points strongly to the fact that medicine is not a science as compared to the ordinarily accepted concept of physical science. In truth, medicine is an ultra science whose phenomena are myriad and defiant of ordinary scientific standards. The explanation seems to lie in the exceptionally complex structure of the human organism, a structure infinitely more complicated than even the most complicated inanimate object; and added to this already intricate organization, there must be considered that inevitable something called life for which no scientific explanation has ever yet been satisfactorily adduced.

Hence progress in medicine can be expected best along the lines already set by precedent; namely, empirical observation serving as a basis for the deduction of law, rather than law serving as the basis from which to experiment for a desired result. After all, the method of medicine is statistical. Observations are first gathered, then sorted and classified into similar groups. Finally, they are given to the laboratory scientist with the view of establishing the fundamental structure underlying the empirical observations.

There is no "scientific" theory to offer in explanation of the clinical facts presented in this paper. There are some scientific precedents referred to, from time to time, which tend to show that these empirical results have somewhere a corelated precedent in medical observation.

The apparatus used is simple, the application is without difficulty, and the clinical results are instant. The basic theme is essentially borrowed from nature. The actinic rays of the sun impinging upon the peoples of a world, become necessary for the fit survival of those inhabitants. Fit survival implies natural prophylactic measures and natural curative measures. Local actinism, therefore, increases the effects on the skin at the point applied, similarly as solar actinism is manifested on the peoples of the world. It is well recognized that solar actinism was necessary for the protection of people closest exposed to the sun; and the result was that a permanently sun-burned or dark race was perpetuated. The empirical observations of this research make use of this phenomenon which has been constantly observed.

THESIS

A comparative study of *x*-ray and ultraviolet-ray dermatitis reveals several very important differences. An *x*-ray dermatitis comes on rather slowly, usually in from eight to fifteen days or longer, while the ultraviolet-ray dermatitis comes on rapidly, generally in from three to twenty-four hours. The *x*-ray dermatitis causes the hair to fall out, and, if severe enough, is followed by permanent alopecia. The ultraviolet-ray dermatitis—no matter how severe unless compression has been used and the skin destroyed—checks the falling

* MSS. submitted in Leonard Prize Competition.

out of hair, stimulates the hair follicle, causes extra rapid growth of normal hair and often causes lanugo to take an added growth, size, and in some cases, pigment. The stronger the actinic ray reaction, the more stimulating it is to hair growth, one or two good ultraviolet-ray erythemas usually being sufficient to arrest the falling out of hair even when due to heavy *x*-ray dosages. The *x*-ray dermatitis, if severe enough, is followed by atrophic changes, ulcer formation, sloughs, or telangiectases. The actinic dermatitis—no matter how intense the overexposure if compression has not been used and the burner has been kept far enough from the skin to prevent a heat burn—is followed by desquamation or blisters, if the overexposure has been great enough, and the formation of new skin normal in every respect. An *x*-ray dermatitis increases the irritability of that area to subsequent *x*-ray doses, while the inflammatory reaction following heavy actinic dosage decreases the irritability of that area to subsequent applications of the ultraviolet ray. By means of rapidly repeated erythemas from the actinic ray, an area of skin may soon be in such a condition that it will require some fifty times the original dermatitis dose of the ultraviolet to produce even the mildest grade erythema. This increased tolerance of the skin to ultraviolet rays is not confined to the action of the actinic rays alone, but includes, to a lesser degree, the *x*-rays. Whether this increased tolerance is due solely to the tanning produced, or whether the repeated inflammatory reactions produced by the actinic rays cause the skin to lose some of its irritability, or whether the blood-chemistry changes which follow the application of ultraviolet light have an antidoting or damping effect upon the cycle of tissue changes set in train by massive *x*-ray dosage, cannot be stated positively at this time. Clinical evidence would seem to show that all three factors have a part in the increased tolerance. Surfaces tanned gradually by exposure to sunlight or weak applications of the actinic rays without noticeable erythema being produced, show a slightly increased tolerance to *x*-ray dosage, but nothing like the increase caused by repeated heavy erythemas, rapidly produced, by the quartz mercury burner. This increased tolerance seems to follow whether the surface tans or not, but possibly not to so great a degree where tanning does not take place.*

Case IV, while only a basal cell type, is included to illustrate this point. This patient's skin blistered easily, but refused to tan under the most rigorous actinotherapy, yet the reaction—or rather lack of reaction—following the roentgen-ray dose was the same as in the other cases. This holds true with all other cases of the same peculiar skin that we have treated so far. One man with a skin of exactly the same type that refused to tan after repeated heavy actinic erythemas, was given 50 ma. min. with a 4 in. back-up spark, 8 in. target skin distance, 1 mm. aluminum and 1 mm. flexible leather filter at one dose, for a general cheloidal condition of numerous gas scars over one side of face and chin, with no visible reaction; 44 men were given 45 to 50 ma. min. in divided doses in a three-week period with the same factors, with no trace of erythema in any case. Most of these men tanned well. Seven of them did not tan visibly. When attempting to explain *exactly* how the ultraviolet light applications may antidote the constitutional effects of massive roentgen-ray doses, we meet with difficulty from both sides. Although both remedies have been in use for a long time, and much is known of the clinical effects of each, little has been definitely ascertained in regard to the minutiæ as to how either produces its constitutional effects. There are almost as many theories as there are research centers. Hall and Whipple,[1] in a very instructive series of experiments with the effects of massive *x*-ray dosages upon dogs, discuss the constitutional effect, and state so succinctly the difficulties of drawing conclusions, that we shall quote them.

"Lange maintains that the reaction is the result of an acidosis resulting from cellular degeneration or from increase in

*The tanning of the skin is only *one*—and in our opinion one of the least—factors, and the subsequent vigorous actinic treatment applied after the heavy *x*-ray dosage is much more important than the preliminary treatments.

catabolic cellular activity. He submits no analyses of blood or expired air to support this claim.

"Edsal and Pemberton advanced a theory which we believe to be more nearly correct. They noted that roentgen rays sometimes produced a constitutional reaction which they ascribed to an acute intoxication. They state their belief. 'The tissue destruction accomplished by the roentgen rays undoubtedly involves chiefly tissues especially rich in nucleoprotein. The decomposition products of this form of protein are especially rich in substances that are more or less toxic and difficult to metabolize and excrete.'

"This general systemic reaction which may follow the use of roentgen rays in therapeutic doses has another appeal to the investigator. This reaction must be '*non-specific*' as no group of bacteria can possibly be concerned. If any injurious substances are formed in the body, these substances must be formed from the body tissues or fluids and not from any protein substances introduced. It seems safe to assume that the body protein must be injured in some fashion, as there is a distinct increase in urinary nitrogen and in the non-protein nitrogen of the blood. In fact, the primary injury may react upon the body protein in some manner so that the tissue autolysis of the injured protoplasm may form toxic split products* which cause further injury to the body protein—a vicious circle.

FIG. 1. Case I. Showing case the day before amputation was performed, and location of metastases.

FIG. 2. Case II. Epithelioma, with general involvement of adjacent glands.

FIG. 3. Case III, (*a*). Showing primary tumor on right clavicle and metastatic areas. Also showing absence of dermatitis after a 90 ma.m. roentgen-ray dose with a 10 in. gap.

"The question of ferments and roentgen-ray exposure is a most important one. When we finish the analysis of the anatomical changes caused by the roentgen rays and the review of the clinical symptoms of intoxication which may be due to the specific action of the roentgen rays on the leucocyte or the intestinal epithelium or the epidermis, we come up against the fundamental question: How do the roentgen rays injure a living cell? It is claimed by Hertwig that the chromatin is first injured and that this injury is the

* The validity of the split protein product theory is not generally subscribed to by the majority of immunologists nor by the writer; but the theme that seroprotein changes are involved is an established concept that requires no defense.

fundamental one. But Richards has shown that the cytoplasm is also injured. Many workers are tempted to leave the morphology of the cell and venture into the field of cellular ferments, which is equally difficult, to say the least. One must be very careful in accepting *in vitro* ferment experiments on unicellular organisms or isolated ferments to explain ferment reactions in the living complex of a warm-blooded animal.

"Yet there are observations which indicate that the body ferments in the living cells are actually influenced by the roentgen rays.* A spleen removed from a rayed animal will show more rapid autolysis than a control (Heile. *Ztschr. f. Krebsf.*, 1904, ii, 171). Our experiments indicate that the same holds for the epithelium of the intestinal mucous membrane exposed to ,the roentgen rays. A. Richards (*Am. J. Physiol.*, 1914, xxxv, 224; *Science*, 1915, xlii, 287), who has done the best experiments upon the roentgen rays and ferments, is able to show *in vitro* that small doses of the roentgen ray accelerate and larger doses inhibit certain ferment action. He does not believe, however, that this direct action of the roentgen rays on ferments is adequate to explain all the reactions of a living cell to the roentgen ray. This conservative opinion should have much weight.

Fig. 4. Case III, (*b*). Showing metastatic areas in spine and exfoliation following overdose of actinic ray.

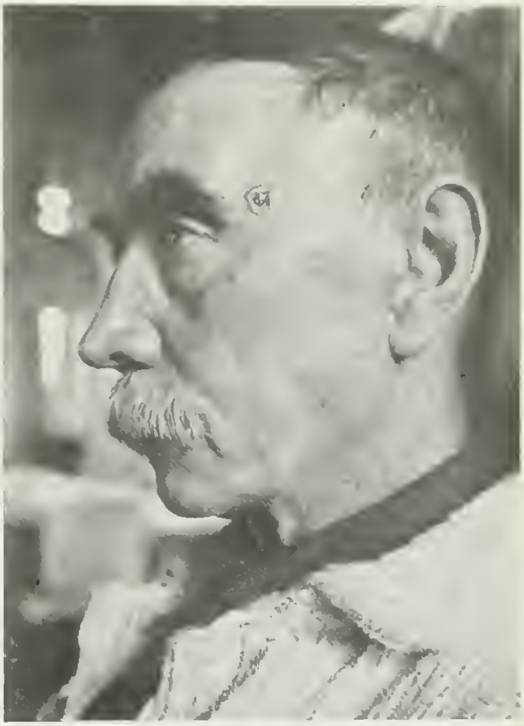

Fig. 5. Case IV. Showing type of basal cell epithaelioma, clear skin, freckled, which would not tan under actinic ray.

"We should not lose sight of the fact that the roentgen rays pick out certain cells with no apparent rhyme or reason. Why, for instance, is the leukocyte injured and the pancreatic cells, which surely are rich in ferment, escape entirely? Simple disturbance of cellular ferments by the roentgen rays cannot explain any such peculiar reaction as this just mentioned. There must be some initial stimulus or injury inflicted upon certain cells of the body and other body cells must be tolerant and escape this injury or stimulus. It is

* Recent trend of investigation would point to the possibility of vitamine changes in *x*-ray and radium treatment. (See "Similarity of Effects Produced by Absence of Vitamins and by Exposure to X-Rays and Radium" by W. Cramer, A. H. Drew, and J. C. Mottram, London, D P.H.). From the Imperial Cancer Research Fund, and from the Radium Institute, London. *Lancet*, May 7, 1921, i, No. 19, 963.

conceivable that the primary injury may form toxic split products which cause the final intoxication, but we have no right to assume this without some weight of evidence, and this experimental evidence has not been submitted.

"The word *injury* may be as good as any to indicate our belief that some change has been effected within the cell substance (nucleus or protoplasm). This change may influence, *first*, the cell protoplasm, cell lipoids, cell ferments, etc., but who is to say whether the structure or the ferment is first changed or injured by the roentgen ray? We know of many fundamental changes in cells, even fatal changes, which leave no trace that can be detected by modern histological methods. Yet we cannot accept such an instance without question as an example of *primary* injury to the cell ferments. We are too apt to cloak our ignorance by the use of terms which have very little fundamental significance when subjected to analysis.

Fig. 6. Case V. General paronychia.

"In the face of these difficulties the authors hesitate to outline the constitutional reaction to the roentgen rays as pictured in their minds, and put forward this explanation with a proper regard for possible objections and criticisms. Exposure of a dog to the roentgen rays brings about certain changes (or 'injury') in certain of the body cells. In some cells the injury may be evident in a short time (leukocytes) and in other cells the injury may be greatly delayed (epidermis). We cannot explain this latent period. It is at least possible that other body cells may be injured after a longer or shorter latent period, depending upon the individual properties of the cells. The nitrogen elimination shows that the cell injury and autolysis begin promptly after exposure to the roentgen rays and continue with a rising curve to the fatal outcome. The blood nonprotein nitrogen speaks for the same progressive destruction of body protein. We have evidence that the ferments in certain cells of the body are profoundly altered and take part in the cell destruction beyond a doubt, yet we cannot say that this ferment disturbance is not secondary to some 'injury' of cell substance apart from the enzymes. There are individual peculiarities in the reaction of the cells to the roentgen rays which speak for an individuality in the cell reaction and this surely may not of necessity depend upon primary ferment change. The liver and pancreatic cells are rich in ferments, yet, so far as we know, they escape the roentgen-ray injury. The epithelium of the small intestine is closely related to the liver and pancreatic eipthelium, yet it appears to be 'injured' by the roentgen rays. Is this due to a primary injury of ferments? Then how may we explain the immunity of other parenchyma cells which contain similar autolytic ferments?

"The obvious 'injury' of the intestinal epithelium offers a satisfactory explanation for many of the clinical features of the fatal intoxication—vomiting, diarrhea and prostration. Disturbances of this epithelium can produce a severe intoxication (intestinal obstruction) and for this reason we think the injury of the intestinal epithelium by the roentgen rays plays no small part in the general systemic reaction and intoxication."

Subsequent experimentation by Denis, Martin and Aldrich[2] offers further proof of the correctness of some of Hall and Whipple's conclusions, but adds some very strong evidence in the behavior of the alkaline reserve curve* to the proof of the correctness of Lange's acidosis theory, which they were not inclined to favor.

In a series of studies on roentgen-ray effects by Murphy, Hussey, Wakahara and

* Lewis (unpublished communication) points out the influence of psychic influences in affecting, to a slight extent, the alkaline reserve curves in aments. These slight changes would not appear materially to invalidate the conclusions of Lewis, Martin and Aldrich.

Sturm, published in the 1921 volume of *The Journal of Experimental Medicine*, attempt is made to show the fallacy of many of the former theories, and to strengthen the lymphoid reaction hypothesis. Some of their conclusions based upon the experiments are very convincing. In Study No. vi, 301,[3] they state: "Hence it may be assumed that considerable doubt still exists that *x*-rays in a dose suitable for a living animal, i.e., an amount which will not produce a burn, will exert a very great destructive action on the cancer cell. The question arises why uniformly good results should follow the treatment of skin cancers, and almost as uniformly poor results be obtained in the treatment of cancers in only slightly deeper tissues. The problem involved is the immediate basis of the experiments to be described in this paper."

It was a recognition of the question so clearly stated above that impelled us to start our clinical experiments some two years ago, with a view both to increasing skin tolerance, and, if possible, finding some way to prevent or overcome the undesirable sequelae of massive dosage. With increased skin tolerance established, it may still be found that the increased dosage possible will not solve the problem, but that other measures, such as employing superheated air to induce a pronounced lymphocytosis,[4] will have to be used in addition to the roentgen ray and the ultraviolet ray. Again it may be found that the larger doses of a softer ray,[2] made possible by increasing the skin tolerance, will help in the solution. It is admitted by most roentgen-ray therapists that the use of soft unfiltered rays in skin cancer gives results at least equal, if not superior to the hard filtered rays, and the smaller dose of softer rays—larger than formerly possible but still much smaller than the dosage of hard filtered rays—while producing more local reaction, would not cause such a heavy reduction in the lymphocyte count, with the concurrent increase in susceptibility. This has been shown by Amoss, Taylor and Witherbee.[5] No matter from what angle the problem is viewed, the breaching of the stone wall of skin tolerance will allow entrance to new research fields.

A search of the literature serves only to pile up evidence for and against any given hypothesis, without definite proof either way. Any single set of experiments, no matter how valuable they may seem to be, can hardly hope to prove or disprove any given theory as to the exact action of the roentgen rays upon the body tissues. Until the evidence from numbers of research centers is in, and unless such evidence shows a preponderance of weight upon one side or the other, the explanations put forward may be said to be unproven as yet. This being the present status of the question as to why, exactly, certain reactions do follow certain doses of the roentgen rays, the proof as to how ultraviolet light antidotes any of these effects, or could operate in breaking up the cycle of changes following such massive dosage, could not be given (except clinically) even were very much more exact knowledge of the action of the actinic rays at hand than is the case.

The literature upon ultraviolet light, while fairly voluminous, is mostly clinical, and presents all the usual difficulties when attempt is made to draw conclusions from a sifting of the evidence. Edgar Mayer,[6] in a remarkably complete critical review of the literature on sunlight and artificial light in tuberculosis, most of which deals with ultraviolet light (his list of bibliographic references, printed in smaller type than the text and closely spaced, extends over more than thirteen pages and shows a wide search) gives some of his conclusions as follows:

"It is evident that we have yet many problems to solve. Some of these are: (1) The question of the exact mode of the formation of *pigment* and the actual rôle of this substance. (2) The proof of any specific powers possessed by pigment. (3) The ability or inability of pigment to change short rays to longer and more penetrating ones. (4) The relation of pigment to prognosis and lymphocytosis. (5) The ability of pigment to set up focal reaction in tuberculosis.

"We require many more experiments to show the exact *penetrating powers* of the various rays, and additional data in relation particularly to the effect of violet and ultraviolet rays upon tissues, both healthy and diseased, and upon bacteria, especially *in vivo*.

"More experiments are needed to compare the effects of the ultraviolet rays with those of the red and ultrared rays, and many more comparative results between high and lower altitudes are necessary.

"From clinical experience with surgical tuberculosis, evidence points to the greater value of the ultraviolet rays, although it appears that the heat rays may also aid.

"Insufficient comparative and statistical studies upon patients, especially upon those with pulmonary disease, leave much to be desired.

"Much more knowledge must be had experimentally of the effect of light upon non-tuberculous conditions."

Again: "The action of light on ferments and so-called 'antibodies' and other constituents of the blood, as well as its means of influencing the deeper organs, is mostly a matter of speculation up to the present. Its effect upon protoplasm is not well understood.

"The more important ultraviolet rays that affect cells, toxins, bacteria, ferments, etc., are present in the quartz mercury lights but absent in the sunlight as it reaches us."

The conclusion that the shorter the wave-length of ultraviolet the more soluble it is in protoplasm and the more powerful it is in its effects is expressed also by Bayliss[7] in his conclusions after his discussion of the action of light. Kober,[8] in a spectrographic study of amino-acids and polypeptides, and Harris and Hoyt,[9] in a study on the possible origin of the toxicity of ultraviolet light, have added some evidence to that already known, but much more is needed. All the ultraviolet work, up to a very recent date, was done with the iron core arc, tungsten core arc, and the old type quartz mercury vapor arc. The ultraviolet-ray apparatus is going through much the same evolution that the roentgen-ray apparatus has gone through; from the static with a capacity of one or a very few milliampères through the tube to the modern high tension transformer and Coolidge tube outfit, capable of answering almost any demand made upon it.

The old carbon arc gave limited quantities of ultraviolet light of the longer wave-lengths. The various improvements as different minerals were substituted in the composition of the carbon, resulted in greater quantities, but the wave-lengths remained comparatively long, and the constant attention demanded, the noise, heat, their unsteadiness and their many mechanical faults, kept them from being extensively used. With the advent of the quartz mercury vapor lamp with its spectrum reaching into the shorter wave-lengths, and nearly all the faults of the older arc lamps eliminated, a distinct move forward was made. A new type of quartz mercury burner has been on the market about a year. Spectrum tests just being finished at the University of Chicago would indicate that its spectrum goes to the limit of quartz transmission, or about 1,800 Angström units. No intensity tests have been made, so far as we have been able to determine, but judging by its clinical effects it will probably be found to give a great volume of the shorter wave-length rays. With the new burner an erythema can be produced in about one-third of the time required by the older quartz mercury type. Air and water cooled lamps of old and new quartz mercury type are in constant use in our clinic, and both are efficient in increasing skin tolerance to the roentgen rays when used properly. By a series of experiments with the effects of ultraviolet light from an iron arc unscreened and filtered through various substances, such as clear glass, red glass, Wood's ultraviolet glass, picric acid, etc., upon the leukocyte count in rabbits, Clark[10] has shown that the shorter ultraviolet rays are the ones producing the leukocytosis, and that the longer ultraviolet wave lengths, in common with nearly all the longer light wave lengths, produce a fall in the leukocyte count. It would seem, therefore, that the use of the quartz mercury lamp, which gives much shorter wave-lengths than any of the arc lamps, would be preferable wherever a high leukocyte count or a marked dermatitis is to be desired. From a clinical standpoint, it is a matter of common knowledge among extensive users of the ultraviolet light that this physical remedy possesses remarkable value in a wide range of conditions. The rapidity with which certain morbid conditions can be modified is illustrated by Case V, which illustration could be duplicated in extenso from our case records, did space permit. It is a routine practice in our clinic to prescribe general ultraviolet radiations in all suboxidation states and all so-called toxemic conditions. Results from its use in metabolic disorders are usually prompt and vigorous. Its anodyne properties in such conditions as gastritis, gastric and duodenal ulcer and many malignancies have been, and still are, an unexplained mystery to us. Diabetes seems to be the only metabolic derangement where actinotherapy cannot be used. In any dosage whatever, it causes a diabetic to show, promptly, symptoms duplicating surgical shock, or even anaphylaxis. The best explanation of this that we have seen is one given by McCaskey,[11] than whom, certainly, very few men in this country have had more experience in actinotherapy or have kept closer metabolic check upon their cases. Discussing diabetes he states:

"Let us for a moment discuss the constitutional disease, diabetes. Here we have an endocrin breakdown. We now know that ultraviolet light affects the acetone components of metabolism by increasing or activating their decomposition to gas formation (Schanz, F., *Arch. f. d. ges. Physiol.* (Pflüger's) 1918, pp. 170, 646.) It has been my observation that in the application of quartz ultraviolet light to the human body, the individual's oxidation index is invariably raised to a higher percentage. For instance, a patient free from diabetes, whose urine reveals a proportion of urea nitrogen to total nitrogen of 50 per cent, will, after the application of several months' treatment with quartz ultraviolet light, have this proportion raised 20 to 30 per cent. Ordinarily there exists an idea that diabetes is a disease of suboxidation. This idea is a fallacy; it is not borne out by the chemical facts, for invariably the urine oxidation index of this type of endocrine breakdown is above 85 per cent urea nitrogen to total nitrogen. My last two diabetic cases revealed a peak of 89 per cent, and 88 per cent respectively. As quartz ultraviolet light stimulates the oxidizing power of the synthetical forces of the body and as, in my judgment, diabetes is a superoxidization process, treatment with ultraviolet light cannot be administered at all, so long as the patient's metabolism is not in chemical equilibrium. During the past four years of my work with ultraviolet light in constitutional disorders, I have tried it repeatedly in diabetes, from small to moderate doses. Always the same result occurred, namely, the patient reacted poorly and gave every indication of increased toxic distress similar to anaphylactic shock. As a result of these detrimental toxic experiences, I, today, do not administer ultraviolet light to a diabetic.

"To summarize: A technique for the better coordination of the kinetic bodily forces may be divided into two parts, one relating to internal, the other to external technique.

"Internal technique involves the accurate quantitative knowledge of the constituent chemical ingredients of the blood and urine and a heart electrocardiogram. It further involves the regulation of the chemical food intake to the chemical outgo, so that a nitrogen equilibrium is maintained.

"The external technique involves the treatment of the body skin surface with quartz ultraviolet light, the absorption of which stimulates tissue metabolism. In toxic quantities quartz light produces anaphylactic shock. With the exception of diabetes, however, quartz light results in a raising of the factor of tissue vitality, or, it might be termed, of the patient's prophylactic resistance to disorders of nutrition, whether of acidosis or other low oxidation states."

So much for the ultraviolet constitutional effects. The conjoint use of the ultraviolet and the roentgen ray was suggested to us gradually by a comparative study of both their local and general effects, and by the ease with which a *beginning* roentgen-ray dermatitis could be cut short and, clinically at least, cleared up by vigorous actinotherapy. And the ultraviolet therapy in these cases, to be effective, must be vigorous. It is effective even after ulcer formation begins, provided it is used before masses of cicatricial tissues have formed. Once these have formed, the case should not be expected to respond to actinotherapy alone. Surgery, radium, diathermia, or some other means of softening or eliminating the scar tissue must precede the application of the ultraviolet light. We have seen it stated that the use of the actinic rays might be followed by xeroderma pigmentosum or skin cancer. We have never been able to authenticate a case of this kind from heavy actinic doses. No doubt there have been cases due to irritation from the actinic ray in the sunlight (which is of the longer wavelength—never below 2,910 Ångström units, and of no great intensity as compared to quartz-burner intensity) but in this case we would state that clinical experiences lead us to believe that the skin may react to the actinic ray irritation somewhat as it acts when telangiectases form from roentgen ray, i.e., that it is more apt to form from small doses over considerable area, often repeated, than from heavier dosage. We have been cautioned by prominent roentgen-ray therapists that it was against all the rules of the game to superimpose an actinic erythema upon a skin that had already received a dermatitis dose of roentgen rays. We can only answer by stating the clinical fact that we have been doing it for a number of years without a single depilation occurring, or symptoms which would indicate that a dermatitis had occurred, and have greatly exceeded dosages which, before the use of this method, regularly gave us a dermatitis. These well-meant cautions have had the effect of causing us to treat a few hopeless cases first and wait for months before increasing the dosage proved safe in those cases. The result is that we have pushed the dosage only to the figures given in the appended cases. Whether these dosages can be much extended is a problem for future research. We have, until now, been handicapped by the fact that our laboratory has been running overtime on routine work and could not take on any research work for us along this line; but preparations are being made for expansion, and facilities planned for the doing of a great number of experiments by which we hope to prove on a large scale the value of this combined technique, and set out the limits of safety.

The *x*-ray outfit used in these cases was a Wappler, King model, Coolidge tube, medium focus; and the constant factors were: Spark gap, 9 in., (except splenic area, Case II, where it was 10 in.); target skin distance, 8 in.; filter 6 mm. aluminum, 2 mm. leather; ma. in tube, 5; time variable, as given. The ultraviolet outfits were of the quartz mercury vapor type both air cooled and water cooled. The roentgen-ray treatments were given by the medical officer roentgenologist and 2 competent *x*-ray technicians, and every factor checked up by each of us. The timing was done by an interval timer checked by three standard watches set in synchronism. The spark gap was always at least that given, and broke over several times, with the parallel gap set at 10 and 11 in. respectively. A series of 27 skin areas tested on control subjects of approximately the same ages and complexions as the cases cited (areas were on back between shoulder blades) gave the time necessary to produce a first degree erythema with the 9 in. gap, and other factors used as an average of 17½ ma.m.

As the ultraviolet technique was the same in all cases, the detailed dosage will be given only in the first case. The essence of the technique is to prepare the skin area to be treated by the roentgen rays by a series of actinic-ray erythemas produced as rapidly as the preceding one begins to die out, and repeated until heavy tanning takes place, or, in case the subject will not tan, for approximately four weeks; and at the same time give general ultraviolet radiations (not necessarily so severe, but as strong as comfort of patient will allow) for the constitutional effect. When it is decided that the area is prepared sufficiently, allow the last actinic erythema to fade out, and then give the roentgen-ray treatment. On the same day, but *after* the roentgen-ray treatment, give at least as much ultraviolet exposure as was given at the last previous ultraviolet treatment over the area treated by the roentgen rays. Also keep up the general ultraviolet exposures. Repeat the application of the ultraviolet in the same or slightly increased dosage over the roentgen-treated area about every forty-eight or seventy-two hours, as the actinic reaction indicates, until that area has had at least 3 good actinic exposures, and then allow all actinic erythema to die out, so as to be able to detect the roentgen erythema which will come up later if it is to appear. In practice we cover a small central area after 2 or 3 actinic treatments, and keep up the ultraviolet applications to all the rest of the area for a period of three weeks, using the small covered area as a control for the *x*-ray erythema.

CASE I. Male, aged thirty-seven, American, Sergeant, U. S. Army.

Family History. Negative.

Personal History. Negative.

The first appearance of a tumor size of a hickory nut on left forearm in October, 1918. This was removed in March, 1919, at Fort Riley, Kansas.

Patient was sent to Camp Upton in December, 1919. Diagnosis, recurrent tumor, left forearm. This was removed December 17, 1919, being the second operation. A specimen was sent to the laboratory for pathological report.

Diagnosis. Sarcoma, mixed cell type. Tumor recurred rapidly after second operation.

Patient admitted to Army General Hospital April 27, 1920. Tumor size of cocoanut on the ulnar aspect of left forearm.

X-Ray Report (April 27, 1920). Stereo of left forearm, upper third including elbow shows growth of soft tissue not involving the bone. From the lateral plates the upper third of radius is bowed forward as if from pressure in this region. There is a slight amount of thickening of the periosteum of the ulna in this region. The cortex of both bones is intact, the elbow is negative, as are the plates of the chest.

May 11, 1920. Specimen from epitrochlear gland to laboratory.

Gross Examination. Small mass 1 cm. long by ¾ cm. thick.

Microscopical Examination. Small amount lymphoid elements, being a small lymphoid follicle at one edge of section. Main structure of section is a loose mass of cells, large spindle cells predominating, with numerous large round cells. Also connective tissue and newly formed blood-vessels. No giant cells.

Diagnosis. Sarcoma, mixed cell, large spindle cells predominant; not a lymph gland.

May 29, 1920. *X*-ray of chest. Stereo of chest shows slight retraction on lower right lateral aspect of chest wall. Heart and chest otherwise negative except for four circular areas of consolidation which give the typical snowball appearance of metastasis of sarcoma.

Three areas appeared after the last plate was made and one, which was present in the last plate, was not more than a third of its present size and had not taken on any characteristic appearance at that time. It was located in the lower part of the hilum where small areas of consolidation are often found. No special significance could have been given it then. Small accumulation of fluid at the base of left chest which was not present at the previous examination.

Diagnosis. Sarcoma of left forearm with metastases of chest. Patient referred to physiotherapy service May 27, 1920, at which time preliminary treatment was started and the photograph which accompanies this article was taken.

Operation Report. (May 29, 1920.) Sarcoma left forearm with axillary and pleural involvement by metastasis.

Operation. Amputation middle third humerus; dissection of axilla. Curved incision 12 inches long from middle of pectoralis major along course of cephalic veins to lower third of upper arm. Tendon of pectoralis major divided ¾ inches from its insertion and turned back. Axilla dissected, removing all fat and glands. Axillary vein dissected clear, exposing brachial plexus. Flap dissected on upper arm (rachet) and brachial artery and vein, cephalic and basilic veins tied. All nerves injected with alcohol and cut by fishtailing after pulling down. Muscles cut through and bone sawed, periosteum removed off cut edge, triceps sewed to biceps over bone end by interrupted sutures, wound closed. Major Jones.

PHYSIOTHERAPY TREATMENT

NOTE. In giving the ultraviolet exposures, to save space, the air cooled ultraviolet lamp will be designated by "A" and the water cooled ultraviolet lamp by "W." The time in minutes will be the first numeral, X will mean "at," and the following numeral will be the number of inches from target to skin, or in the case of contact exposures with the water cooled lamp the letter "C" will denote contact; thus 2 × 18-A will mean two minutes at 18 inches with the air cooled lamp and 10 × C-W will mean ten minutes at contact with the water cooled lamp, etc.

Date	Region Irradiated	Exposure	Ultraviolet Skin Reaction
May 27	Over metastases	6 × 1-W	Mild erythema
May 28	Over all sides chest	2 × 22	Mild erythema
	Operation		
June 15	Over metastases	6 × 1-W	Mild erythema
June 15	General over chest	2 × 22-A	Mild erythema
June 18	General over chest	2 × 22-A	Mild erythema
June 20	Legs, front and rear	2 × 22-A	Mild erythema
June 21	Over all chest	3 × 22-A	Mild erythema
June 21	Over metastases	4 × 1-W	Mild erythema
June 22	Legs, front, rear	4 × 22-A	Mild erythema
June 23	Over chest	4 × 22-A	Mild erythema
June 24	Over metastases	9 × 1-W	Good reaction
June 25	Chest, legs, all sides	3 × 22-A	Mild reaction
June 26	Legs	5 × 20-A	Good reaction
June 26	Chest	4 × 20-A	Good reaction
June 27	To metastatic areas	10 × C-W	Heavy reactions
June 28	Chest	8 × 20-A	Good reaction
June 28	Legs	4 × 20-A	Good reaction
June 29	Chest	7 × 20-A	Good reaction (tanning well)
June 29	Legs	9 × 20-A	Good reaction
June 30	Chest	10 × 20-A	Mild reaction
June 30	Legs	8 × 18-A	Mild reaction
July 1	Legs	8 × 18-A	Mild reaction
July 1	Chest	10 × 18-A	Mild reaction
July 2	Chest	12 × 18-A	Mild reaction
July 2	Metastases	10 × – C-W	Mild reaction
July 5	Metastases	10 × – C-W	Mild reaction
July 5	Chest	8 × 15-A	Mild reaction
July 6	Chest	10 × – 15-A	Very slight reaction (Acct. deep tan)
July 6	Legs	8 × 18-A	Very slight reaction (Acct. deep tan)
July 7	Metastases	11 × C-W	Good slight reaction
July 8	Chest, legs	10 × 18-A	Mild reaction
July 10	Chest	12 × 18-A	Mild reaction
July 10	Metastases	12 × – C-W	Mild reaction
July 12	Chest	12 × – 18-A	Good reaction
July 12	Legs	10-18-A	Good reaction
July 13	Chest	12 × 18-A	Mild reaction
July 13	Legs	10 × 18-A	Mild reaction
July 15	Metastases	15 × 1-W	No reaction
July 18	Chest	15 × 18-A	None
July 19	Chest	15 × 18-A	None
July 20	Chest	15 × – 16A	None
July 20	Legs	15 × 16-A	None

Area of experiment 6 × 4½ inches on antero lateral aspect of lower right chest, over the largest double metastasis. Diagrammatic reproduction of area follows.

1 A July 30 X-ray dosage 45 ma.m. to areas 1 and A 10 × C-W July 30 10 × 20-A July 31 10 × 1-W Aug. 2 Etc. See below No after treatment with ultraviolet	4 D August 2 X-ray dosage 25 ma.m. to areas 4 and D Ultraviolet same as square Number 1 No after treatment with ultraviolet
2 B July 30 X-ray dosage 62½ ma.m. to areas 2 and B Ultraviolet same as square Number 1 No after treatment with ultraviolet	5 E August 4 X-ray dosage 75 ma.m. to areas 5 and E Ultraviolet same as square Number 1 No after treatment with ultraviolet
3 C August 2 X-ray dosage 50 ma.m. to areas 3 and C Ultraviolet same as square Number 1 No after treatment with ultraviolet	6 F August 4 X-ray dosage 75 ma.m. to areas 6 and F Ultraviolet same as square Number 1 No after treatment with ultraviolet

The lettered areas were not treated with ultraviolet *after* the *x*-ray exposures were made. The numbered areas were treated with ultraviolet as follows:

On the day of *x*-ray exposures and immediately after the *x*-ray had been given:

Same day	10 × C-W
Next day	10 × 20-A
Third day	10 × 1-W
Sixth day	15 × 1-W
Ninth day	15 × 1-W
Tenth day	12 × 16-A

In an ordinary case with a moderate overdose of *x*-rays, the subsequent ultraviolet treatments would be stopped at the end of six or seven days, as the *x*-ray erythema usually comes up in from eight to fifteen days. In this particular case, we carried the ultraviolet treatment to ten days, and used the lettered areas as a control to watch for the *x*-ray erythema. We fully expected to produce an erythema on the lettered areas, and were trying hard to prevent it on the numbered areas. We were pleasantly surprised when no erythema resulted upon either the lettered or numbered areas. In addition to the radiation directly through the metastases, the two larger ones were treated by crossfiring, from four angles, using a 50 ma. m. exposure. A marked *x*-ray dermatitis appeared in the left axilla, the hair coming out and ulceration starting on the skin of the stump where we had neglected to tan the skin of both areas, on account of the dressings on the stump. This was not from direct exposure of these areas to the *x*-rays, but was caused by the crossfire rays emerging from the body at this point. It quickly cleared up under a few ultraviolet treatments. In addition to the *x*-ray experiment upon areas F and 6, and to test the irritability of the skin after these massive dosages, a capsicum plaster was applied. When no result was evident in twenty-four hours, a second, and later a third plaster was applied to these same areas before a mild blister resulted. A control gave a blister overnight.

Location of metastases has been marked on the chest wall on the photograph. Under this treatment the metastases rapidly dropped out of the picture. Patient's general condition improved from the start. He was transferred to a hospital nearer his home a short time after his course of treatment was finished, but continued to improve. He visited our clinic last month (May, 1921). He has regained his normal weight and says he has, and looks to have, rugged health. He is developing a hard mass in his left calf which is probably sarcomatous in character, and has a small suspicious area in the lower posterior chest, which is not one of the original metastases. This area was not in the heavily rayed portion of the chest. He has been advised to return at once for a full course of treatment, and is taking the necessary steps to be admitted as a patient to this hospital. We hope to control these metastases as the others were controlled.

Case II. Male, aged twenty-nine, American, chauffeur.

Family History. Negative. No cancer, tuberculosis or insanity in family.

Personal History. Negative. Habits good. Smokes cigarettes.

Drafted May 18, 1918. Discharged March 15, 1919. First noticed sore on lower lip, left side, December 10, 1918, in Beautesart, France. Wassermann done at this time negative. Sore started as small pimple, ointments applied. Healed and broke open at intervals until his discharge, gradually growing larger. Discharged at Camp Dix and immediately consulted his family physician. Wassermann again negative. May 20, 1920, excision of growth was done. Remained in hospital one week and returned home. Three weeks later gland in neck removed. Wound broke down after five months, and after consulting his physician again, he was treated until February, 1920, when he was referred to another hospital, where he received 2 applications of radium, three weeks apart. Relief for some months and then pain and swelling started again. Admitted to this hospital December, 1920. Condition as shown on April 2, 1921, when he was referred to our clinic for treatment. Ultraviolet treatment in preparation for roentgen-ray treatment started, although results were very problematical, due to degree, age and previous operations. At end of ten days urgent pressure symptoms developed with a rapidity which made it inadvisable to defer roentgen-ray treatment, and after consultation with several surgeons it was decided to give him the maximum dose although he had not had the areas properly prepared. On April 11th, he received 75 ma. m. over metastatic tumor in left occipital triangle; on April 12th, 75 ma. m. over primary growth area and over metastases in left superior carotid triangle; on April 13th, 75 ma. m., over metastases in right occipital and right superior carotid triangles; and on April 14th, 75 ma. m., over metastases in region of left parotid gland. On May 2nd, he received 75 ma. m., over left parotid region again; on May 9th, 75 ma.m., over night submaxillary triangle. In spite of these dosages with their crossfire rays emerging in some cases in another treated area, and his insufficient preliminary ultraviolet preparation, no dermatitis resulted. On June 11th, 13th and 15th, he again received 75 ma. m., over the left parotid, right submaxillary and primary areas respectively. His ultraviolet was kept up regularly. He is still alive, but failing, and his latter treatments were more to satisfy him than in hope of doing any real good. His beard is still in place and pains him when it is pulled. Blood count ranges from 6,624,000 reds to 4,080,000 and whites 6,600 to 7,200. Hemoglobin 65 to 73 per cent, differential small mononuclears 16 and 17 per cent, large mononuclears 3 and 4 per cent, eosinophiles 1 and 2 per cent, neutrophiles 77 per cent.

Case III. Male, aged thirty-four, Italian.

Diagnosis. Osteosarcoma with metastases.

Family History. Negative.

Personal History. Negative. Smokes cigarettes.

May, 1920, had pains more or less generalized over body, but especially over right clavicle. In July, 1920, noticed lump over right clavicle. Treated at home until October, 1920, when he was admitted to a hospital in New York City, remaining there until February 3, 1921, when he was admitted to this hospital. Condition on being admitted: Cast from 7th cervical to junction between middle and lower third of the tibia. Report of consulting orthopedist (February 4, 1921):

"There is a large, spherical mass attached to right clavicle. Condition is probably a sarcoma with metastases in spine and chest. Liver also enlarged, edge being felt about 12 cm. below costal margin. Condition inoperable. Request that *x*-ray and summary of history from the New York hospital be obtained."

In December, 1920, patient also had pleurisy with effusion while in the New York hospital. Patient was sallow, anemic, emaciated, and could not be removed from his cast, which shell extended from neck to heel and partly up the sides of the body. Careful lifting and turning were required to get him out of his cast for treatments, and at first this caused him great pain. On April 11, 1921, was given preliminary ultraviolet treatment, and then 75 ma. m. in. over each of the two most painful areas on spine. On April 12th, the primary growth at sternal end of right clavicle received the same dose; on April 13th, the metastases in region of sternal end of left clavicle received 75 ma. m. in., and on April 14th a cluster of metastases at costal extremities of 6th, 7th, 8th and 9th ribs received 75 ma. m. in. The roentgen-ray plate showed all these metastases except that clear plates of the spinal lesions were impossible to obtain. Pain began to lessen in all areas thirty-six to forty-eight hours after the roentgen-ray treatment was given. On April 28th, after patient had complained of constantly increasing pain in splenic area, and a hard mass could be made out by palpation, he was given 90 ma. m. with a 10 in. back-up spark over this area. The pain lessened at once, but persisted for some two weeks, when it also disappeared. No roentgen-ray sickness resulted from this dose, and Figure 3*a* shows the condition of the hair over this area, showing that on the sixteenth day after the *x*-ray dose, when this plate was taken, the skin of the abdomen could be pulled out an inch or more by tension on a dozen hairs. This test was made daily for six weeks after the administration of the *x*-ray dose, and showed a healthy condition of the hair follicles all the way through. Figure 3*b* of the same case shows what happened when he was given the usual time and distance in one of his preliminary actinic ray treatments, but when a brand new burner had been substituted, and the attendant overlooked the notice on the lamp ordering exposures cut in two until the new burner could be standardized. The whole exposed area exfoliated in large strips, and small blisters were produced in the center where the intensity was greatest. In spite of his poor condition (his blood picture showed a condition almost exactly simulating pernicious anemia) he became so much better after the *x*-rays were administered that he was able to get out of his cast into a wheel chair by his own efforts and propel himself around the ward. His anemia is gradually taking him down again, and it is only a question of time for him, in spite of transfusions or other expedients. The primary growth has retrogressed one-third in size, and the nodules on the ribs have practically disappeared. He is too ill to move to the roentgen-ray department for further plates.

Case IV. Male, aged fifty-seven, Irish, merchant marine.

Diagnosis. Basal cell epithelioma.

Family History. Negative.

Two and one-half years ago a small sore appeared. Treated with various ointments, healed, but broke open again. Says there was no mole in that locality. Sore gradually grew larger until it reached the size and appearance shown. This case is shown only because of his complexion, his skin being of the type that blisters readily, but will not tan under the strongest ultraviolet-light exposures. After preliminary erythemas from actinic rays, under which the lesion almost disappeared, he was given 75 ma. m., and parotid and carotid regions are now being prepared for prophylactic raying, on the remote possibility that a metastasis might appear later. He was given the *x*-ray treatment on May 31st, and up to June 25th had shown no signs of erythema.

Case V. Male, aged twenty-nine, American.

Diagnosis. General paronychia.

Family History. Negative.

Personal History. Negative, except that patient was gassed in 1918. A short time afterwards he developed the pustular condition of the nails which progressed in spite of all treatment. When he came to our clinic a year ago he had lost, or had had removed, every finger and toe nail, and pus was exuding from the matrix. The *x*-ray plate showed a periostitis of every terminal phalanx. He had been given vaccines, both stock and autogenous, had had applications of iodoform and glycerine for months, etc., and was finally referred to us for treatment. Every one of our air cooled actinic-ray lamps was running overtime on serious cases, but after a few days a place was found for him on one of the water cooled lamps, and he was started on *local* ultraviolet treatments. He made no improvement until a vacancy occurred on one of the air cooled lamps (ultraviolet) when he was given *general* treatments in addition to the local ones. Improvement was manifest by the fifth day, and in seven and a half weeks he was discharged from the army and went home. He kept in touch with us by writing at intervals, and after a lapse of eight months he wrote that his hands and feet were perfectly well, and that he had new nails coming in on all fingers and toes; but he wanted to know why they were so brittle. This case had received no treatment for months before he came to our clinic, and received no other treatment at the hospital at any time except the actinotherapy outlined. An *x*-ray plate taken the day before he left showed no signs of a periostitis.

SUMMARY

In the human organism the epidermis is the natural covering which acts as a defense against certain stimuli in which the individual is immersed. Individuals have constantly been exposed to the sun's actinism, so that, a priori, the skin is the naturally provided filter against such actinic effects as must be excluded from the body, but it is at the same time permeable to those actinic effects which act as adjuvants in fostering the physiological unity of the individual.

The tanning or sun-burning of the skin may be accomplished more rapidly and under more perfect control in the clinical theater by the use of scientifically elaborated apparatus, whose function it is to duplicate with intensity the therapeutically useful actinic spectrum.

The trial and error of empiricism has established that an effect of clinically induced "ultra sun-burn" is such as to provide an epidermal pigmentosis. This newly induced epidermal pigmentosis so reacts that the area involved, when exposed to relatively soft *x*-rays, permits of the assimilation by that part of a greater quantity of physiologic roentgen radiation, at the same time precluding the physiologically detrimental effect that would otherwise be produced on an area of skin unexposed to intense actinism.

An extremely important principle is discovered; the principle that nature has provided the guide for offering a protective mechanism whereby spectral phenomena closely allied to ultraviolet activity, or *x*-rays, can exert very helpful and stimulating influences without exercising deleterious effects such as are produced without proper preparation.

The application of this fundamentally important principle is at once obvious. It precludes the necessity for elaborating expensive and impractical apparatus to generate an unnatural radiation in the treatment of disease. For with the unnatural *x*-ray radiation, unnatural filters of copper, aluminum and zinc are made necessary. In effect, ultraviolet treatment of an area provides the natural means that the laboratory experimenter endeavors to secure through the use of copper and other unusual metallic elements.

The essential feature of this clinical research is to point out that ultraviolet and *x*-ray radiations are physiological complements. The one may be used in symbiosis with the other. That is, the ultraviolet applied first renders the area more resistant to the subsequent radiation with the roentgen rays. The roentgen rays applied first may produce a dermatological change injurious to the organism; but the effects of that injury can be alleviated or entirely neutralized by applying secondarily the

ultraviolet radiation. From this foundation it is adduced that the ultraviolet greatly extends the previous limits of x-ray efficacy in the treatment of disease.

Hence the conclusion of an empirical research is obviously the empirical restatement of the research itself and carries with it the single conviction that the clinical trial of the method presented accomplishes more than speculative conjecture based on hypothetical presumptions.

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TREATMENT BY RADIUM OF NASAL POLYPS*

BY HORACE R. LYONS, M.D.

Section on Otolaryngology and Rhinology, Mayo Clinic

ROCHESTER, MINNESOTA

THE underlying cause of nasal polyps is inflammation which involves either the nasal mucous membrane or an accessory nasal sinus and, in some cases, both. The fact that inflammation, due either to irritation as in vasomotor changes, or to suppurative conditions, usually is a cause of nasal polyps, has a direct bearing on the treatment, in that simply removing the polyp will not affect the underlying inflammatory process which must be eradicated. The pathological condition associated with the polyp, is usually disease of a sinus. In the majority of the cases, the anterior and posterior ethmoid sinuses are affected, although the inflammatory process may involve any or all of the other sinuses.

Nasal polyps may be divided pathologically into five groups: (1) Myxomatous, (2) adenomyxomatous, (3) fibromyxomatous, (4) adenofibromyxomatous, (5) fibromatous.

Group 1. Myxomatous polyp is the type most commonly found in the nose. Such polyps may occur at any age, but are most often found in middle-aged persons. At examination the tumor appears large, soft, and water-logged. It may be spherical or pear-shaped with a neck or pedicle which is attached to the mucous membrane over a sinus. It bleeds very freely when touched and is movable.

Group 2. Adenomyxomatous and myxomatous polyps are identical clinically and are differentiated only by microscopical examination. This reveals that an adenomyxomatous tumor has, in addition to the structure of a myxoma, a number of glands scattered throughout the tissue. Regeneration of myxomas and adenomyxomas is very rapid and these

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types tend to recur over a larger area than that of their original appearance.

Group 3. A fibromyxomatous polyp, on observation, has a distinct water-logged appearance, but, unlike the polyps of Groups 1 and 2, is firm and bleeds less freely when touched. It is much more resistant to a probe than the others, and is usually attached to the mucous membrane over one of the sinuses. Microscopic examination shows the structure of a myxoma with a varying amount of fibrous tissue throughout. This tumor usually does not recur over an area increasingly large.

Group 4. An adenofibromyxomatous polyp clinically resembles a fibromyxoma and is differentiated from it only on microscopic examination, which shows the structure of a myxoma with fibrous and glandular tissue throughout. This type of tumor is similar to fibromyxoma in recurrence and reaction to radium.

Group 5. A fibromatous polyp is a clinical entity. It is hard, and may or may not have a pedicle. It offers considerable resistance to the probe on examination and does not move freely. Fibroma is more likely to be single than multiple. Clinically, there are two types, the hard, or so-called fibroma durum, and the soft fibroma, both of which microscopically are seen to consist of fibrous tissue only. Fibromas are the least common of all nasal polyps.

TREATMENT

All possible methods of medical and surgical treatment have been attempted and, as yet, a definite procedure that will effect permanent cure has not been found. The use of radium was introduced about three years ago in an effort to aid operative measures in effecting a cure, or, at least, in delaying recurrence. The operative procedure will not be discussed, except to say that in the Mayo Clinic it has been found that rather radical removal of the tumor is not sufficient to produce the desired effect and radical exenteration of the involved sinuses is necessary. We attempt to eradicate the suppurative disease of the sinus as well as to remove the polyp. It has also been found that simply removing the polyp at its point of attachment is insufficient, because the polyp is likely to recur in the surrounding mucous membrane. Therefore, a wide excision of the membrane around the point of attachment is necessary.

Radium. The use of radium for nasal polyps postoperatively was undertaken in the Mayo Clinic three years ago in the hope that radium would stimulate the production of fibrous tissue in the recurring polyp and thus make a second operation more successful. This is based on the fact that the more nearly a polyp pathologically simulates the fibroma, the more easily a complete cure is effected by removal; in myxomatous polyps it is very difficult to effect a cure.

This study is based on a series of 55 cases of nasal polyps in which radium was used postoperatively 111 times to total 14,892 mgm. hours. At first, radium burn was very much feared, particularly because data were not found in the literature with regard to the use of radium in nasal polyps, and only a 25 mgm. tube of radium was used postoperatively for one hour. Burns did not result, and since more radiation was deemed necessary, a 50 mgm. tube of radium has been used for from two to three hours at intervals of one week, the first treatment being given on the second or third day following operation. In 3 cases, as much as 1,000 mgm. hours of radiation has been directed to the point of attachment of the polyp. The radium is screened by a thin silver tube with a small ring at one end to which a string is attached. The silver tube, in turn, is covered by a sterile rubber finger-cot. The tube of radium is embedded in the center of the area most active in the production of the polyps and the string is attached to the cheek by adhesive tape. The use of 150 mgm. hours of radiation postoperatively at one-week intervals can be continued for an indefinite time without causing a burn. In the cases herein reported, radium was used as often as five times; complications due to the radium did not result.

The ultimate results in a few of the 55 cases are unknown because some of the patients did not remain for more than one radium treatment postoperatively. I shall report in detail 3 representative cases which have been under my observation every two or three months for three years. In general, nasal obstruction is the complaint of all these patients; nasal discharge is usually associated. Many have had a large number of operations for removal of polyps, and examination of their noses shows that most of the membrane is involved in polypoid change.

REPORT OF CASES

Case I (A106551). Female, aged forty years. First came to the Mayo Clinic in 1914 complaining of nasal obstruction of nine years' duration and loss of the sense of smell. Her first operation for the removal of nasal polyps had been performed in 1909. Since then she had had eight such operations.

Innumerable irrigations of both antrums were given without relief and submucous resection of the nasal septum was performed. Not being benefited by this treatment, she left the Clinic.

In 1921, the patient returned to see if any new treatment had been found that would offer even temporary relief. Severe attacks of asthma, which had occurred since the onset of her trouble, had become more frequent during the last two years. The sense of smell was completely lost. We advised our usual operative treatment and radium postoperatively.

On March 5, 1921, a specimen of a polyp was removed from the patient's nose; pathological examination revealed adenomyxoma. All polypoid tissue in the nose was then removed radically and the antrum and posterior ethmoid sinuses, which showed hyperplastic suppurative change, were exenterated. Considerable reaction followed this extensive operation and use of radium was impossible until March 11, when 200 mgm. hours of radiation was applied in each middle meatus. March 21, 200 mgm. hours was applied to each side. Further local treatment, chiefly shrinkage and suction of each middle meatus, was given and the patient was dismissed to return again in two weeks.

On April 9th, when the patient returned, she was most elated over the fact that she was able to smell all odors; from then on her sense of smell was very acute. Two hundred and fifty mgm. hours of radiation was applied in each side of the nose.

On June 2d, the patient again returned, at which time she received 250 mgm. hours of radiation in each middle meatus.

This patient has been seen at least every two months since operation and her nasal condition has remained most satisfactory. In March, 1922, at the time of her last visit, her sense of smell was very acute. She did not have nasal obstruction or discharge, and the region of her nose from which polyps had been removed so many times was now covered by pale membrane resembling fibrous tissue, which was resistant to the probe. There were no polyps in either side.

In this case the effect of the radical operation, followed by 1,800 mgm. hours of radiation, was first, restoration of the sense of smell, lost since 1913; second, elimination of the large number of adenomyxomatous polyps; third, reduction to a minimum of the discharge which had previously occurred from both sides of the nose; fourth, absence of nasal obstruction which had been present for many years.

Case II (A45999). Female, aged fifty years. First came to the Clinic in 1907 because of severe asthma and nasal obstruction. Between 1907 and 1919, she had frequent attacks of asthma which were so severe that she had become unconscious and hypodermic injections of epinephrin had not given relief.

In 1919, the patient returned seeking relief from nasal obstruction. She had had ten or twelve operations on her nose for removal of nasal polyps—so many, in fact, that she could not remember the number. She had recently had a severe attack of asthma. Multiple myxomatous polyps filled both sides of the nose, and there was associated anterior hyperplastic ethmoiditis. Two operations, one on each side of her nose, were necessary at this time in order completely to remove the polypoid tissue and thoroughly to exenterate the anterior ethmoid labyrinth. On November 20th, 200 mgm. hours of radiation was applied on each side of her nose.

During the following two months the patient was seen every week and then every two weeks until May 20, 1920. at which time 200 mgm. hours of radiation was again applied on each side of her nose. Since then she has been observed at frequent intervals. She has had remarkable relief. Since her operations in 1919 and subsequent radium treatment, she has not had asthmatic attacks. At her last visit, April 1, 1922, there was no nasal obstruction and only a small amount of mucus on the floor on each side of the nose. The middle meatus was free from polyps and the membrane was pale and definitely resistant to the probe.

Case III (A135740). Male, aged forty years. First came to the Clinic in 1915 because of nasal obstruction. Small polyps were found, but apparently the chief cause of obstruction was a fractured septum. A submucous resection of the septum was performed.

The patient returned to the Clinic in April, 1920, because of marked nasal obstruction and discharge. Examination revealed multiple, large, obstructing polyps in both sides of the nose, and hyperplastic suppurative ethmoiditis. The tonsils, which were definitely septic, were removed on April 27th.

On October 21st, the patient returned and the polyps from both sides of the nose were completely removed and radical exenteration of both anterior and posterior ethmoids on each side was performed. Both middle turbinates were involved in the polypoid change and were amputated. A second operation for removal of the polyps was performed on December 3rd. Between this time and February 4, 1921, 1,600 mgm. hours of radiation was applied to the diseased area.

The patient has been seen at intervals of one month; in March, 1922, his nose was still in good condition. There was a slight polypoid change in the posterior end of each middle meatus, which, however, had not progressed. Microscopic examination revealed adenomyoxma.

Many of the other patients in the series of 55 pursued the same course, but it was not possible to observe them frequently after the operations and the treatments by radium.

CONCLUSIONS

Definite conclusions with regard to the results obtained by the use of radium following operation for nasal polyps await more experience and more general use of radium. Information obtained from the observation of cases in this series indicates points as follows:

1. The application of radium should be started on the second or third day after operation.
2. Radium should be applied not oftener than once a week.
3. Two hundred milligram hours of radiation at weekly intervals has not produced a burn, and is, therefore, safe radiation.
4. Radium, in the majority of cases, undoubtedly definitely lengthens the intervals of recurrence.
5. Definite operative cures occur more often with radium than without it.
6. Radium does not affect an associated suppurative sinus disease.

DISCUSSION

Dr. Lillie. The number of recurrences in this type of case following radium treatment has been greatly decreased. It seems to us that radium offers the best chance for the control of this type of disease process in the nose. As our knowledge and experience grow clinically, in the choice of case, and in the choice of the proper dosage to affect the desired change pathologically, it is felt that the management of these cases will be more rational and scientific, and results will be better from the patient's standpoint.

RADIUM TREATMENT OF DISEASED TONSILS*

BY CARL F. ROBINSON, M.D.

BARRE, VERMONT

GRANTED that the tonsil needs treatment whether from infection or hypertrophy, five methods of attack present themselves, namely, (1) the application of radium tubes or needles directly against the tonsil, (2) the application of radium externally over the tonsil, (3) the application of the placque directly, (4) the introduction of radium needles, (5) emanation tubes introduced directly into the substance of the organ.

I will report a series of 75 cases of enlarged and diseased tonsils, treated by radiation, many of which were referred by throat men. Operation was contraindicated because of stone-cutter's disease, heart conditions, hemophilia or fear. The general practitioner, the throat man and myself have been impressed by the manner in which these throats cleared up after radiation.

MODE OF ACTION

According to Witherbee, after *x*-ray treatment of the tonsil, there is an atrophy of the tonsil and an absorption of the immature lymphatic cells in the follicle which lessens the depth, and results in a distortion of the crypt causing an eversion and an evacuation of the crypt contents. Radium probably acts similarly.

We were able to secure good results with the *x*-rays, but on account of the time needed (six to eight treatments two weeks apart), fear of a noisy apparatus, and possible danger to overlying structures, our attention was turned to the possibilities of a direct application of radioactive material.

METHOD OF APPLICATIONS AND TECHNIQUE

Method 1. The tonsil and nasopharynx are swabbed with a solution of novocaine to eliminate gagging rather than to ease pain. Many do not receive this preparatory treatment. Two 12.5 mgm. radium needles are threaded and introduced into the center of the tonsil and left in place from two to four hours. We usually treat both tonsils at the same sitting. The patient rarely has a noticeable reaction from this amount of radiation. In four to six weeks complete atrophy will be found—the anterior pillar having to be retracted in order to find any remaining tonsil.

Method 2. Fifty mgm. of the element—I use four 12.5 needles,—screened by 0.4 mm. steel, 1 mm. brass and one thickness of rubber tubing, is held directly against the tonsil for one hour, by means of the Cameron Adjustable Radium Applicator.

Method 3. A 50 mgm. tube screened with .4 silver, 1 mm. brass and 1 mm. rubber and one-half inch of gauze is applied externally over the tonsil for six to ten hours depending upon the age and skin of the patient.

Method 4. An unscreened 20 or 30 mgm. placque is held directly against the tonsil for one or two hours.

Method 5. Unfiltered emanation introduced into the tonsillar substance.

I have used only the first three methods and will report the results. My first 30 cases were crudely treated by the external method with a more or less complete atrophy in 25. The cases receiving this method of treatment were usually small children and infants whose mothers positively refused the operation, or in whom some contraindicating condition was present. Their ages ran from eight months to fifteen years. Small children received six hours over each tonsil, and older children up to ten hours. I have rarely seen more than a very slight erythema. These patients breathe better in two weeks and the atrophy is very noticeable in four weeks. The second treatment is rarely needed. My own three-year-old baby was treated in this manner, and I thus had the rare opportunity of watching daily progress of the action of the element. The cases which I count more or less as failures were in patients with thick or fat necks and older or chronic tonsils. Even in these cases where a very noticeable atrophy could not be secured there was a marked smoothing out of the surface of the tonsil and less

* Read at the Seventh Annual Meeting of The American Radium Society, St. Louis, Mo., May 22–23, 1922.

susceptibility to frequent attacks of the so-called colds.

Twenty-five cases have been treated by the needle method. All these have responded beautifully to treatment; and I can confidently say that if the throat men would watch such cases with unbiased minds, the operation would be a thing of the past, resorted to only after failure with radium. The men in my vicinity certainly acknowledge that the results are equal to theirs by operation, and without the danger of an anesthetic, hemorrhage or pulmonary abscess. The only apprehension they express is that the result may not be permanent. I have been doing these cases for only a year, and therefore cannot testify on that point. My patients, however, prefer a radium treatment once a year to going through the operation. I might remark here that 15 cases in the series which I am reporting had had one operation, and 3 had had two tonsillectomies. Repeated tonsillar abscesses brought 3 to me.

Twenty cases have been treated by holding the radium applicator directly against the tonsil. This method secured results similar to the needle method. I feel, however, that the needle method is the method of choice because of the perfect application with radiation attacking the tissues in all directions. A smaller amount of radium is needed—12.5 mgm. in the needle as against 50 mgm. in the method under discussion. We find many patients who rebel against even the introduction of the needles, and in such cases we fall back upon either Method 2, or the external one, Method 3.

C. Augustus Simpson, of Washington, D. C., who because of ill-health could not read his paper, uses a 30 mgm. applicator held directly against the tonsil by means of a long applicator for one hour. He writes, "With this original technique it is perfectly remarkable how quickly the tonsil begins to shrink and show atrophic changes. A mild reaction which turns the part white is to be seen where the radium was held. This slight irritation disappears in two to three days. In one patient with a temperature of 101° F., with exudate in the crypts of the enlarged protruding and inflamed tonsils, with cervical glands in the neck the size of half an orange, associated with malaise and loss of appetite, the picture was changed in one week after a single treatment. The enlarged glands disappeared in three weeks and only a part of the tonsil was to be seen when the anterior pillar was pulled to one side."

AUXILIARY TREATMENT

Simpson uses an *x*-ray treatment externally the same day that radium is used. This seems practical, and I now do likewise, giving a four-minute treatment with spark gap of 7 inches, ma. 5, distance 10 inches, filter 3 mm. aluminum over the region of the tonsil, protecting the surrounding tissues with lead, exposing the area plotted as when taking a picture of the lower molars. The patient lies face downward, head turned to one side with a pillow under the chest to throw the head away from the shoulders.

I will digress from straight radium treatment to quote from Witherbee, who probably was the pioneer in radiation treatment of diseased tonsils. His original *x*-ray method created considerable comment when he issued from the Rockefeller Institute the following: "The *x*-ray method . . . is not only safe and permanent, but will more thoroughly and completely remove this focal infection than any other method yet devised, surgical or otherwise; and furthermore, the contraindications for operation in no way interfere with this procedure."

The fifth method, that of using emanation has not been used by us, and I find no records recording its use.

EFFECT ON MICRO-ORGANISMS

We read that radium is not bactericidal, and herein lies the main criticism of radium treatment of infected tonsils. Bacteria are not directly affected by gamma or *x*-rays, but they may be killed by large amounts of beta or alpha rays. As the alpha rays are absorbed on the surface these may be eliminated from the discussion. The beta rays and the secondary beta rays probably are largely responsible for therapeutic results. I have noticed that an acutely inflamed tonsil reacts much better and quicker than does the quiet tonsil, probably because of the increased amount of blood with its iron content. I am now doing a series in which we inject the tonsil with a solution of iron before radiation, with the idea of stimulating more secondary beta radiation. I am not ready to report on this at this time.

Whatever the cause of the effect, patients radiated for infected tonsils exhibit marked remissions of symptoms such as neuritis, rheumatism, malaise etc., similar to the effect noticed after tonsillectomy.

POSSIBLE CRITICISM

Dr. Murphy, at the 43rd Annual Congress of the American Laryngological Association, warns us thus: "The region of the neck is one containing numerous important anatomical structures which must be carefully guarded against injury. Inasmuch as a knowledge of the safe and effective use of both *x*-rays and radium is acquired only through highly intelligent study and much experience, it is far better that experiments be carried out by those qualified for the work than that the success of a method of such good promise should be compromised and perhaps discredited through errors due to incomplete understanding of the medium or to faulty technique in its application."

Several surgeons have expressed the same thought to me recently, and I find that the general public also is somewhat afraid of this powerful agent. Radiologists, however, scoff at this fear. I have been unable to learn of any harmful results occurring after correct *x*-ray treatment of adenitis. Boggs writes, "Most laryngologists are referring tuberculous adenitis for radiation as a routine procedure." A review of the literature on this subject does not reveal the report of any case in which the untoward effects of radiation on the thyroid, parathyroid, pituitary or parotid gland has been recorded.

ADVANTAGES OVER OPERATION

These are obvious—no anesthetic, no danger of hemorrhage, lung abscess, damaged pillars, etc., no loss of time, and equal results. In a few instances it has been noted that the ear condition, chronic catarrhal otitis media, when present, has been benefited. This subject requires, it would seem, more extended observation, and opens up a field pregnant with possibilities.

ADVANTAGES OVER *X*-RAY TREATMENT

There is no danger, in the direct methods, of causing a disfiguring burn, and if there is danger to overlying structures by *x*-radiation, direct radium application eliminates this objection. In children and nervous adults the simple radium applicator arouses no fear, whereas the *x*-ray apparatus may frighten the timid.

CONCLUSION

Radium seems to me to be the agent of choice, no matter what method is under discussion. It requires but one application, and it can be relied upon to do the same thing under the same circumstances—something that the surgeon and the *x*-ray technician cannot always do. The introduction of the needle directly into the substance of the tonsil, supplemented, if desired, with the external *x*-ray treatment, seems to be the most logical of the different methods of radium application.

DISCUSSION

Dr. Withers. I do not like to take up time for the discussion of so small a point as the treatment of tonsils by radium, except to call attention to the fact that Dr. Robinson has not mentioned the use of bare tubes of radium emanation in the treatment of so-called hyperplasia of the tonsil and lymphatic tissue of the pharynx.

The use of such bare tubes is, to my mind, the treatment of choice, and I can speak from personal experience in regard to this mode of application, inasmuch as there were embedded into my tonsils two weeks ago two small spicules, each containing 0.4 mc. of emanation. This method has been tried out on a small series of cases, and a report was given in *The Laryngoscope* for March, 1922.

After having used surface applications by means of radium plaques, and interstitial applications by means of needles, I am convinced that the use of bare tubes of emanation, two or more of such tubes, containing about 0.2 mc. of emanation, embedded in each tonsil, is the method of choice. It is frequently unnecessary to use even a local anaesthetic for the introduction of these bare tubes. The reaction is not painful and is confined to the depths of the tonsil, which does not interfere with swallowing, so that patients are more comfortable, during the radium reaction, than with the use of either needles or plaques.

Dr. Broeman. I have not personally treated a sufficient number of hypertrophied

tonsils with radium to report on its efficacy in this condition. I would however, like to show a simple applicator for the surface treatment of enlarged tonsils that I have found to work very satisfactorily.

I have taken the ordinary Corwin and Wilder tonsillar hemostat which has been on the market for years, and had the ball end removed. This ball end as a rule, is placed in the cavity after the tonsil has been enucleated to control the bleeding. In place of this end I had a small brass plate made to hold two of the universal silver 25 mgm. radium tubes. The tubes are retained in the grooves by means of small wire clamps. Silk thread can be passed through the ends of the silver tubes if desired as another safeguard against losing the tubes. A small piece of rubber dam is placed over the entire end. The cost of this applicator is about $12.00. My main reason for showing it is its simplicity and inexpensiveness. Anyone who has radium tubes can use it without purchasing a special radium tonsillar applicator, which has a limited field of use.

Dr. Pfahler. I will simply say that I used this apparatus in the treatment of my own tonsils, which shows my faith in it, and I also treated my wife's tonsils in the same way, which shows still more faith.

CARCINOMA OF THE ANTRUM*

BY D. CROSBY GREENE, M.D.

Report of Treatment by Radium: Technique and Statistics. From the Clinic of the Huntington Memorial Hospital
BOSTON, MASSACHUSETTS

In dealing with the treatment of carcinoma of the antrum by radium, we are at once confronted with difficulties, due, in the first place, to the lack of definite knowledge in a given case as to the extent of invasion of adjacent and deeper structures, and in the second place, to the inaccessibility of the deeper parts of the growth to effective radiation.

As to the first difficulty, anterior and posterior rhinoscopy and the x-ray give some assistance in locating the direction and extent of the growth, but this is, at best, indefinite and uncertain, as may be often demonstrated when the full extent of invasion is exposed at operation. As to the difficulty of inaccessibility, I believe this can only be overcome by an open operation which will give a wide permanent access to all the nasal and paranasal cavities.

Cases of carcinoma of the antrum may be divided into two groups:

1. Those originating in the antrum or adjoining nasal or paranasal cavities.
2. Those which originate in the epithelial structures of the mouth or the teeth.

In both groups, as the disease progresses, we may find it disintegrating the bony barrier which separates the mouth from the antrum, and breaking through, in one type, from the mouth into the antrum, and in the other, advancing from the antrum into the mouth or the soft structures of the cheek.

The tendency for the growth, starting in the antrum, to invade the postethmoidal and sphenoidal sinuses is quite characteristic. Sometimes we find it breaking through the nasal septum and invading the sinuses of the other side. These cases are not suitable for surgery alone, but the combined treatment by surgery and radium has been productive of a considerable proportion of favorable results. In using

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this method we assume that the operative part of our treatment alone is incomplete. That is, although we remove all visible tumor, it is usually impossible to go sufficiently wide of the limits of the growth in the cases as we see them, to avoid leaving some cells in the periphery which will go on to proliferate. The result of the operation is to bring the region involved within the field of radiation, and keep it under observation for an indefinite period. A wide permanent opening is left for this purpose. This opening is made, in the cases originating in the antrum, through the cheek; in those starting in the buccal cavity, the approach may be through the mouth. In our experience the procedure of choice in these cases consists in a wide exposure and removal of the growth followed by radiation of the resulting cavity.

In this report I propose, first, to give a brief summary of the results to date of 84 cases of carcinoma of the antrum admitted to the Huntington Hospital during the six-year period, 1916 to 1921. These cases are divided into 4 groups:

1. Those in which no treatment was attempted, either on account of the hopeless condition of the patient, or on account of refusal of treatment by the patient (6 cases).

2. Those which were operated upon without subsequent radiation (8 cases).

3. Cases treated by radium alone, including cases of recurrence after operation elsewhere (33 cases).

4. Cases treated by radium immediately, or shortly after operation (36 cases).

END RESULTS TO DATE

Group 1. No treatment; (6 cases).
- Died 4
- Untraced 2

Group 2. Operation, no radiation; (8 cases).
- Recurrence (died 5, untraced 2) 7
- Well, 3 years after operation 1

Group 3. Cases treated by radium alone; (33 cases).
- Died from the disease 24
- Treated without permanent improvement, *untraced* . . . . –
- Alive and under treatment, but growing worse 1
- Apparently well $2\frac{1}{2}$ years after beginning treatment 1

Group 4. Cases treated by radium immediately or shortly after operation; (36 cases).
- Died from recurrence 11
- Died from hemorrhage, secondary to operation 1
- Died from metastases without local recurrence 3
- Died from meningitis, secondary to operation 3
- Died from other disease, without recurrence 1
- Alive with recurrence and under treatment 3
- Alive without evident recurrence . . 12
- Untraced 2

A comparison of these groups shows that by far the most favorable results have followed the method of operation followed by radiation. This is the method we advocate except in hopeless cases in which only palliative treatment is indicated.

Of the 12 cases in this group, living without recurrence, the time elapsed since operation is as follows:

1 case	5 years	1 case	2 years
3 cases	$3\frac{1}{2}$ years	3 cases	$1\frac{1}{2}$ years
2 cases	3 years	2 cases	1 year

Only 6 of these cases have passed the three-year limit and can be considered as probably cured. The percentage of these is $16\frac{2}{3}$, while the percentage of cases free from recurrence for one or more years is 33.

The operation preliminary to radiation is an essential part of the technique.

Operation. The surgical approach employed is through that portion of the face or mouth which gives best access to the tumor in the individual case. In the majority of cases in our series, the incision has been through the face because in these cases the antrum and acessory sinuses were chiefly involved. A modified Moure incision extended horizontally outward to about the center of the malar prominence and vertically upward to the inner portion of the eyebrow, is the one which we have most frequently used.

The soft tissues and periosteum are elevated from the anterior and external wall of the nose on the affected side. Frequently in the course of this procedure, a portion of the growth is encountered which has destroyed and penetrated the wall of the antrum. The entire bone surface uncovered, is removed by chisel and rongeur. This gives a large opening and good access to the growth, which is now rapidly curetted out. Extension of the growth into the nose and other sinuses is followed up by removal of the entire nasoantral wall and complete exenteration of the ethmoid and sphenoid sinuses. The inner part of the floor of the orbit, the lachrymal bone and orbital plate of the ethmoid, may also have to be removed. Extension of the disease into the oral cavity may necessitate excision of a considerable portion of the alveolar process and hard palate also. The large cavity thus left is carefully examined with a view to the removal of any remains of tumor tissue. When this has apparently been satisfactorily accomplished and the bleeding controlled, the flap of skin overlying the anterior surface of the antrum is cut off at its base, leaving a wide, triangular opening for subsequent observation and treatment.

The actual removal of the tumor is accompanied by rather profuse hemorrhage, which, however, usually stops in a rather surprising manner after the growth has been curetted out. Occasionally, bleeding persists, but it can be dealt with effectively by ligature or pressure, on account of the easy access afforded by the large facial opening.

Steel-jacketed radium tubes, covered with rubber tubing, are now applied to the periphery of the cavity, being distributed over the surface and held in place by gauze packing, soaked in sterile alboline. The dosage employed varies from 500 to 1,000 mc. hours. I wish to emphasize the importance of the application of the radium tubes by the operator himself. It is essential that one who is thoroughly acquainted with the topography of the field, who knows in what regions the growth may not have been most thoroughly removed, and who is equipped to see the remoter parts, and place the tubes accurately, should make the application.

When the growth presents itself most prominently in the mouth, the best method of approach is, I think, from this direction. The incision is made well outside the periphery of the tumor, as it appears on the hard palate and alveolus, and a large opening made into the antral cavity through which the tumor is removed by curettes and rongeurs, and its extensions beyond the antrum followed up and removed. This method of approach is advocated by New of Rochester, who performs his entire operation with the cautery. It does not give nearly as good access to the posterior ethmoid and sphenoid regions as the opening through the cheek. The exact method of approach is not, however, the essential thing. A wide opening, giving free access to the affected region, and thorough removal of all visible tumor, followed immediately by strong radiation of the cavity, are I think, the important factors in the treatment.

After the first radiation the patient is kept under close observation, and any area in which there is a suggestion of beginning recurrence, is subjected to further radiation.

ABSTRACT OF CASES TREATED BY OPERATION FOLLOWED BY RADIATION

Case I. Hospital No. 15.42.27. Male, aged fifty-one. Examination, extensive recurrent tumor of upper jaw, antrum and nose with large buccal opening. Operation, curettage of antral cavity through mouth, followed by radium treatment. Microscopical examination, carcinoma, J. H. Wright. Result, this patient lived at a distance and did not report personally. Reported by mail one year after operation, as being well.

Case II. Hospital No. 16.259. Female. Examination, tumor of upper jaw, antrum and ethmoid. Operation, facial route. Exenteration of tumor. Radium treatment begun on sixth day after operation. Five treatments. Microscopical examination, reported from Massachusetts General Hospital, carcinoma, H. F. Hartwell. Result, recurrence. Died in one year and four months.

Case III. Hospital No. 16.75. Male, aged sixty-one. Examination, recurrent tumor of antrum. Operation, facial route. Excision of tumor involving antrum and ethmoid followed by radium treatment.

Microscopical examination, carcinoma, reported from Massachusetts General Hospital. Result, four years after operation, no local recurrence. Died four and one-half years after operation from lesion in liver, probably metastasis. No autopsy.

Case IV. Hospital No. 17.320. Female. Examination, large opening, right side, roof of mouth, leading into antrum, result of operation by Dr. Finney at Baltimore two months before, which was followed by radiation, 500 mc. one hour. Second prophylactic radiation at Huntington Hospital, 260 mc. two hours. Microscopical examination, reported from Johns Hopkins Hospital, squamous cell carcinoma. Result, no recurrence five years after operation.

Case V. Hospital No. 17.500. Female, aged forty-six. Examination, extensive, recurrent tumor, involving right antrum and roof of mouth. Operation, facial route. Excision of tumor from antrum, ethmoid and sphenoid, followed by radiation. Microscopical examination, reported from Massachusetts General Hospital, H. F. Hartwell, carcinoma. Result, well three years after operation.

Case VI. Hospital No. 17.615.275. Female, aged thirty-four. Examination, extensive tumor, upper jaw and antrum. Operation, facial route. Excision of tumor followed by radiation. Microscopic examination, not recorded. Result, death from recurrence one year and two months after operation.

Case VII. Hospital No. 18.74. Male, aged forty-two. Examination, wide opening right side, roof of mouth, leading into antrum—the result of operation at Boston City Hospital, Dr. J. B. Blake, one year previous. Recurrent tumor in walls of antral cavity. Operation, curettage, followed by radiation. Microscopical examination, carcinoma, J. H. Wright. Result, died from recurrence one year and two months after operation.

Case VIII. Hospital No. 18.332. Male, aged fifty-one. Examination, wide opening from mouth into antrum from operation at Boston City Hospital, ten days previous. Three radium treatments, each about 30 mc. hours. Microscopical examination, reported from Boston City Hospital, carcinoma. Result, death from pneumonia, four months after operation. Autopsy report, Boston City Hospital, no evidence of carcinoma, bronchopneumonia.

Case IX. Hospital No. 18.653.277. Female, aged fifty-two. Examination, tumor of left cheek, left exophthalmos. Operation, facial route. Excision of tumor, followed by radiation. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence. Died two years after operation.

Case X. Hospital No. 18.775. Male, aged sixty-three. Examination, tumor of right cheek, ulceration of overlying skin, cheek and nose. Operation, facial route. Excision of tumor, followed by radiation, 1012 mc. hours. Second radium treatment, one month later, 900 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, well three and one-half years after operation.

Case XI. Hospital No. 19.16. Male, aged fifty. Examination, tumor, completely blocking left nostril. Operation, facial route. Excision of tumor. Five radium treatments, beginning four days after operation, 75 mc. hours. Three days later, 140 mc. hours. One month later, 64 mc. hours. Two weeks later, 54 mc. hours. One month later, 46 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, well two and one-half years after operation.

Case XII. Hospital No. 19.101. Male, aged thirty-six. Examination, tumor mass obstructing left nostril. Operation, facial route. Excision of tumor, followed by one radium treatment, 75 mc. hours. Microscopical examination, malignant adenoma, J. H. Wright. Result, well three and one-half years after operation.

Case XIII. Hospital No. 19.109. Male, aged seventy-three. Examination, operative opening in mouth leading into left antral cavity. Tumor mass involving greater part hard palate on right side. Polypoid masses, occluding both nares. Operation, curettage of tumor through mouth, followed by radium treatment beginning one week after operation. Twenty-two radium treatments. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence from time to time, apparently controlled by radiation. Alive with recurrence at present, three years after operation.

Case XIV. Hospital No. 19.170. Male, aged fifty-six. Operation, facial route. Excision of tumor involving antrum, ethmoid, sphenoid and septum. Microscopical examination, carcinoma, J. H. Wright. Result, died from meningitis, three days after operation.

Case XV. Hospital No. 19.757.346. Male, aged fifty-six. Examination, tumor of left cheek. Operation, facial route. Excision of tumor involving antrum and ethmoid. Microscopical examination, epidermoid carcinoma, J. H. Wright. Result, recurring, secondary hemorrhages from which he died four months after operation.

Case XVI. Hospital No. 19.363. Male, aged fifty-seven. Examination, wide opening, left side, roof of mouth, leading to cavity of antrum and left nostril, result of operation two months previous at Manhattan Eye and Ear Infirmary. Recurrence of growth noted in posterior and upper parts of cavity. Radium treatment, seed insertions into tumor masses on three occasions, first, 2 seeds, each 4 mc.; second, two weeks later, 1 seed, 4 mc.; third, three months later, 1 seed, 4 mc. Microscopical examination, reported from Manhattan Eye and Ear Infirmary, carcinoma. Result, patient reported by mail three years later, well.

Case XVII. Hospital No. 20.150. Male, aged fifty-nine. Examination, tumor, right upper jaw and antrum. Operation, partial excision of right upper jaw through mouth. Curettage of tumor, followed by radium treatment, 402 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, rapid recurrence. Died two months after operation.

Case XVIII. Hospital No. 30.203. Male, aged seventy. Examination, tumor of left antrum. Operation, facial route. Five radium treatments beginning one month after operation. Microscopical examination, reported from Massachusetts Eye and Ear Infirmary, carcinoma, Dr. Verhoeff. Result, died from recurrence eleven months after operation.

Case XIX. Hospital No. 20.233. Male, aged forty-five. Examination, tumor obstructing right nostril. Operation, canine fossa route. Excision of tumor followed by radium treatment through the nostril. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence after one and one-half years, patient alive and under treatment.

Case XX. Hospital No. 20.389. Female, aged thirty-eight. Examination, tumor involving right antrum. Operation, facial route. Excision of tumor. Radium treatments begun three weeks later, three treatments. Microscopical examination, report from Massachusetts Eye and Ear Infirmary, carcinoma, Dr. Verhoeff. Result, died six months after operation.

Case XXI. Hospital No. 20.433. Male, aged fifty-three. Examination, tumor, left upper jaw and left side of nose. Operation, buccal route. Excision of tumor followed by radium treatment. Microscopical examination, carcinoma cells, resembling histologically, the enamel organ—adamantinoma, J. H. Wright. Result, well two years after operation.

Case XXII. Hospital No. 20.559. Male, aged fifty-one. Examination, tumor of left antrum involving left nostril. Operation, facial route. Excision of tumor from left antrum and ethmoid, followed by radium treatment, 140 mc. hours. Microscopical examination, reported from Massachusetts Eye and Ear Infirmary, carcinoma, Dr. Verhoeff. Result, no recurrence two years after operation.

Case XXIII. Hospital No. 20.894. Male, aged fifty-three. Examination, tumor of right antrum. Operation, buccal route. Excision of tumor, followed by radium treatment. Microscopical examination, squamous cell, carcinoma, J. H. Wright. Result, died from recurrence six months after operation.

Case XXIV. Hospital No. 20.190. Male, aged sixty-seven. Examination, small opening in cheek, result of operation six days previous at Massachusetts Eye and Ear Infirmary. Radium applications within cavity of antrum beginning six days after operation. Microscopical examination, reported from Massachusetts Eye and Ear Infirmary, carcinoma, Dr. Verhoeff. Result, died from recurrence ten months after operation.

Case XXV. Hospital No. 20.1511. Female, aged forty-six. Examination, tumor of left cheek and antrum. Operation, buccal route. Excision of tumor, followed by radium treatment, 260 mc. hours. Two subsequent treatments. Microscopical examination, epidermoid carcinoma, J. H. Wright. Result, not known, untraced.

Case XXVI. Hospital No. 20.1166. Female, aged fifty-nine. Examination, tumor of right antrum, occlusion of right nostril by tumor. Operation, facial route. Excision of tumor, followed by radium treatment, 450 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence noted six months after operation which was treated by radiation and later, further operation. Enucleation of right eye, eleven months after first operation. Alive one and one-half years after first operation, six months after second operation. Recurrence now.

Case XXVII. Hospital No. 20.1282. Female, aged forty-one. Examination, wide opening in left cheek, communicating with cavity including antrum, ethmoid and sphenoid sinuses, result of operation two weeks previous at Eye and Ear Infirmary. Tumor had involved chiefly ethmoid and sphenoid. Radium treatment, 164 mc. hours. Second treatment two weeks later, 104 mc. hours. Microscopical examination, reported from Massachusetts Eye and Ear Infirmary, carcinoma, Dr. Verhoeff. Result, died six months after operation. Autopsy showed no local reccurence. Metastases in abdomen.

Case XXVIII. Hospital No. 20.1177. Female, aged fifty-seven. Examination, tumor, right antrum. Right nostril completely blocked by tumor. Operation, facial route. Excision of tumor, followed by radium treatment, 747 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, patient well one and one-half years after operation.

Case XXIX. Hospital No. 21.216. Male, aged thirty-eight. Examination, recurrent tumor of antrum. Operation, at Massachusetts Eye and Ear Infirmary, facial route. Excision of tumor, exenteration of antrum, ethmoid and sphenoid, followed by radium treatment, Dr. H. P. Mosher. Microscopical examination, reported from Eye and Ear Infirmary, adenocarcinoma, Dr. Verhoeff. Result, reported by Dr. Mosher as free from recurrence one and one-half years after operation.

Case XXX. Hospital No. 31.219. Female, aged sixty-three. Examination, tumor of left cheek. Growth obstructing left nostril. Secondary operation, facial route. Excision of tumor, followed by radium treatment, 57 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence. Died six months after operation.

Case XXXI. Hospital No. 20.212. Male, aged forty-seven. Examination, recurrent tumor of right upper jaw, extending into antrum. Large opening leading from mouth into antrum cavity. Operation, buccal route. Curettage of cavity, followed by radiation. Microscopical examination, carcinoma, J. H. Wright. Result, unknown, patient lost sight of.

Case XXXII. Hospital No. 20.558. Female, aged fifty-four. Data incompletely recorded. Operation, facial route. Excision of tumor, followed by radiation, four weeks after operation. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence, untraced.

Case XXXIII. Hospital No. 21.839. Female, aged forty-seven. Examination, tumor of antrum, right. Obstruction of right nostril by growth. Operation, facial route. Excision of tumor, followed by radium treatment, 2430 mc. hours. Microscopical examination, carcinoma, J. H. Wright. Result, recurrence. Death in five months.

Case XXXIV. Hospital No. 21.1160. Male, aged forty-one. Examination, tumor, right antrum and upper jaw. Operation, facial route. Excision of tumor, followed by radium treatment. Microscopical examination, carcinoma, J. H. Wright. Result, died of meningitis on sixth day after operation.

Case XXXV. Hospital No. 15.4227. Male, aged fifty-one. Examination, large opening, left side, roof of mouth, communicating with antral and nasal cavities, the result of ulcerations from treatment by liquid air. Recurrence of tumor in left antrum. Operation, buccal route.

Curettage of tumor, followed by radium treatment. Microscopical examination, carcinoma, J. H. Wright. Result, patient alive and doing well, one year after operation.

Case XXXVI. Hospital No. 20.1325. Male, aged fifty-two. Examination, ulcerating tumor of left upper jaw extending into antrum. Operation, buccal route. Excision of tumor followed by radium treatment, 1776 mc. hours. Patient well one and one-half years after operation.

DISCUSSION

Dr. Pancoast. I heard Dr. Greene read a paper on this subject about a year ago and was very much attracted by the technique which he employs because of the easy access it gives to the antrum and other sinus for the application of radium primarily, and particularly during subsequent treatment. I think that is a very important part of any technique. The large opening also permits watching for any recurrence through the months or years that follow. I have observed a case several times that was operated on by Dr. Greene and was much surprised at the ease with which one could watch the area in this way. It is very much better than through an opening made in the mouth in which one has a great deal of difficulty in watching for recurrences as well as in making the application.

Dr. Clark. I have been called upon to treat a great many cases of malignant disease of the antrum, both primary, and recurrent after operation. I have attacked this lesion by the electro-coagulation method through an opening similar to the one described by Dr. Greene. Where there has been post-orbital involvement, and a complete exenteration is found necessary at the same time, I prefer an opening through the floor of the orbit. I have also treated the antrum by way of the canine fossa, but my best results have been obtained by entrance through the hard palate and alveolus. A mouth-gag is employed and a transverse suture drawn through the tongue, which may then be pulled forward out of the way. It may be necessary also to use a tongue-depressor. A long sharp needle is used as the active electrode. The soft tissue and bone are quickly devitalized by the current and immediately removed with bone instruments without hemorrhage. The contents of the antrum are also coagulated and curetted away, likewise without hemorrhage. Radium may then be used, but care should be taken not to overtreat, else it will be found that necrosis of the bone will result, which is in itself a serious matter. Heavy radium or *x*-ray treatment should, however, be employed in addition from the outside. Experience has taught that even advanced sarcomata and carcinomata of the antrum can be thus treated with considerable hope of success. Very satisfactory dental plates can subsequently be made, which will permit of the patient talking plainly and also prevent food from collecting in the antrum.

Dr. Bloodgood. I believe this treatment of tumors of the antrum, nasal cavity and other sinuses offers a great opportunity. I have in my laboratory the records and specimens of an accumulated material of thirty years. We have gone over this again and again, and when we come to estimate what the operation for the removal of the upper jaw has accomplished, no matter how extensive, or the removal of growths within the nose, or the curetting of sinuses accessory to the nose with a knife or curette, we find we have not a single cure in all those years of undoubted carcinoma or sarcoma. Now, if we would include certain cases in which the radical operation has been done, we would have a great many cures, but they are not carcinoma and not sarcoma. So surgery alone in the antrum, nasal cavity and other sinuses, has nothing to offer. The next point is that of diagnosis. You can divide all this accumulated material into three groups: In one there will be no disagreement that all the cases are cancer or sarcoma. In this group there are no cures. In the next group there is no question as to the diagnosis that they are all benign. In this group there are not many radical operations. There were a few resections of the upper jaw for cysts and giant cell tumor that were not necessary. Then there is the third or border-line group, largely diagnosed sarcoma, and to that group I think belong the cases shown here microscopically—the fibromatous and myxomatous tumors. Most of these are well after a radical operation; apparently the radical operation was not necessary. That leads to a very important conclusion. If you have a tumor of the antrum or nasal cavity or other sinuses, you have no evidence that a mutilating operation with the knife will accomplish a cure. If you take pieces out for diagnosis, you know you are dealing in some instances with malignancy, and in some with benignity; also without any doubt, in a very large group you do not know what you are dealing with. Therefore, as we cannot diagnose positively the border-line group, and cannot cure by surgery the malignant group, what can we do for these two groups?

My first change was from the knife to the cautery and I have now one five-year cure of a cancer of the antrum in which I opened the antrum and burned out the tumor with a cautery, and later removed the glands of the neck which were metastatic. This patient is well over five years, and that is my only case. I have three cases of fibromas, well after five years, treated by cautery. These may or may not be sarcoma.

What I wish to urge is a careful study of these tumors and the application of the things that are valuable today, such as radium and *x*-ray, the direct attack of the local growth, and perhaps in the sinuses, where you can have a large opening, the ordinary electric needle. It seems to me a large number of cases of malignant disease of the sinus might be treated by means of electrocoagulation necrosis. I think if Dr. Pfahler and Dr. Clark will invite me to Philadelphia, I would like to study this method of destruction of tissue by the cautery, the only one which can be applicable for the same opening in nasal and sinus diseases. I do not know what the danger is of incomplete removal of tissues, in which radium and *x*-ray follow and precede that method, but my whole experience shows that if a malignant disease is cut into by a knife or a curette you might as well send for the undertaker. It disseminates the disease. The same is true of some of the benign tumors, such as myoma. Some say these always recur. I have recently reported that without exception every myoma cut into in my entire experience has recurred. Of course, a chondroma or a lipoma cut into and removed, may not recur. Those of you working in connection with nose and throat men have a very great opportunity. I think you will begin to feel that malignant disease of the sinuses is much more common than you think. In my experience, the treatment by surgery alone has been hopeless.

Dr. Stone. The technique of treating these tumors is one which the late Dr. Janeway initiated and carried out, in many instances, to a successful conclusion. It appeared at first to be an unsurgical method, and I did not think it would be successful. Dr. Janeway learned that in order to attack the tumor successfully by means of radium a sufficiently large opening must be made. In the first few cases the necrosis was so severe and was allowed to remain so long that the pain and suffering did not appear to justify the effort. Finally, however, he learned that by curetting carefully the necrotic areas, the pain disappeared. If any tumor tissue remained, the imbedding of the emanation and the curetting of the necrotic tissue were repeated, so that success crowned his efforts in numerous instances. It requires painstaking effort, but I believe that cases have been cured in this way which could not have been cured by any other procedure.

Dr. Burnam. I have been interested in this subject for a long time. It should be remembered that many of the tumors of the antrum are sarcomas; they are perhaps not as common as carcinomas, but they are common enough. Many of these sarcomas can be cured by heavy external radiation without opening the antrum and without any operation. No squamous cell carcinoma can be cured in this way. We have had a great many malignant tumors of the antrum. The sarcomas are treated either by external radiation alone or by a combination of external and internal radiation. The carcinomas have been treated by operative removal and radiation and by simple exploration and making a way for radiation treatment intra-antral. One of these carcinoma cases was operated on by Dr. John Finney in 1913. He explored from the front of the face very much in the way that Dr. Greene has been doing. There was a great opening into the antrum with a definite recurrence on the posterior wall. This patient was treated by local tubes, he remained well for a number of years and the defect in the face was finally closed by a plastic operation. Another patient of six years ago came to Dr. Finney after seeing surgeons in Boston, New York and Philadelphia. She had, not an early carcinoma, but one still limited to the antrum. The *x*-ray pictures showed clouding of the entire antrum. The late Dr. Janeway had seen her and expressed an opinion that it was an entirely hopeless case from the operative standpoint. Dr. Finney sent the patient to me for an opinion. At that time I had not very definite ideas as to what should be done in these cases, but, after consultation, we decided that the combination of operation and radium was the best treatment. I believe this patient is still well.

Dr. Bloodgood has worked with and helped me in many of my cases. In many of the patients on whom he has operated, there has been an opening through the palate, which allowed an inspection of the antrum and the topical treatment equally as well as the opening through the face. It seems to me, therefore, that the opening through the mouth should be considered in some cases. I do not know whether it is preferable as a routine or not; it is probably easier to close the opening in the face by a plastic than it would be in the mouth.

Dr. New. Dr. Greene emphasizes particularly the classification of these tumors from the anatomic standpoint and, in this way, has placed them in several groups. We know that a tumor that involves the antrum secondarily is entirely different from a primary tumor of the antrum, with regard to the prognosis. In the tumors involving the jaw primarily and the antrum secondarily, statistics will show a much higher percentage of cures than in the primary antrum growths.

I wish particularly to discuss two points. First, I do not believe that a malignant tumor should be curetted, and, if Dr. Greene would use some form of cautery in removing such tumors, his end-results would be still better. Second, I do not believe it is necessary to open the antrum through the cheek in order to obtain sufficient exposure to remove these tumors thoroughly. The procedure of choice is to explore the antrum above the alveolar process or through the palate, and by the use of water cooled retractors obtain a good exposure, even if the growth invades the nose or ethmoids.

Note. Slides were used to show that extensive tumors of the antrum could be removed through the mouth with the cautery, leaving practically no external deformity, the opening in the mouth being closed later by a dental plate.

Dr. Greene (closing discussion). Dr. Bloodgood's criticism may be justified in the report of the cases as I have given them, for I have not given the details of the microscopic findings in each of the cases. I have an abstract of these findings which I have not read. In every case we had a report of carcinoma by a pathologist of standing. Most of the examinations were made by Dr. J. H. Wright of the Massachusetts General Hospital. In view of what Dr. Bloodgood has remarked, however, I feel that in reporting any such series of cases as these it is important that slides should be available for further examination, and I propose sometime in the near future to go over some of these slides with Dr. Bloodgood himself.

As to the method of approach at operation, I feel that where the cribriform plate has been involved, as it has in many of my cases, the approach through the face has a decided advantage over that through the mouth. Many of these cases were hopeless from the surgeon's standpoint, and yet we have had a fair proportion of favorable results.

STATISTICS AND TECHNIQUE IN THE TREATMENT OF MALIGNANT NEOPLASMS OF THE LARYNX*

BY DOUGLAS QUICK, M.B. (TOR.), AND F. M. JOHNSON, M.B. (TOR.)

Attending Surgeon, Memorial Hospital — Adjunct Assistant Surgeon, Memorial Hospital

NEW YORK CITY

IN discussing the use of radium in treating cancer of the larynx, several factors relative to this new physical agent must be considered. Radium is not a cure-all, but it has limited the field of operability to strictly early cases, at least, and in these, if operation for other reasons is contraindicated, with sufficient experience and an adequate supply of radium, it is perfectly justifiable to depend upon this agent alone. Certain types of malignant disease respond very favorably to radium, and in these we feel we are well beyond the experimental stage. In other types, either the resistance of the growth itself or various other factors, have made progress slow. Unfortunately, laryngeal cancer belongs in this group and the present report of our experience at the Memorial Hospital must be looked upon as incomplete experimental evidence rather than a definitely proven method.

We feel, however, that the results to date give definite proof of the value of this agent and warrant the drawing of certain conclusions.

Here, as in other types of malignant disease, the work has been carried out almost entirely on advanced and hopeless cases. This is more especially true of the earlier years of the work. Technique is continually changing as clinical information accumulates, so that in comparable cases the work of today cannot be compared with that of one, two or five years ago. For these reasons, a report for statistical

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purposes at present would be both useless and misleading.

The literature on the subject to the present time gives very little data of value. Reports are invariably of small groups or single cases, are usually incomplete, and deal chiefly with palliative results in advanced cases only.

It is not my purpose here to discuss radium in primary operable cases as compared with the various surgical procedures. While I, personally, offer no apology for treating such cases with radium, I frankly admit that sufficient data is not available on paper to prove the wisdom of such a course.

There are many factors that make us look to radium as a possible advance in the treatment of cancer of the larynx. Leaving out of consideration the so-called operable cases, with all the attendant dangers and disappointments of radical surgery, we still have a vast group in which surgery offers nothing. A considerable percentage of intrinsic growths and—I believe I am correct in stating—practically all extrinsic growths, are inoperable when seen by the laryngeal surgeon. It is from this group, largely, that our radium data must be obtained, for it offers possibilities of more than has heretofore been accomplished.

In applying radium to a laryngeal growth, certain difficulties arise which are not met with in other parts of the body. If efficiently applied, radium creates a sharp inflammatory reaction of several weeks' duration, and in the cases under discussion this reaction is just at the vantage point of two body systems. It often interferes with both swallowing and breathing. Hence the danger of impairment of the patient's general health, which is usually already undermined. It is impossible to put the treated part at rest and consequently the factor of mechanical irritation is added. It is very frequently impossible to determine accurately the extent of disease in these cases. Vision alone is not sufficient aid in satisfactorily examining a malignant growth. Palpation, to determine the depth of neoplastic infiltration, is most important, but, except for a few extrinsic lesions, this is impossible in laryngeal work.

CLASSIFICATION OF CASES

For the proper management of the patient a careful appraisal and classification is one of the first essentials. From a statistical standpoint it is imperative, and it is equally necessary in order to determine the method of and extent to which treatment with radium should be pushed. For statistical purposes, cases must be divided of course into intrinsic or extrinsic, primary or recurrent, and operable or inoperable. For treatment purposes they should be classed as "operable" or "inoperable" to radium. The "operable" group should be further divided as favorable or unfavorable, depending on whether a complete regression or only palliative relief can be reasonably hoped for. The group classed as "inoperable" to radium should be left alone as far as this agent is concerned. There comes a time in the treatment of malignant diseases when even the physical agents are of no avail for palliative relief. Unfortunately, a considerable number of laryngeal carcinomas can be relieved only by opiates and tracheotomy. I am convinced that, in our own service, several patients have been treated who would have been better off had no radium been used.

METHODS OF TREATMENT

Once the decision to use radium has been made, it is essential to decide what can be reasonably hoped for by its use. Treatment designed to eradicate the disease is attended with considerable discomfort for several weeks at least. The inflammatory reaction causes pain, and may interfere with swallowing and breathing as a result of edema. In bulky extrinsic growths, sloughing and hemorrhage must be reckoned with. A tracheotomy may be necessary before beginning treatment or may become imperative later on. If there is any question as to the necessity for tracheotomy, I am convinced it is best to err on the side of safety and do it early. If there is a reasonable chance to produce a complete regression of the disease, it is then perfectly justifiable to push treatment to the limit and risk putting the patient through a strenuous period of discomfort. If, on the other hand, only palliative relief can be hoped for, then the pateint's physical comfort demands first consideration throughout.

RADICAL TREATMENT BY RADIUM

This is obviously a relative term. We now have a large fund of available information both on the physics of radium and on its action on malignant growths in various parts of the body. Our big problem at present is to apply this information in perfecting our laryngeal technique. The technique of using a scalpel to best advantage has required several generations. Radium must be looked upon as a new instrument with the technique of its application in the making. Too often we see reports of radium applied in the larynx in a manner which signifies utter disregard of available information. We have long since passed the time when a piece of radium could be placed in the vicinity of a new growth and adequate treatment assumed. Accuracy and, to a certain extent, intimacy of application are essential. Each case must be studied individually and a plan of treatment outlined which will give the greatest intensity of radiation in the diseased area with least damage to surrounding normal structures. The only place where anything approaching a stereotyped method is permissible is in the external radiation. I believe that every case accepted for treatment should receive intensive radiation by heavily filtered radium applied over both sides of the neck and directed toward the primary growth. For this we have employed filtration of 2 mm. of brass and doses ranging from 2,200 mc. hrs. at 3 cm. distance to 9,000 mc. hrs. at 6 cm. distance on each side of the neck; the dose and distance in each instance depending on the needs of the individual case. If sufficient radium is not available to do this properly, then efficient *x*-radiation should be used as the second choice.

The decision as to the method of internal application is not so simple. In our earlier work we made extensive use of radium emanation tubes filtered by 1 mm. and 2 mm. of platinum placed end to end in small rubber tubing and introduced within the lumen of the cocainized larynx. The dosage ranged from 100 to 300 mc. hrs. per tube. This provides a very efficient dosage of gamma radiation all about the tubes and serves a useful purpose in intrinsic lesions involving practically the whole of the interior of the larynx. It has many disadvantages. It is difficult even with very strong tubes and in a well-cocainized throat to retain the radium accurately in place long enough to give proper dosage unless a tracheotomy has been done. For all extrinsic growths it is purely a gunshot procedure and very inefficient. It furnishes radiation to normal and diseased tissues alike, depending on their proximity to the center of radiation, and from this, unwarranted damage may result. The method of treatment by intubation, and radium application within this, as advocated by most of the Spanish workers, is essentially the same thing from a physical standpoint and is open to the same criticism.

The greatest advance in our internal treatment has been through the introduction of radium emanation tubes directly into the growth. These are fine capillary glass tubes approximately 0.3×3 mm. in size, containing radium emanation. This emanation decreases in value at the rate of approximately 15 per cent per day. It is evident therefore, that the exact dosage to be delivered by these tubes can be calculated at the time of introduction. One mc. of radium emanation buried interstitially and left *in situ* until exhausted gives a dosage of 132 mc. hrs. The emanation in this form is entirely unfiltered except for the thin wall of the glass tube, which removes little more than the alpha rays. Hence the full effect of both beta and gamma rays is obtained, and since the radiation is extended over several days, a larger dose can be given. The tubes are small and readily introduced through fine trocal needles, so that accurate distribution can be made throughout the growth, especially toward the deep infiltrating base where most efficient radiation is required. We use curved trocar needles for application by the indirect method and straight needles for the direct method. In the majority of cases I prefer using the direct method under local anesthesia.

There is some danger, of course, from introducing mixed infection deeper in the tissues, but this is very slight, especially if care is taken to avoid introduction through the ulcerating surface wherever possible. We have never had trouble from the glass emanation tubes as foreign bodies. They are either expelled and expectorated with minute particles of slough later on or are encysted in scar tissue as a result of the inflammatory process created by the radium. In our earlier work with buried emanation we made the mistake of using tubes of too strong individual values. As a result, very severe reactions with considerable sloughing were encountered. We now feel that such reactions are both unnecessary and unjustifiable. Tubes of approximately 1 mc. each permit of most adequate dosage with uniform distribution and a minimum amount of destruction of tissue. This method is applicable in the majority of intrinsic lesions and in in all extrinsic lesions. We have found it practical to bury amounts of 1 to 6 or 7 mc. in intrinsic growths and as high as 15 mc. in some bulky extrinsic growths. The size, shape and location of the individual lesion, together with the local anatomical relations, must be the guide to dosage in each instance. Apart from the problem of beta radiation obtained, these emanation tubes for laryngeal work have a very definite advantage over needles containing radium salt in that they are smaller, cause less trauma, and cannot be dislodged as a needle with a string at the end might. In addition, the whole procedure is over at one sitting and there is nothing left to be removed later.

For a certain limited group of localized, relatively superficial, intrinsic growths, we employ another method of unfiltered radium application to the surface. This consists of a small glass bulb 6 to 8 mm. in diameter, containing 500 or 600 mc. of emanation and mounted in a protecting metal cone with paraffin. The cone is open at its base and to the apex a long flexible wire is attached. This permits of holding accurately in place by the indirect method a very large quantity of unfiltered radium emanation for a time long enough to give an intensive dose. A few minutes is sufficient and, in addition to accurate localization, the surrounding normal tissues are protected from injury.

In the application of any or all of these methods to a favorable case, maximum doses should always be given. Best results are obtained by aiming at complete regression from a single dose. The inflammatory reaction excited by a first application makes difficult the differentiation of malignant from inflammatory tissue. The inflammatory reaction results in the formation of new connective tissue which in turn protects remaining malignant cells. Furthermore, the repeated induction of these uncomfortable reactions within the larynx is devitalizing to the patient. This refers more especially to the use of buried emanation tubes. There is no objection to the repetition of heavily filtered doses externally as long as the skin remains in good condition and edema internally is not marked.

PALLIATIVE TREATMENT BY RADIUM

In considering radium as a palliative agent, we must reverse the plan outlined for its radical use. Where no reasonable hope for complete regression of disease can be entertained, the patient's comfort must be given first place and radium dosage kept down to such a point that no severe reactions will be encountered

In all these cases, heavily filtered radium applied externally at crossfire is indicated. A considerable amount of retardation of growth is produced through the direct effect of radiation on tumor cells, while the fibrosis excited tends to limit the growth locally and prevent distant extension. In certain cases emanation, in small doses, may be buried in the primary growth to advantage, but large doses applied in this manner are definitely contraindicated. I am confident that, in our earlier work especially, we have been guilty of many grave errors in this direction.

In many advanced cases cervical nodes are present on one or both sides. Emanation buried in these has a two-fold value. It is not only the most efficient method of affording palliative relief to the nodes, but they in turn serve to hold a considerable quantity of emanation which by reason of its gamma radiation exerts a marked inhibitory effect on the primary growth. Thus the interior may be satisfactorily held in check for a considerable period without subjecting it to the inflammatory reaction of a dose applied directly. We feel that this has been a distinct advance in our palliative technique.

Time does not permit of a detailed discussion of treatment of extension of the disease to cervical nodes. In general, our plan is that outlined in a report last year of the treatment of cervical nodes secondary to intraoral carcinoma. No surgery is done in the neck unless a definite node is palpable. If the primary growth warrants it, a unilateral neck dissection is done under local anesthesia and radium emanation tubes buried in the wound at the points of severance of the lymphatic channels. Advantage is taken of this surgical exposure to ligate the external carotid artery and also to bury emanation as near the base of the primary laryngeal growth as possible. If the primary growth is unfavorable or the nodes infiltrating beyond their capsules, no dissection is attempted. Instead, emanation tubes are buried uniformly through the skin, depending on the merits and anatomical conditions of the individual case.

THE COMBINATION OF SURGERY AND RADIUM

Our experience does not warrant expressing an opinion on the value of radiation followed by radical removal. In the small series in which we have attempted this plan, the disease was so far advanced that the surgical procedure was with one exception shown to be ill-advised. Based on our information in general, however, it would seem that pre-operative radiation would be very valuable to those following the radical surgical methods. Postoperative radiation of squamous cell carcinoma is too much of a gun-shot procedure to be considered of much value.

In addition to the combination of surgery and radium already referred to, in the neck, we have employed surgical exposure to advantage during the past year in another direction. Certain deeply infiltrating growths are very difficult to localize by the intralaryngeal methods, and here we have employed laryngofissure as a means of more accurately exposing the growth and inserting emanation tubes.

STATISTICS OF TREATED CASES

The foregoing suggestions for treatment of malignant disease of the larynx are based on a series of 156 cases treated at the Memorial Hospital during the past five years.

Of these, 20 cases were classed as primary operable intrinsic carcinomas. Seven of this group are now free from clinical evidence of disease: one for three and one-half years, 3 for two and one-half years, one for two years, one for one year, one for eight months.

One of the cases now well two and one-half years had an involved cervical node and was treated by surgical dissection of the neck plus radium emanation buried in the wound. The case reported well for eight months and had a severe secondary radium reaction recently, but this is now subsiding satisfactorily.

Four of these cases, only, were verified by microscopic section, and for this we must expect to be severely criticized—perhaps justly so. However, we have here, as elsewhere in the body, followed out our principle of refusing to take a section if it seemed to be not in the best interest of the patient. The dangers of opening up avenues of extension deeper into normal tissues, of infection, and of edema must be reckoned with where the growth is not bulky and fungating. Under such circumstances we have favored the clinical opinion of observers trained in the diagnosis of malignant disease even at the risk of criticism from some quarters.

Seven cases are progressing favorably with reasonable hope for a complete regression of disease, although it is too early to draw any definite conclusions.

One case treated over two and one-half years ago had a violent reaction from the use of tubes of too high individual values, infection and sloughing resulted and a laryngectomy was done in another institution. This patient is reported free from disease at present, but cannot be classified as benefited by radium.

Another case treated one year ago had a complete disappearance of disease after four months, but since then has been lost to our observation.

Four cases were complete failures. One of these returned to his home at some distance from New York, treatment was neglected, and he has been recently reported dead. Another died of pneumonia following tracheotomy. A third was unimproved, laryngectomy was resorted to, and death from infection resulted four weeks later. The fourth case is still living, but is steadily going downhill.

Of the entire series, 51 cases were classed as intrinsic inoperable. Forty of these were primary and 11 recurrent. Of the primary cases, 8 had definitely involved cervical nodes, and of the recurrent cases, 3 had cervical nodes involved, one of them recurring locally later: 2 were recurrent in the nodes only, following total laryngectomy. The 32 primary cases without involvement of nodes were inoperable because of extensive local lesion coupled either with poor general physical condition or advanced age or both.

In this group of 32 cases, 2 were malignant granulomas. Both of the malignant granulomas have been free from clinical evidence of the disease for periods of a little over a year. One case of carcinoma remained free from disease for one and one-half years, after which time it was lost track of. Another case, treated ten months ago, is reported by his laryngologist in Cuba, free from disease. Nine cases are showing continued palliative improvement over periods of two and one-half years to six months. Seven cases showed temporary palliation over periods of two years to six months, and then either died or are at present going downhill. Ten cases were unimproved and quite possibly made worse. Two cases were lost track of. Of the 8 primary intrinsic inoperable cases with cervical nodes, one case has received palliative relief for eight months to date, but the other 7 have been totally unimproved. Of the 11 recurrent cases, one has shown a very striking result: after heavy radiation a total laryngectomy was done and she has now remained well for five years. Three cases are too recent to draw any conclusions. Three have received palliative relief for six to eighteen months. Three were totally unimproved, and one lost track of.

All of the extrinsic growths in our series have been classified as surgically inoperable. Twenty-nine were primary and one recurrent without cervical nodes; 53 were primary and 2 recurrent with cervical nodes. All were classed as carcinomas, with one exception—a lymphosarcoma—although all were not confirmed by microscopic section.

Of the 31 cases without cervical nodes, four, all confirmed by sections, are free from clinical evidence of disease at present. One for two years, two for one and one-half years and one for fifteen months. Three show palliative improvement to date over periods of four to twenty months. Four were improved for eight to twelve months and then began going down. Three are too recent to classify. Eleven were unimproved, and would have been better off had no treatment been given; and five were lost track of.

Of the 55 extrinsic cases with cervical nodes, two are now free from clinical evidence of disease for periods of ten and twelve months following the use of buried emanation in the primary growth and a combination of surgical dissection and buried emanation in the neck. Twelve cases show palliative improvement to date over periods of four to twenty-two months. Two cases, while showing a satisfactory initial response, are too early to classify. Ten cases were temporarily benefited over periods of six to twelve months. Twenty-one cases were totally unimproved and eight we have been unable to trace.

SUMMARY

1. While radium offers hope to a larger number of cancers of the larynx than the older methods, its use must be considered, to a certain extent, experimental as yet.

2. Before treatment of a laryngeal neoplasm is undertaken, proper classification, based on what can be reasonably hoped for, should be made, and the method and intensity of treatment governed accordingly.

3. While treatment of primary operable intrinsic cancer of the larynx is permissible,

the evidence to date does not warrant advocating it as the agent of choice.

4. It is suggested that the pre-operative use of radium in operable cases would add materially to the end result.

5. Surgical exposure may frequently be used to advantage in radium localization.

6. The radical use of intensive radiation is permissible in cases offering a reasonable hope for complete recovery.

7. The conservative use of radiation in inoperable cases offers palliative relief in a large percentage.

8. Radium should be withheld in the very advanced cases.

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DISCUSSION

Dr. Pfahler. I wish to refer for just a minute to some work which I presented last Saturday before the Radiological Society, which I think is rather new. That is the implantation of radium needles through the hyothyroid membrane, for carcinoma of the larynx. First of all, I request that a tracheotomy be performed; the first of the treatment being given by external radiation, and about a week after this radium needles are inserted through the hyothyroid membrane, approximately on each side if both are involved, or five on one side if only one side is involved. If the larynx is detached from the side you can pass the needles down through the hyoid inside. You are passing through healthy tissue, you have the needles retained exactly where you put them, and you remove them at the end of the period, which in my work has been eight hours. I have had only eight cases but the results have been more encouraging than anything I have seen in these cases.

Dr. Clark. The successful treatment of malignant disease of the larynx requires most careful consideration. If seen early, laryngectomy offers a fair chance of success, as shown by Crile, Lewis and others. But, since the advent of radium, *x*-rays, desiccation, and coagulation methods, laryngectomy need be practiced only in advanced cases, and then always in conjunction with radium or other methods. I have given up the application of radium to the larynx through an endoscope. Much better results have been obtained by the following technique: A preliminary tracheotomy is invariably performed, after the lapse of about ten days a laryngotomy, or longitudinal-slit operation is performed and both sides of the larynx retracted. The lesion may then be palpated and inspected at close range.

If the growth is localized and does not extend through the cartilage, it is thoroughly desiccated and then curetted away, which latter operation can be accomplished without hemorrhage. Radium needles of proper size are then inserted wherever there appears to be any chance of remaining disease. Excellent results have been obtained in several cases by employing this technique. The operation described appears not to be hazardous and healing is very rapid. The tracheotomy tube may later be discarded, and, unless the cords have been destroyed, the voice will be little impaired. If the lesion is so extensive as to involve the cartilage all the way through, laryngectomy is performed, followed by desiccation, or radium needles, or both. The *x*-rays, or radium, should be applied at subsequent intervals from the outside.

The foregoing mode of procedure has in my hands been much more satisfactory than others previously tried.

BOOK REVIEWS

Protein Therapy and Nonspecific Resistance, by William F. Petersen, M.D., Associate in Pathology, University of Illinois, College of Medicine, Chicago, Illinois; with an Introduction by Joseph L. Miller, M.D., Professor of Medicine, Rush Medical College, University of Chicago, Chicago, Illinois. Cloth. Price $4.50. Pp. 314. New York: The MacMillan Company, 1922.

At first glance this book would not seem to be of particular interest to the radiologist; but an investigation of its contents reveals the fact that much food for thought is offered for the radiotherapist who wishes to understand the whys and wherefores of the effects produced by the therapeutic measures in his specialty.

Nonspecific therapy is recognized even by immunologists as one of the factors of resistance to disease. How far-reaching the field of nonspecific stimulation is in its various modifications becomes apparent from a consideration of the number and the character of the agents which have been employed to bring about therapeutic results. Even the purely physical and mechanical means—including irradiation, electricity, baths, massage, etc.—must be included in the survey.

To all those interested in the treatment of infections—and this includes both physicians and immunologists—this book will be most welcome, presenting as it does in a comprehensive manner a complete analytical review of the subject, which will be of assistance in furnishing a basis for further carefully controlled studies.

James T. Case.

The Pathological Gall-bladder, by A. W. George, M.D. and R. D. Leonard, M.D. Contains 143 pages besides 135 Roentgen-ray studies on 44 full page plates, of which three are photographs and two text illustrations. Price $10. Paul B. Hoeber, New York, 1922.

This monograph presents the ideas of those who have done most to advance and popularize *x*-ray examinations of the gall-bladder region in America.

The technique which the authors have found most satisfactory is carefully described.

The chapter on interpretation is the most important one in the book. Lesions of the gall-bladder are considered from two angles. The visualization of gall-stones and the gall-bladder is regarded as direct evidence, while the effect produced by the pathological gall-bladder upon the surrounding structures is regarded as indirect evidence.

The illustrations, 135 in number, are well done, and the captions for the illustrations are in English, French and Spanish. The volume is a beautiful example of the book-maker's art. This book will be much appreciated by all who are interested in lesions of the right upper abdominal quadrant.

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EXTRACT FROM A PAPER ON MEASUREMENTS USED IN RADIOACTIVITY AND THE RADIUM STANDARD

BY MADAME P. CURIE
PARIS, FRANCE

The International Radium Standard was prepared during the month of August, 1911. The salt used was taken from the very pure radium chloride reserve, weighing about 0.4 gm., that I had prepared in 1907 for the purpose of obtaining the atomic weight of radium. The great purity of this salt had been ascertained by spectrum analysis; its atomic weight is 226.5. The salt had been stored with precautions so as to eliminate all risks of accident; one part of it had been used for the preparation of metallic radium and of standard solutions.

The manipulations made in order to bring the salt back to a definite state were the following: A quantity of water containing a small amount of hydrochloric acid was added to the salt; the salt dissolved nearly completely in it, leaving a very small quantity of an insoluble salt, as is always the case after a time, probably due to the corrosion of the vessels, even when all the moisture has been eliminated. This residue was removed by filtration and a very small quantity of lead acetate was added to the clear solution; it was afterwards treated with hydrogen sulphide. The lead sulphide, while being precipitated, was expected to draw with it the total amount of radioactive lead (radium D), of radium E, and of polonium, (radium F) formed in the radium salt in the course of four years. After the sulphides had been removed by filtration, the solution was evaporated until dry. The salt was dissolved again in a mixture of water and pure hydrochloric acid and the solution was concentrated so as to crystallize. When cool, the crystallization water was decanted and the crystals were washed in pure concentrated hydrochloric acid, then dissolved again in a mixture of pure water and pure acid so as to obtain crystals again. The crystallization was of a beautiful character, and some large crystals, needle-shaped and very elongated, were formed. The crystallization water was plentiful, because the crystallization took place in a very acid medium, and was decanted. The crystals were first dried in a water-bath and then in an oven at a temperature of 150° C. This temperature was sufficient to bring back the salt to an anhydrous state and to the formula $RaCl_2$.

The tube was then prepared. Its appearance was that of a glass tube with very thin walls; its inside diameter was 0.9 mm.; wall thickness, 0.27 mm.; clear glass. The extremity of the tube was drawn and closed over a platinum wire, using a flame to accomplish the operation; this wire was very fine and extended inside the tube. The purpose of this wire is to keep any electric charges from accumulating inside the tube by establishing a communication with the outside. A small glass cap fitting over the tube was prepared, and the tube, together with the cap, was carefully weighed. It was feared that the salt would accumulate water during the filling operation, and that it would be difficult to expel the water afterward on account of the shape of the tube. To avoid this, the filling operation took place in a warm atmosphere. The vessel with the crushed crystals and a stirrer were placed on a thick metal plate and heated. The temperature of the air surrounding the crystals was about 80° C. The tube to be filled was kept constantly in that warm air. After being sufficiently filled, the tube was fitted with its cap and alternately weighed, put back in the oven, heated at 150° C., and left to cool down to a normal temperature while in a dry chamber. During these operations the weight of the tube and its contents did not change beyond the limit of 1/50 of a mgm. The tube was then sealed in a flame at a point very near the top of the salt which occupied the entire length of 32 mm. It was then made sure that no salt had stuck to the removed section, the quantity of which could have been detected using a scale. It has been possible to accomplish the filling in such good conditions and without the salt sticking to the walls with the help of a thorough dessication of the matter. Figure 4 is an illustration of the tube.

The balance used was a Curie balance of the rapid check type and fitted with a microscope; it was adjusted so as to be sensitive to 1/100 of a mgm. The weights used were accurate and in conformity with the standards. A tube similar to the principal tube was used as tare.

The salt reached a definite state and an invariable weight equal to 0.02199 gm. of $RaCl_2$ (anhydrous chloride) within a limit of about 1/50 of a mgm. The weight of the tube is 0.1022 gm. The quantity of metallic radium enclosed in the tube weighs 0.01675 gm.

Due to the thinness of the glass and to the elongated shape of the tube, the fraction of gamma radiations absorbed by the salt and the walls of the tube probably does not reach 0.5 per cent.

Nearly the whole length of the tube is occupied by the salt; such a condition is of advantage as regards the accuracy of measurements, for it may be affected by a shifting of the salt as a consequence of jolts. On the other hand, the question might arise whether by reducing thus the free space there are any risks of jeopardizing the safety of the tube due to the fact that the continuous accumulation of gases might cause it to explode. But as the salt has been carefully deprived of all its water of crystallization, the production of explosive gases, a usual occurrence with a hydrated salt, is not to be feared. The only gas production to be considered is that of helium; this cannot be avoided, and its value is about 2.5 c. mm. per year for the quantity of radium enclosed in the tube referred to. As the volume of the tube is about 25 c. mm. and the actual space occupied by the particles of matter cannot be more than 6 c. mm. a period of eight years will elapse before the pressure due to helium production equals the atmospheric pressure, the gas being supposed to be set free. (In reality the gas stays within the salt, but may be driven out by an accidental overheating of the tube.) As the tube was sealed while hot, the initial air pressure decreased when cooling and was then less than atmospheric pressure. It may be said that it will require fifteen years before it may be advisable to open the tube at its pointed extremity so as to allow any excess of helium gas to escape.

At the time the International Standard was being prepared in France, a similar operation was carried out at the Radium Institute of Vienna, where several standard tubes containing different quantities of anhydrous radium chloride were being prepared with a carefully purified salt owned by the Academy of Sciences of Vienna.

It seemed then possible to take the final steps concerning the standards, and to call for that purpose a meeting of the Committee to whom this work had been intrusted by the Brussels Congress.

The meeting of the International Committee was called in Paris at the end of March, 1912. Seven members were present. The work of the Committee was to compare the different standards prepared and to determine rules for their use.

The comparison of these standards was made by measuring the gamma radiations. The measuring apparatus was prepared by the Radioactivity Laboratory of the Faculté des Sciences of Paris under the direction of M. Debierne. However, its installation was not made in that laboratory, due to the fact that the air in these rooms had a spontaneous conductivity much higher than air in a normal state, and this condition is unfavorable for accurate measurements. Due to the kindness of Prof. Lippmann, the apparatus was set up in an inactive room which was part of his department.

The comparison was made by two different methods: First, by a compensation method in use by the Paris laboratory; its characteristic feature is the use of a large plate condenser, especially constructed for this event. The dimensions of this apparatus are the following:

Diameter of plate E	50 cm.
Diameter of cylindrical box P	52 cm.
Distances from plate E to bases of the box	3.5 and 2 cm.

A lead shield one cm. thick was laid on top of the box P. The tube to be tested was placed on a piece of paper laid on the shield. The current produced in the chamber was measured by a device made up of an electrometer and a piezoelectric quartz. The effects observed when shifting the tube to another position were carefully noted as regards the value of the current. These effects were not perceptible for slight differences in position from the center.

The second method is of the same kind, but slightly different. The apparatus was set up under the supervision of Mr. Rutherford. A steady current produced in an auxiliary ionization chamber containing a quantity of uranium is compensated by the current produced in the principal ionization chamber by the action of the tube placed at the proper distance. As the distance from the tube depends on its radium content, it is necessary that the law governing it should be known, in order to compare different quantities of radium to one another. With this method, the conditions are not quite as nearly the same as with the first method for the comparison of tubes.

With both methods, results were obtained which agreed with each other and which showed for the different standards a very satisfactory similarity. The differences were estimated to be about 0.2 per cent, which is within the allowable limits of experimental error.

It is quite remarkable that these results were obtained with standards prepared in France and in Austria respectively, and that the pure salts used had been prepared independently in these two countries. This shows, on one hand, the confidence that may be placed on the composition of anhydrous radium chloride, and, on the other hand, the high degree of perfection of the methods using gamma radiations for the measurement. By these means, a basis for the measurement of the radium content has been established, and can be relied on with perfect confidence.

Comparisons were made easy by the fact that the glass walls of the tubes were not only thin, but were also of the same thickness for each of the standards.

After the experiments the Committee made the following statements:

1. The Standard prepared by Madame Curie has been given the preference as International Standard and it has been decided that this standard should be kept at the *Bureau International des Poids et Mésures* of Paris, with the consent of the director of this Institution. The International Standard shall be used solely for the measurement of secondary standards intended for different countries.

2. One of the standards prepared in Vienna shall be kept at the Vienna Institute as an auxiliary standard ($RaCl_2$-31.17 mgm.).

3. The secondary standards shall be prepared using for each from 10 to 40 mgm. of a radium salt whose purity is at least 90 per cent; they will be similar in

shape to those prepared in Vienna.* They shall be measured, first in Vienna, then in Paris, and a certificate shall be issued stating their radium content.

4. As the radium used for the International Standard was the property of Madame Curie, the Committee recommended that the necessary steps be taken so that an equivalent amount of radium be given to Madame Curie by the countries involved.†

We still have to consider the actual state of the International Standard and discuss the evolution laws as they have been predicted, as well as their influence on the value of the Standard.

From a chemical standpoint, at the time the tube was sealed, the salt of the standard was a pure and anhydrous radium chlorid, in conformity with the formula $RaCl_2$. From a radioactive standpoint, the salt has since its crystallization become the seat of an accumulation of emanation and of its subsequent products. From this standpoint, the nature of the salt reached a stationary state in about one month; the quantities of emanation, of Radium A, B, C, which are now formed inside the tube are in a state of radioactive equilibrium with the salt and are present in small amounts (less than $1/10{,}000$ of a mgm.).

Nevertheless the part they play in the emission of radiation is considerable; in fact, the gamma radiation can be attributed to radium C. As a result of the slow evolution which took place thereafter, substances D, E and F have accumulated and their relative amounts will increase during a period of about one hundred years. Of these substances, Radium E alone seems to emit gamma radiations; but these radiations are far less penetrating than those emitted by Radium C, and it may be assumed that they are an unimportant factor for measurements based on radiations that have passed through a sufficient thickness of lead (1 cm.). This point therefore should be carefully determined. If it is admitted, for the time being, that no consideration should be given the slow evolution products, it must be expected that the very penetrating gamma radiations will follow the law of radium evolution; that is, will decrease according to an exponential law, with a period of two thousand years. Whence the decrease over a period of one year should be about 0.04 per cent, so that during a period of ten years the standard can be considered as invariable. During a subsequent period of from twenty to thirty years a slight correction, approximately known, would permit of still using it; this is sufficient to obtain the services that are anticipated from it.

One might wonder, now, if radium extracted from uranium ores could not be accompanied by a trace, defying the most sensitive balance, of any other radioactive substance than its derivatives and capable of emitting very penetrating gamma radiations. Of these, the substance most to be feared is mesothorium. This substance is a derivative of thorium, which is generally present in uranium ores. Mesothorium accompanies radium in the chemical separations of the substances in the ore and in the fractional crystallization. This substance is the starting point of a series of derivatives which follow a complex law; resulting finally in the emission of gamma radiation which can be compared to those of Radium C as far as their penetrating power is concerned. The presence of mesothorium in radium therefore would affect the evolution law of the gamma radiation, and hence the accuracy of radium measurements. Fortunately, there are some uranium ores accompanied by only a very small proportion of thorium; for this reason, the ores can contain only a quantity of mesothorium too small to give rise to the difficulties mentioned above. This is the case with the St. Joachimstahl pitchblende, which contains about one k. of thorium per 50,000 k. of ore, consisting of 53 per cent uranium oxid, this amount being capable of yielding 3.7 gm. of radium. (See St. Meyer and Hess, Vienna Academy of Sciences, 1912.) The gamma radiation of one k. of thorium is absolutely negligible compared to that of 3.7 gm. of radium (about 3 hundred-

* The diameter of the Vienna tubes is 3.2 mm., and the salt occupies only one part of the tubes. The shape of the International Standard is more nearly perfect, but is more difficult to obtain.

† This question was settled as soon as the text of the statements was published. Dr and Mrs. G. P. Beilby made an offer to the Committee to assume the expenses of replacing the International Standard, wishing to give their offer a character of special friendship toward me, for which I thank them most sincerely.

thousandths) and the presence of mesothorium can in that case be of no noticeable inconvenience. This applies to the International Standard as well as the Vienna standards which were prepared with radium extracted from St. Joachimstahl pitchblende.

The International Standard can therefore be used with great safety. This degree of safety can be further increased by preparing under similar conditions a tube, the activity of which can be compared from time to time by means of an absolute measurement apparatus (method of the piezoelectric quartz, for instance). This will permit the experimental determination of the law of the evolution of the standard in the course of time.

In conclusion, the adoption of an accurately known standard will result in the following services:

1. From the standpoint of the science of radioactivity: It insures an agreement among the numerical results obtained in various laboratories by the use of a given amount of radium. In case results should not agree, the experiments would be repeated and possibly lead to the discovery of new facts.

2. From the standpoint of medical applications: It insures a judicious use of the physiological properties of the radiations due to the fact that it will be possible to measure exactly and with perfect safety the intensity of the radiation source used.

3. From a commercial standpoint: It establishes a basis for the radium industry and renders it secure, due to the fact that it will be possible to know exactly the amount of radium contained in the quantities sold; this will promote complete confidence between the manufacturers and the buyers. This service can be extended to the sale of mesothorium, as I have explained before.

Taken as a whole, the points explained in this article show plainly the high general value of the International Radium Standard. It may be rightfully anticipated that the initiative taken in this connection by the Radioactivity Congress of 1910 will be fertile in happy consequences, showing that real progress is being made towards various achievements.

FOURTH ITALIAN CONGRESS OF RADIOLOGY, BOLOGNA, MAY 9-11, 1922.

The Fourth Congress of Radiology held its opening meeting on May 9th at the Rizzoli Institute. Professor Busi presided. Professor Corbino delivered a lecture on the physical basis of radiation therapy, emphasizing the progress made in this branch of physics.

In the afternoon Professor Balli read a paper on "The Limits between the Normal and Pathological in the Radiology of the Digestive Tract." He discussed numerous diagnostic problems and illustrated them by lantern slides. Papers on the same subject were also read by Professors Alessandrini, Saraceno, Arnone and Pesci. Papers on the *x*-ray diagnosis of pulmonary and cardio-vascular lesions were read by Professors Ceresole, Gortan, Siciliano, Maragliano and others.

The most important paper of the next session was on "The *X*-Ray Diagnosis of Duodenal Ulcer," by Dr. Tandoia of Naples. Professors Parola, Ponzio, Palmieri, and Vespignani took part in the discussion. An executive meeting of the Italian Radiological Society followed. Professor Corbino was unanimously elected honorary president of the Society and of the Fifth Congress.

At the afternoon session several papers on deep therapy were presented. From these and the extensive discussion which followed, it may be concluded that in many cases deep radiotherapy is the method of choice for the treatment of neoplastic diseases of the uterus and breast. In spite of the progress which has been made in the biological, physical, and therapeutic aspects of the work, we cannot really speak as yet of radiotherapy as a cure for cancer. Papers on deep therapy dealing primarily with technique were read during the morning session on May 11th The German methods advocated by Seitz and Wintz, Friedrich, and Dessauer were discussed. Professor Ceresole made the suggestion that the radiologists who are connected with large institutions undertake systematic researches, and that the results be presented at the next Congress.

Professor Ross, Dr. Pais, and Dr. Spagnolio read papers on the treatment of malaria by *x*-rays. Extensive statistical data were given.

Doctors Tarchini, Vigano, and Conti read papers on radiotherapy in dermatology. Professor Gortan reported some interesting observations on the therapy of brain tumors; Professor Gavazzeni on Basedow's disease.

Mr. Lubostiez brought out some important points in radiographic technique. Mr. Iten explained the Potter-Bucky diaphram and the Victor stabilizer. He also showed moving pictures illustrating the process of the manufacture of the Coolidge tube.

The numerous exhibits of *x*-ray apparatus, showing the progress which has been made, attracted considerable attention.

The Fifth Congress will be held in Palermo, with Professor Scaduto as president and Professor Arnone as vice-president.

CANADIAN RADIOLOGICAL SOCIETY

The Third Annual Convention of the Canadian Radiological Society was held in Winnipeg in conjunction with the Dominion Medical Association, June 20–23, 1922. The scientific session lasted for three days, and included a series of extremely interesting communications. We had the honor to have present with us, contributing to the program, Doctors Lewis Gregory Cole, Russell D. Carman, B. H. Orndorf, R. H. Stevens, F. S. Bissell, and C. J. Sutherland.

The officers elected for the coming year are: President, Doctor L. J. Carter, Brandon; First Vice-President, Doctor C. W. Prowd, Vancouver; Second Vice-President, Doctor J. C. McMillan, Winnipeg; Third Vice-President, Doctor L. T. Pariseau, Montreal; Secretary-Treasurer, Doctor L. K. Poyntz, Victoria. The Executive Committee is composed of Doctor G. E. Richards, Toronto; Doctor A. E. Walkey, Hamilton; Doctor L. K. Poyntz, Victoria.

The rules and regulations governing the Canadian Register of Technicians established in 1921 were adopted, and Doctor L. K. Poyntz of Victoria was appointed Registrar and Examiner.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page ix of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

Russell T Boggs

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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ROENTGEN STUDIES OF THE THORACES OF THE STILLBORN AND NEWBORN*

BY WM. A. EVANS, M.D.

DETROIT, MICHIGAN

THE FUTILITY OF INSUFFLATION IN ASPHYXIA NEONATORUM

MY interest in chest work has led me, during the past year, to undertake a study of the thorax of the stillborn and newborn. Special attention was directed to the newborn with respiratory disorders. The findings in this type of case were of definite clinical interest, and also, we believe, of considerable practical value.

A review of the literature of the past three years on the subject of asphyxia neonatorum indicates that very little work has been done. The reason given for the neglect of this field is that neither the obstetrician nor the pediatrician considers this field his province, and each is apparently waiting for the other to solve the problems pertaining to the subject. Von Reuss, of Vienna, in his book on the "Diseases of the Newborn," adopted the following classification:

(*a*) Stillborn—When there is no heart-beat.

(*b*) Asphyxia—Two types:

1. Asphyxia pallida—heart-beats but no respiration.
2. Heart-beats but respiration impaired.

We believed that *x*-ray study of the chest would give valuable information, and with this in mind, we undertook the examination of newborn children, using the plate method.

A knowledge of the embryology and histology, as well as the gross anatomy of the chest, is necessary for intelligent interpretation of such chest plates. There is a surprising lack of knowledge of the condition of the lungs during fetal life, the usual conception being far from the facts in the case.

To review briefly the development of the respiratory tract: The epithelium is developed from the entoderm and the connective tissue portions from the mesoderm. The first differentiation of the respiratory system appears as a dipping down of the entoderm by one or possibly two invaginations of the floor of the pre-existing pharynx. This tubule divides into two branches. These again divide, two from the left, and three from the right, corresponding with the lobes of the lung. By repeated subdivisions of these tubules, the entire bronchial system is formed. Up to six months this process goes on, the development being that of a compound alveolar gland. The last structures to develop are the respiratory divisions of the bronchi with their alveolar passages and alveoli, this appearance of the alveoli being wholly characteristic of lung. The epithelium of the alveoli is at first entirely of the fetal cell type, the lining cells are polyhedral or rounded, and project from the walls. Opinions as to when the cells change to the flat type vary. Certainly, most of the change occurs immediately after birth.

In fetal life the lung entirely fills the thorax, but is completely atelectatic. All of the plates which we obtained of the

* Read at the Midwinter Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, Chicago, Ill., February 22, 1922

stillborn show that the shape of the chest and the abdomen is ovoid, the bulging no doubt being the result of the large liver. The lower ribs flare to accommodate themselves to the wide upper abdomen. The upper pole of the thoracic cage is distinctly narrowed. The ribs are sloping. There is an even density throughout both the lung fields, and the heart shadow cannot be differentiated from the lung tissue. Immediately after respiration, there is a distinct change in the contour of the chest. The ribs elevate and lie at right angles to the spine, and the upper thoracic cage shows a definite increase in the diameter. On several of the plates which we obtained, the tracheal shadow was shown throughout. This negatives Mink's contention that the fetal air passages are collapsed and that the glottis and nostrils are closed.

Fig. 1. Chest of stillborn. Forced expansion used. Note gas-distended stomach and cone-shaped chest.

This series of plates of the newborn includes a number of cases where insufflation of the lungs was done with the gas machine. In all these cases we found gaseous distension of the stomach and intestines, but as far as we could determine, no changes were produced in the lungs themselves. In the first case we studied, the disturbed respiration was associated with enlarged thymus and incomplete expansion of one of the lungs; that is, one of the lungs remained in part atelectatic. In the remaining cases where the impairment of respiration was of sufficient importance to warrant treatment with the gas machine, we found a complete expansion of the lungs, but a wide upper mediastinal shadow, which we interpreted as thymus. Plates of these cases showed, as referred to previously, gaseous distension of the stomach.

Fig. 2. Case of asphyxia neonatorum. Forced expansion used. Note gas-distended stomach and wide thymus shadow. Also note expansion of upper thoracic cage.

Experiments with the insufflation of the lungs of the stillborn by means of a catheter passed into the trachea, demonstrate that it is impossible to inflate the lungs by air pressure. Rather, there is an early rupture with the escape of the air into the pleural cavities which is sufficient to distend the chest wall. Usually pressure equal to 10 mm. of mercury is considered the limit of safety in forcible expansion of the lungs in infancy.

Our conclusions as to the efficacy of insufflation for faulty respiration are that the procedure has no merit, and that it has the disadvantage of widely distending the stomach and intestines.

THE THYMUS GLAND AS A FACTOR IN ASPHYXIA NEONATORUM

As to the large thymus gland being the basis for the faulty respiration, we have conclusive evidence that in practically every case the symptoms result from pressure on the trachea. The severity of the symptoms is not always in direct proportion to the enlargement of the thymus shadow, but the fact still remains that there is a constancy between the large thymus shadow and the faulty respiration. The thymus gland was exposed by removal of the sternum in several cases. The gland appeared in the median line, projecting no more to the right than to the left. The average length of the gland was about three

Fig. 3. Chest of stillborn. Forced expansion by gas machine and expansion through tracheal catheter used. Lungs not expanded. Note pneumothorax and gas-distended stomach.

Fig. 4. Chest of newborn. Normal shadow in thymus area.

Fig. 5 Plate of newborn with asphyxia. Note broad upper mediastinal shadow due to large thymus gland.

Fig. 6. Plate of newborn with asphyxia. Note wide thymus shadow.

inches, and the width a little more than an inch. We concluded from the post-mortem studies that the shadow of the normal thymus gland could not be differentiated from the shadow of the spine.

While we found a wide upper mediastinal shadow in most of the cases presenting respiratory symptoms, it is also true that in a number of cases of these wide shadows there was no disturbance in respiration.

Fig. 7. Plate of newborn with asphyxia. Upper right lung atelectatic. Note extension of thymus shadow to right.

In three of the cases studied, there was incomplete expansion of one lung. As the lungs expanded, the expansion being checked by serial plates, there was improvement in the respiration. In searching for a possible cause of the non-expansion of the lungs, it was noted that in all cases of unilateral atelectasis, the lobe of the thymus on the affected side showed the greater enlargement. It seems a fair conclusion that the enlarged thymus may even be a factor in the failure of the lung to be properly aerated.

In several of the cases there was a definite deformity of the cardiac outline. No doubt, disturbed circulation is an important factor in asphyxia neonatorum, but sufficient work has not been done on the heart to permit of proper classification of cardiac deformities or the determination of the frequency of cardiac complications.

DISCUSSION

Dr. Bissell. My discussion will take the form of an inquiry. I would like to ask relative to the treatment of these cases first, whether Dr. Evans noted marked aggravation of the symptoms following treatment before there is

Fig. 8. Plate of newborn with asphyxia. Note cardiac deformity and atelectasis of upper left lobe.

improvement. In the cases which I have seen in which there was marked stridor so that there was no doubt about the respiratory involvement, the patients have shown marked aggravation of symptoms following treatment, so that in two or three instances the physicians in charge have been very much alarmed and would not let the patient go out. The next day there was marked improvement.

Another question is whether he has had opportunity to ray these cases following treatment and see whether there was a concomitant reduction in the size of the gland as well as improvement in the symptoms. My personal observation has been that the improvement is due to some functional change rather than an actual reduction in gland tissue.

Dr. Murphy. I would like to ask Dr. Evans whether he has had any cases in which there was a reduction in the symptoms, but the baby did not recover and showed signs of generalized tuberculosis throughout the chest. I had one case in which the baby recovered from the thymic asthma, but died some months later from what appeared to be a generalized miliary tuberculosis of both lungs.

Dr. Allison. I would like to make an inquiry; that is, regarding these cases that are coming in showing unquestioned thymic disturbances and yet no enlargement of the thymus in the *x*-ray plate, but a beautiful response to *x*-ray therapy. I wonder if we do not have an anteroposterior enlargement of the thymus. We see a lateral enlargement quite commonly on the plate, but I have wondered whether we could not demonstrate a lesion in the light shadow which Dr. Evans described as the anterior mediastinum. I wonder if the thymus is not enlarged from before backward rather than from side to side.

Dr. D. Y. Keith. I think it would be well for Dr. Evans to tell us if an autopsy was held on these patients and whether there was an atresia of some portion of the bronchus below, particularly in the child that was stillborn.

Dr. Potter. I do not see these children very early, but frequently they come to the office and the referring physician will give some sort of instructions like this,—that we should do whatever we can to find out whether the child has a thymus and do whatever we can to cure him of it. These children are several days old at least when I see them. It is our custom to fluoroscope the babies and see what we think about the shadows and then make a study of the plates to see if they will show anything. Then we run them right into the treatment room if they are breathing hard or if an obstruction is shown under the fluoroscope. I believe the therapeutic test in symptomatic thymus cases is worth more than the roentgenogram for showing the presence of a thymus that will give real symptoms. You can have a thymus or thyroid so situated in the median line that it will give dyspnea or obstruction, but it will defy recognition by the *x*-ray. I know a doctor whose daughter showed some very moderate signs of obstruction with a little thyroid in the neck. She had perfectly negative upper mediastinal shadows. He went to Boston to visit her and found that she was going around with signs of pressure; in fact, any one could recognize them as signs of pressure. He took her to an internist who agreed with him and again they rayed her. Still there were negative findings. She was operated upon, and a long lobe of thyroid was found sticking down in the chest which was plenty large enough to give any amount of obstruction. She was immediately relieved clinically. So I think we must, as some of the speakers said, discount our negative findings in thymus cases where there is probably an obstruction due to the thymus, and go ahead and treat them. Inasmuch as the ray is such a good way to treat them, a therapeutic dose is usually given.

Dr. Hickey. Along the line of Dr. Potter's case I would like to refer to a case, a child that passed under our observation. I do not remember the age exactly. The clinical diagnosis was probably thymic obstruction. She was sent in to be rayed. We could not find any enlargement of the thymus and we reported it so, though we thought it might be a good plan to treat the child. She received several therapeutic doses and was not any better. The case then fell into the hands of a nose and throat man who thought it would be a good plan to look down the child's larynx. He did so and found a tumor, which he removed.

Dr. Evans (closing discussion). I want to point out that this work was all done during the first few hours of life. We were dealing, not with the clinical type of enlarged thymus as we get it in children after two weeks or a month, but with the disturbed respiration of the newborn. I think that will answer Dr. Murphy's question regarding the diseases of respiration. We did not secure a reaction in any of the cases, and we treated quite a large number. We got no increase in the symptoms in the cases treated. As Dr. Murphy suggests, we encounter this sometimes in treating older children.

Regarding atresia of the air passages, Dr. Keith, we did a post on the case and there was no atresia. Just why the child was stillborn we did not determine. We made lateral studies of these chests, and we were not able to show anteroposterior compression of the trachea due to enlarged thymus. It is difficult to demonstrate enlarged thymi in the stillborn.

A SIMPLIFIED PNEUMOPERITONEUM TECHNIQUE

BY L. R. SANTE, M.D.

Assistant Professor of Roentgenology, Medical Department, St. Louis University; Roentgenologist to St. Louis City Hospitals

ST. LOUIS, MISSOURI

IN 1919, pneumoperitoneum, as an aid in roentgen-ray diagnosis, was first introduced into this country by Stewart and Stein.[1] Since that time the method has been taken up by many roentgenologists all over the country and thousands of examinations have been made. Recently, after an exhaustive study from many American sources, Case[2] has reported the inconveniences and dangers which he feels are attendant upon the process. He has collected reports of 4 cases in which death was directly attributed to the performance of pneumoperitoneum. This investigation is timely, and serves very well to point out the dangers of the procedure. It will no doubt stimulate other roentgenologists to attempt the formulation of a safer technique. Assuming that in addition to these four deaths several others have occurred which have not been reported and consequently have not come to light, is this sufficient ground upon which to reject such a valuable procedure? By no means. It merely shows us that the method is not without danger when using present technique and apparatus, and it should stimulate us to perfection of a safer technique.

It behooves us then, as roentgenologists, to establish some simple, convenient technique which will bring pneumoperitoneum to the point of practical safety.

An investigation of the apparatus and procedure in general use for the production of pneumoperitoneum shows that they vary widely. It is unfortunate indeed that many have deviated from the recommendation made in the original paper of Stewart and Stein to maintain simplicity in apparatus and procedure. Where oxygen is used, a tank of this gas is connected by suitable tubing to a lumbar puncture needle. Many have added to this apparatus manometers and sterile water bottles for "washing" the gas before introduction into the peritoneal cavity. Some have even introduced devices to measure the quantity of gas introduced. Others have utilized a large rubber bag which is inflated before the needle is introduced into the peritoneal cavity. With this arrangement the needle is attached by rubber tubing directly to the bag and is inserted into the abdomen with the stream of gas flowing from the bag through the needle. The resistance of the subcutaneous tissues against the end of the needle permits very little escape of the gas; when the abdominal cavity is entered, however, the sudden release of pressure is indicated by the rapid deflation of the bag. With this arrangement it is much easier to cause puncture of a blood-vessel, since the needle is introduced without the stylet in place. If such an accident should occur, it could not be detected and air embolism would surely result. Where carbon dioxide alone is used, a similar apparatus has been advocated, allowing a definite amount of carbon dioxide to accumulate in a rubber bag, connecting the needle before the puncture is made, and inserting it without the trocar in place. Where a combination of carbon dioxide and oxygen is used, even more extensive apparatus is required. The procedure advocated has been equally complicated and varied in each instance.

To establish pneumoperitoneum as a successful procedure it must fulfil certain requirements.

1. It must be capable of production with simple apparatus which can be easily secured.

2. It must be readily performed by the roentgenologist himself or an assistant.

3. It must be convenient for the operator and not consume too much time.

4. It must be safe as regards the life and condition of the patient.

5. It must be of least possible discomfort to the patient.

The apparatus and procedure which we have used successfully during the past two years will be briefly outlined, in the belief that they come nearer to fulfilling these requirements than any other procedure yet advocated.

On the evening before treatment the patient is given a cathartic, preferably castor oil, and the next morning, about thirty minutes before examination, a soap suds enema. This is essential for the success of the examination. Omitting to rid the intestinal tract of gas and fecal material will result in failure. A light breakfast may be allowed, but this should not exceed two slices of toast and a cup of coffee. In approximately 175 cases in which pneumoperitoneum has been performed, there has been vomiting only once; this was in a patient who, disregarding these instructions, partook of a heavy meal just before examination. This merely added a disagreeable phase to the examination. Fifteen minutes before inflation, the patient should receive $1/6$ gr. of morphine sulphate to relieve any apprehensiveness and discomfort which may result from inflation. Just before inflation he should be catheterized or caused to void, so that an empty bladder during inflation will be assured.

With these preliminaries, preparation is made for inflation. The patient is placed on a hospital stretcher in a convenient position so that the stretcher can be rolled before the vertical fluoroscope. Special types of tables have been constructed for this purpose[3] but these are not essential; they merely add to the convenience of making the examination. With the patient lying on his back, and the entire abdomen exposed, the left lower quadrant is prepared for injection. The entire abdomen is washed with green soap and water, is rinsed, and then dried. Tincture of iodine is liberally applied to the left lower quadrant, and allowed to dry. This may be either removed with alcohol or allowed to remain, according to the desire of the operator. It would seem better to allow it to remain, since the demarcation of the iodine is an ever-present indication of the antisepticized area. The remainder of the abdomen is draped with sterile towels. The operator should prepare as for any other surgical procedure: scrub his hands with liquid soap and warm water, using a brush, for fifteen minutes, and should use sterile rubber gloves.

The patient is then ready for inflation. The inflating apparatus used is very simple (Fig. 1). It consists of a pump, such as that used with a Potain aspirator, which is connected by rubber tubing and suitable connectors to an ordinary lumbar puncture needle, with a rectal drip (vent-hole plugged) interposed as a trap to prevent any possible introduction of foreign material from the pump. With the exception of the pump, the entire apparatus is sterilized by boiling for fifteen minutes.

Fig. 1. Apparatus used for production of pneumoperitoneum. An ordinary lumbar puncture needle fitted to the pump of a Potain aspirator by suitable rubber tubing and connectors with a rectal drip interposed as a trap (vent-hole plugged).

The abdomen should be palpated over the site of the operation, so as to detect any possible abdominal masses or abnormal pulsations. The site most suitable for puncture is $1\frac{1}{2}$ to 2 inches to the left of, and a similar distance below, the umbilicus. The left lower quadrant is chosen rather than any other, because in this position there are no solid abdominal organs, the sigmoid and descending colon are situated far posteriorly and there is rarely any inflammatory process encountered such as is attendant upon appendical involvement. Anomalous conditions of the bladder will be avoided by inserting the needle on one side of the midline and by emptying the bladder before introduction of the needle.

The only structures which must be contended with are the deep epigastric artery in the abdominal wall, the intestines and the mesenteric vessels within the abdomen. If all manipulation of the needle within the abdomen or in the abdominal wall is carried out only when the stylet is in place in the needle, there will be little danger from puncturing a vessel. We have repeatedly attempted to insert a lumbar puncture needle in the veins of the forearm when the stylet was in place, and have been unable to do so except with great difficulty. If the obturator is withdrawn, however, the puncture of a vessel becomes a much simpler matter. Puncture of the intestines should be a very remote possibility if the stylet is in position and no adhesions are present. Postoperative scars should be avoided.

Having observed these preliminary precautions, we may proceed with the insertion of the needle. The needle should be disconnected from the apparatus and the stylet inserted. No local anesthetic is necessary for the passage of the needle. The skin and subcutaneous tissues of the abdomen are grasped firmly between the thumb and index finger of the left hand and raised away from the abdominal structures (Fig. 2). The needle, stylet in place, is held firmly in the right hand, the heel of the needle resting against the palm, the point being guarded about 1 inch from the end by the extended index finger. The point of the needle, guided by the posterior aspect of the left thumb is inserted into the subcutaneous tissues of the abdomen. In traversing the remainder of the abdominal wall, the needle is held almost perpendicular, directed slightly upward

Fig. 2. The skin and subcutaneous tissues of the abdomen are grasped firmly between the thumb and the index finger of the left hand and raised away from the abdominal structures. The needle, stylet in place, is held firmly in the palm, the point being guarded about one inch from the end by the extended index finger. The point of the needle, guided by the posterior aspect of the left thumb, is inserted into the subcutaneous tissue.

Fig. 3. With the index finger over the hilt, and the barrel of the needle grasped between the tips of the fingers and thumb, firm but steady pressure is exerted. Two distinct impulses will be felt, one as the needle traverses the fascia, the other as the peritoneum is pierced.

and inward so as not to put the mesentery on a stretch, should the needle-point come in contact with the intestines. With the index finger over the hilt, and the barrel of the needle grasped between the tips of the fingers and thumb, firm but steady pressure is exerted (Fig. 3). Two distinct impulses will be felt, one as the needle traverses the fascia, the other as the peritoneum is pierced. To be sure that the needle projects into the abdominal cavity the following test is then applied (Fig. 4). Holding the needle carefully, the stylet is withdrawn, and the apparatus connected. A few strokes of the pump will be sufficient for the purpose. If the needle is in the abdominal cavity, the inrushing air can be heard with each stroke of the pump, by a stethoscope placed at some remote position on the abdomen. This same method can be utilized in detecting the entrance of air into the abdominal cavity through the tubes, in transuterine insufflation. If this characteristic sound is not heard, the needle has not yet traversed the abdominal wall; the apparatus should be disconnected, the stylet reinserted in the needle and the needle inserted farther. The needle should never be manipulated unless the stylet is

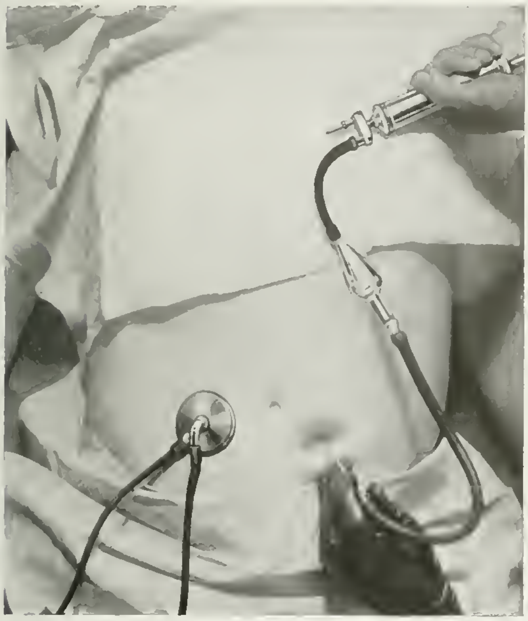

Fig. 4. To be sure that the needle projects into the abdominal cavity the following test is applied. Holding the needle carefully, the stylet is withdrawn and the apparatus connected. A few strokes of the pump will be sufficient for the purpose. If the needle is within the abdominal cavity, the inrushing air can be heard with each stroke of the pump by a stethoscope placed at some remote position on the abdomen. If this characteristic sound is heard you can be sure that the needle is in the peritoneal cavity. If it is not heard, you can be sure that the needle has not entirely traversed the abdominal wall.

in place. The slight amount of subcutaneous emphysema resulting from the injection of a few syringefuls of air into the subcutaneous tissues is of no consequence. The short space of time which elapses between the withdrawal of the stylet and the connection of the inflating apparatus is sufficient to detect the presence of the needle in a blood-vessel, should such a mishap have occurred. Air embolism should thus be entirely avoidable.

When the presence of the needle in the abdomen is assured, by the characteristic sound heard with the stethescope, the stretcher is rolled to a position before a vertical fluoroscope (Fig. 5), and inflation is continued under the guidance of fluoroscopic examination.

We use as a criterion of proper distention, the slight rounding of the abdomen and development of a tympanitic note over the entire abdomen. Inflation before the fluoro-

Fig. 5. The stretcher is rolled to a position before the vertical fluoroscope and inflation is continued under the guidance of fluoroscopic examination.

scope, however, as recommended by Orndoff,[4] is the most satisfactory method of determining proper distention. If an intra-abdominal mass is present, distention must be carried to a point far enough to lift the anterior abdominal wall free from the mass. This is necessary to determine the possible attachment of the mass to the anterior abdominal wall. Where the retroperitoneal space is to be examined, a slightly greater degree of inflation is necessary. Sterilization of the air is not necessary, since air infection does not occur in abdominal operations. The pump, of course, should never be used for aspiration of infected cases. Measuring devices are of no value, since lax pendulous abdomens may accommodate several liters of air and rigid tense abdomens, less than a liter. For the same reason, intra-abdominal pressure is likewise no guide to the suitable amount of air to be used. When proper distention has been obtained, the needle should be withdrawn and the examination proceeded with, before the fluoroscope. The patient is examined before the vertical fluoroscope, first on the back, then on either side, and finally in the retroperitoneal position. This position[5] may be secured by placing the patient in the prone position supported by two blocks; one beneath the chest, the other beneath the thighs. Examination before the vertical fluoroscope reveals the retroperitoneal structures. The patient is then transferred to the horizontal fluoroscope and examined while on the back and on the abdomen. Roentgenograms can then be made in any of the positions desired.

After the examination is completed, a second sterile lumbar puncture needle is inserted through the same hole into the abdomen, the obturator removed, and the air allowed to escape. Gentle pressure on the sides of the abdomen may be necessary to express the air. All the air cannot be thus removed, but the residual quantity is so small that its presence is of no consequence. Within a few days it is entirely absorbed. Do not use the suction arrangement on the pump to withdraw the air unless the second lumbar puncture needle used (an instrument recommended by Tierney[6]), has been filed off flat. With proper cooperation, the entire procedure, from the time of inserting the needle to the withdrawal of the air, should not consume more than twenty to twenty-five minutes. Consequently, before the effect of the morphine administration has worn off, the procedure is over.

A brief consideration will show that this procedure complies very closely with the requisites of an ideal method.

The apparatus is simple, inexpensive and can easily be secured by everyone.

Pneumoperitoneum can readily be produced with this apparatus, by the roentgenologist himself. In practically all cases where fatalities have been reported due to its production by other methods, the mishap was in the hands of the casual user. To be of proper usefulness it should be so simple that it could be safely performed even by the casual user. That the method here advocated can be safely performed by any physician who has a fair conception of anatomy and the principles of asepsis, after practicing five or six times on dogs or cadavers, there is no doubt. Any physician who has not a fair conception of anatomy and aseptic principles has no excuse for practicing medicine. As an evidence of the wide applicability of this method, it can be stated that of approximately 175 successful cases which we have had, not more than 2 have been performed by any one man (with exception of those performed by the author himself) and that these men were all internes just out of college.

The convenience of this procedure is evident. No special apparatus is necessary; no tank of gas is required. That it is absolutely safe as regards the life and the condition of the patient, cannot be positively asserted. But that it is far safer than some other diagnostic methods employed daily by internists and surgeons, there is no doubt in the mind of the writer.

With the use of air as an injecting medium we find far less discomfort than with oxygen or other gas, a fact which has been noted by internists in artificial pneumothorax. When used in conjunction with morphine injection, the discomfort is so much reduced that the patient usually goes through the entire examination without complaint.

The aim of this paper will be fully realized, if the reading thereof shall stimulate, to any degree, the further investigation of this valuable method.

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OSGOOD-SCHLATTER'S DISEASE*

BY ELLIS R. BADER, M.D.

Visiting Roentgenologist, Cincinnati General Hospital

CINCINNATI, OHIO

IN reviewing the literature pertaining to Osgood-Schlatter's disease, one notes with interest that the first case report of this condition was in 1869 by Dr. Paul Vogt. One cannot help but admire the diagnostic ability displayed in the early days, long before the use of the *x*-rays; and considering the comparative rarity of this condition, which is practically never diagnosed to-day except in conjunction with positive *x*-ray findings, one again marvels at the skill of the old practitioner.

Another interesting point, worthy of note in passing, is the absence of articles dealing with this condition in the roentgen-ray journals. The rather exhaustive reports by Osgood in the *Boston Medical and Surgical Journal*, and by Schlatter in German—both of which appeared in 1903—have no counterpart in the roentgen-ray journals.

A condition which depends to such a great extent upon the roentgen-ray findings, therefore, seems worthy of mention, from a roentgen-ray standpoint. In considering the incidence of this disease, the records of the Cincinnati General Hospital were found to show one case of Osgood-Schlatter's disease in six years. This apparent rarity may be somewhat discounted by the fact that this condition is not necessarily hospitalized.

Osgood-Schlatter's disease, as it is commonly called, may be classified either as a disease or as an injury, although it would seem that the classification as an injury is particularly applicable, as the condition is primarily due to trauma. The severity of the lesion ranges from a non-suppurative, subacute inflammatory thickening of the tibial tubercle, due to repeated traumata of ligamentous pulling, to a complete avulsion of the tibial tubercle by sudden muscular contraction. This condition is primarily seen in adolescence, and usually in young people of the athletic type who have occasion to use the quadriceps femoris rather vigorously. In adults, the complete avulsion of the tibial tubercle is most commonly found, and the non-suppurative inflammatory type rarely.

A brief review of the development and anatomy of the upper end of the tibia may not be amiss, since the pathology depends to a great extent upon the developmental anatomy. The upper portion of the tibia usually develops from one center of ossification, which forms the upper articular surface and a tongue-like projection, or beak, anteriorly, and extends downward over the diaphysis. There may be, however, a separate center of ossification for the tibial beak. Ossification is usually not complete until from puberty to twenty years.

Attached to this tibial tubercle is the tendon of the quadriceps femoris. This tendon also sends out lateral aponeurotic

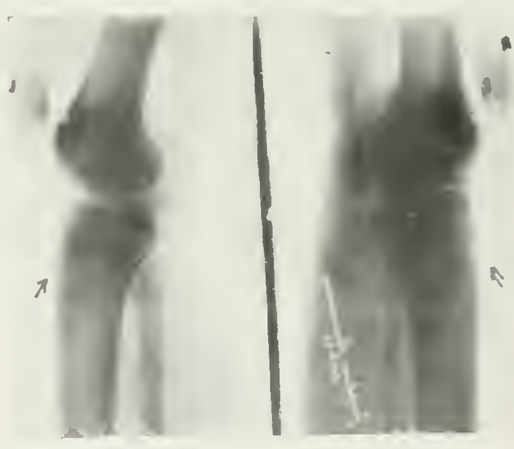

FIG. 1.

expansions which are attached to the anterior portion of the tibia and to the internal and external sides of the tibial beak. This latter fact accounts for occasional fractures of the tibial beak which apparently cause no loss of extensor power of the quadriceps femoris. In other words, although the direct attachment of the

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quadriceps ligament is separated, its lateral expansion remains intact.

Figure 1 shows the knees of a very athletic girl about ten years of age who was taken to the family physician by her mother on account of small painful lumps below the knees—the right knee, especially being most marked. There was no loss of muscular power. The lumps were tender to touch, and also painful upon forcible

Fig. 2.

exertion. There was a slight redness, but no appreciable increase in local temperature.

The roentgenogram showed an irregular and fuzzy tibial beak, rather moth-eaten in appearance, suggesting low-grade inflammatory changes. The left tibial beak showed no evidence of pathology, from the roentgen standpoint.

This case is an example of the typical Osgood-Schlatter disease, of the non-suppurative, subacute inflammatory type. The treatment in this case was firm strapping of the knees and tibial tubercle with adhesive bands.

Figure 2 shows the left knee of an athletic boy of nine years, who sustained an injury to this knee. He was pushed off a fence by another boy, and landed on his feet, with the knee in a slightly flexed position. He immediately fell to the ground, and was thenceforth unable to extend the left leg. The roentgenogram showed a separation of the tibial tubercle, about 1 inch upwards from the normal position. This is another case of Osgood-Schlatter's disease, but with complete avulsion of the tibial beak. This patient was treated by open operation. The tibial tubercle was attached to the tibia by kangaroo-tendon.

In exposing these plates, one should remember to have the knees so centered in relation to the tube that the central ray passes through the tibial tubercle, directly perpendicular to the plate. It is also a very good idea to expose both knees, should only one knee be affected, thus allowing a check of the normal with the pathological.

Clinically, Osgood-Schlatter's disease must be differentiated from tuberculosis of the knee, bursitis, infectious arthritis, fracture of the patella, periostitis, joint fringe, and loose cartilage. The roentgenogram, of course, is the deciding factor in making the differential diagnosis.

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DISCUSSION

Dr. Blaine. I have seen a few cases of Osgood-Schlatter's disease, but I fail to see how we can call this a diseased condition when, as in the second instance which Dr. Bader presented, it is really a trauma. Why do we call it Schlatter's disease? It seems to me it resolves itself into a disease of the tibial epiphysis. On one hand the changes follow long after the injury, and the inflammatory process is so marked that it rightly would be a disease of the tibial epiphysis; but on the other hand, where the change happens in a normal boy or girl with a tearing or fracture, as in the elbow or in the other joints, it is the result of trauma, and is not a disease.

Mr. Dachtler. I had a case recently, a boy of thirteen, who presented a swelling, very slightly sensitive, over the tubercle of the tibia. I expected to find Osgood-Schlatter's disease, but on examination he was found to have a bilateral new-bone formation which was not attached to the tibial spine. It was like a calcification in the bursa, and there was no temperature. I sent him to our orthopedic surgeon, who told me he had two or three similar cases, one of them bilateral. I think Dr. Murphy saw these cases. It was not Osgood-Schlatter's disease, but clinically it would give one that impression. There was no irregularity of the tibial spine, and the only thing we could liken it to was a calcification in the bursa.

Dr. Murphy. I think I can recall the case Mr. Dachtler mentioned. If my memory is dependable, it showed an osteomyelitis when operated upon. I believe there was no injury in that case, but it was purely an infection of the tibia. That is quite a different condition from one brought about by sudden trauma. We all see cases in which there is a definite enlargement of the tibial tubercle. I think that is a condition similar to Perthes' disease of the hip, simply an inflammatory condition of the epiphysis of that joint. There should be a distinction between that and the traumatic type in which there is a fracture.

Dr. Keith. I would like to ask Dr. Bader if there was any bacteriological examination in the cases reported. I believe that in the cases that go to suppuration we should make a culture or animal inoculation, in order to tell definitely what we are dealing with from a bacteriological point of view.

Dr. LeWald. I have seen a number of these cases. I think the thing of importance to emphasize is that they are non-tuberculous; at least all our cases have finally cleared up without suppurating or breaking down, without the formation of sinuses and without requiring operative intervention. It is very difficult from the roentgen-ray appearance alone to make a diagnosis, for one will see irregular variations on the two sides, sometimes both of them very prominent, with an irregular epiphyseal line. In some cases, this process is entirely separated from the tibial shaft. I think one should be very cautious in making a diagnosis without the clinical history. If you have a focus there, you can say it is a diseased condition; if there is an irregularity of the epiphysis, it may be an irregularity in formation. It is a good deal like a discussion on the cecum which I once heard. The surgeon said if the cecum was loose you sewed it up, and if it was surrounded by adhesions you loosened it up.

Dr. Bader (closing discussion). I agree with Dr. Blaine in thinking the disease should be classified both as a disease and as an injury. The last 2 cases I showed were fracture cases and these, I think, should be classed as fractures rather than diseases.

In answer to Dr. Keith's question: I looked over the literature on this subject rather thoroughly and did not come across any cases in which bacteriological examinations had been made.

OSTEITIS DEFORMANS (PAGET'S DISEASE)

BY CECIL M. JACK, PH.B., M.D., F.A.C.P.

DECATUR, ILLINOIS

THE following case of osteitis deformans is reported to illustrate the value of the roentgen-ray examination to the internist in the diagnosis of his obscure cases. Without it, perhaps, this case would have remained obscure.

CASE 20,694. Male, minister, Aged forty-six, married.

CLINICAL HISTORY

Past Medical. Patient was never sick until ten years ago. Since that time he has been ill quite frequently. He had inflammatory rheumatism nine years ago; hemorrhoidectomy seven years ago. Five years ago he had a severe, sharp, acute pain in the right upper lumbar region, lasting twelve hours and relieved only by morphine, diagnosed as a kidney stone. He had a similar attack in January, 1920, which came on very suddenly. In September, 1919, he had an acute cystitis. He was in bed five weeks, and recovery followed soon after a sudden discharge of a large amount of blood and pus.

Family History. No tuberculosis nor cancer. Father is past seventy and well. Four children living and well.

Habits. Appetite remains good, bowel movements regular, no urinary disturbances, except a mild nocturia.

Present Complaint. Impaired vision, headaches, soft area in cranium, fever and weakness.

Onset and Course. Trouble began in August, 1920, following a week or two of diminished energy and vitality. He first noticed sudden severe pains in the head, and consulted a physician for relief two days later; his temperature was 101.5°F. On the following day the temperature went to 103°F. and the patient was obliged to go to bed, where he remained two days. On the following day the pain disappeared and the temperature went down. Two days later the temperature rose again to 102°F. and his headache became severe. Since then he has had headache almost every day. He states it would quite regularly become severe about every second day. He has also had fever occasionally.

On October 5th, he first noticed blurred vision, which progressed rapidly, and in a few days he was unable to read. He consulted an ophthalmologist who said it was eyestrain. The patient obtained some glasses which aided him in close vision; his distant vision, however, remained blurred. At present the patient sees with great difficulty and at times has diplopia.

A soreness has been present at the apex of the cranial vault during the illness, but about two weeks ago he first noticed a puffy, soft area which seemed to contain fluid. It is surrounded by a sensation of pressure and tightness. The patient states that he is somewhat weak and cannot exert himself. The teeth have been roentgenographed, and several, which were abscessed, extracted.

PHYSICAL EXAMINATION

The patient appears well-developed and well-nourished. He suffers no pain; his hearing is normal; his speech approaches the scanning type. Temperature, pulse and respirations are normal. His height is 5 feet, $10\frac{1}{2}$ inches, one inch less than in his student days, and he weighs 176 pounds, which he considers normal.

The head presents a soft and fluctuating area, about the size of a silver dollar, in the vertex region, apparently an area of necrosis involving the skull. The border of this area is bony and the base is soft. The left pupil is larger than the right; both react well to light and accommodation. A slight divergent strabismus is present. The retinae are congested, and the outline of the discs cannot be made out. Several flame-like areas are seen, particularly on the right side.

The abdominal reflexes are absent. The patellar reflexes are equal but exaggerated. The other reflexes are normal.

The remainder of the physical examination is negative.

LABORATORY FINDINGS

Blood-Pressure. Systolic 135; diastolic 80.

Urine. Negative.

Blood. Hemoglobin 70 per cent, red cells 2,920,000, white cells 9,200; color index 1.

Differential Cunt. Polymorphonuclears 60, large mononuclears 1, small mononuclears 38, and transitionals 1.

FIG. 1. Head roentgenogram showing variations in density and thickness of cranium. Note the irregular areas of bone scattered over the vertex.

Wassermann Reaction. Negative. Four tests made during treatment.

Spinal Fluid. Pressure increased; clear; cell count normal. Nonne negative; Wassermann negative, and colloidal gold test 000 000 000 0.

Basal Metabolism. Metabolic rate plus 10 per cent.

ROENTGENOLOGICAL EXAMINATION

Skull. There is a spongy appearance of the compact layer, with increased transparency. The skull is greatly thickened, which is in contrast to its transparency. All through the skull roentgenogram there are scattered irregular spots which could be compared to tufts of cotton.

Chest. The apices are clear; peribronchial infiltration is quite marked; and the costophrenic angles are clear. The heart is definitely enlarged, and the aorta is broadened.

Long Bones. In the tibia and femur, there is an absence of definition of cortex and cancellous tissue with no areas of rarefaction. The bones are more dense than normal throughout. The sclerosed arteries cast a distinct shadow.

Pelvis. A condition similar to that seen in the skull is found in the pelvic bones, more marked on the left than on the right side.

Diagnosis. Osteitis deformans or Paget's disease.

Course. The patient was given a course of six intravenous injections of neoarsphenamine, and the turn for the better was remarkable. The vision cleared, the headaches stopped, the soft spot in the head disappeared, and he gained in weight and felt better in every way. After six weekly gluteal injections of mercury he was given six more intravenous injections of neoarsphenamine.

CONCLUSIONS

We are dealing here with a chronic generalized bone disease characterized clinically by an enlargement of the cranium and deformities of various other bones, and pathologically by a rarefying and productive osteitis.

General arteriosclerosis is a practically constant lesion in cases of Paget's disease. Hypertrophy of the heart is also a constant feature. Both are marked in this case. According to Lannelongue,[1] Paget's disease is a manifestation of hereditary syphilis in the aged, and he bases his opinion on the similarity of the lesions. This is interesting, as improvement in this case followed the giving of neoarsphenamine. A case reported by Dufour and Bertin-Mourot[2] improved in like manner. However, their case gave a positive Wassermann reaction. A diagnosis in the early stages is difficult, and, as a rule, it is not until the case becomes fully developed that it is recognized. For this reason many people suffering from Paget's disease are treated for a long time for rheumatism, neuralgia, etc. Again, it has been found that some cases which early simulate a Paget's disease turn out to be some other condition.

With Paget's description[3] of an early case this patient has very little in common. On subsequent questioning we find that the hats he formerly wore are now all too tight and that he has lost an inch in height in twenty years. A roentgenogram, though taken only on account of his eye findings and headaches, disclosed also that we were dealing with a disease which needed further investigation, whereupon other roentgenograms were taken. Then the diagnosis was apparent.

This case gives no serological nor clinical test for syphilis. However, improvement has been marked under antiluetic treatment and suggests the possibility of Paget's disease being a manifestation of late hereditary syphilis. More study should be carried out along this line. At post-mortem examinations the spirocheta should be sought for in the heart muscle. If found it would probably explain our causative factor.

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MUTATION OF PULMONARY SHADOWS DUE TO TYPE OF BREATHING

H. A. BRAY, M.D.

New York State Hospital for Incipient Pulmonary Tuberculosis

RAY BROOK, NEW YORK

SOME observers believe that the roentgenogram offers a reliable means for the identification of the pathological changes of pulmonary tuberculosis. This tendency is illustrated by the classification of pulmonary shadows in tuberculosis devised by Cole,* in which a strictly pathological nomenclature is employed. By others such claims are accepted with reserve. These opposing views have made difficult the clinical appraisal of this procedure, and the present communication aims to present certain observations which may prove helpful to the solution of this problem.

The correlation of pulmonary shadows with the pathological changes of tuberculosis presupposes that each of the varied lesions encountered in this disease casts a characteristic shadow on the roentgenogram. According to this view, the shadow for any particular type of lesion remains constant and unchanged. Certain observations, however, would appear to question the validity of this position.

Some years ago, when making a comparative study of a series of radiographs of a patient taken at one sitting, I noted an appreciable difference in the appearance and distribution of the pulmonary densities. Such differences, at first attributed to faulty technique, were discovered, upon further investigation, to be associated with the type and depth of the inspiration employed by the patient preparatory to the *x*-ray exposure. The shadow mutations due to this cause, at times, were striking, and are particularly pertinent to the present discussion.

Stereoscopic plates were made at the height of suspended costal inspiration and again at the height of suspended diaphragmatic inspiration. In a few instances, exposures were also made during tidal respiration, but the contrast with the other films was not sufficiently marked to merit especial attention. Posterior ex-

* Cole, L. G., Interpretation of pathology visualized by the roentgen examination of the chest. *Trans. Nat. Assn.* Study and Prevention Tuberculosis, 1917.

posures were preferred to the usual anterior exposures, because on abdominal breathing the thorax does not remain in contact with the film, owing to the protrusion of the abdomen, thus causing a technical difference which might prove confusing in a study of this nature. Exacting standards were employed in the details of *x*-ray technique so as to obtain

Fig. 1. Costal breathing. Case 4291. The outline of the thorax is relatively short and broad. The heart and diaphragmatic shadows are conspicuous and the shadow projecting from the left hilum upward and outward is dense and sharply defined.

uniform photographic results, a requisite for a satisfactory comparative study of the films.

On costal inspiration expansion of the lung is manifested by an increase in the circumference of the chest; while on diaphragmatic inspiration the chest remains immobile, and expansion is effected solely by the descent of the diaphragm. The direction in which the lung expands affects its shape. It is relatively short and thick on costal inspiration, but long and narrow on diaphragmatic inspiration. This difference is also evidenced on the films by a similar contrast in the respective outlines of the lung fields. In Figure 1 we may note the relative increase in the width of the upper intercostal spaces and the elevated position of the diaphragmatic shadow on costal inspiration, and in Figure 2 the elongation of the mediastinal shadow on diaphragmatic inspiration. In addition, the position and shape of the cardiac shadow are noticeably changed. The heart is usually drawn to the left on diaphragmatic breathing, owing to the relatively greater

Fig. 2. Abdominal breathing. Case 4291. The outline of the thorax is long and narrow. Mediastinal shadow is elongated. Note the annular shadow proximate to the left hilum, and almost complete disappearance of the band-like shadow in this region noted in Figure 1. The pulmonary shadows in this region are soft in type and in contrast with those in Figure 1, which conform to the hard type of shadow.

descent of the left leaf, with the result that the cardiac shadow occupies a more prominent position in the left lung field than on costal breathing.

Inasmuch as the hila move in unison with the diaphragm, their shadows will appear lower in the lung field on diaphragmatic inspiration, because of the greater descent of the diaphragm with this type of breathing. This change in the position of the hilar shadows may amount to two interspaces or more, and be associated at times with appreciable changes in both outline and density. In Figure 2 there is an annular shadow adjacent to the left hilum on diaphragmatic breathing, but, as may be seen in Figure 1, this is absent on thoracic breathing.

Of particular interest to the present discussion, however, is a difference in the distribution and mutation of the pulmonary shadows, which may be appreciated best by a comparison of the films on costal inspiration with those on diaphragmatic inspiration. In certain instances, shadows ordinarily termed "hard," and regarded by some observers as denoting fibrosis and inactivity, may be converted into shadows which are "soft" and commonly interpreted as evidence of an active lesion. Thus, the prominent bandlike shadow which projects from the summit of the left hilum in Figure 1 has been replaced in Figure 2 by a shadow which is more or less characteristically soft in type. The adjacent shadows also partake of the change, although to a lesser degree. In Figures 3 and 4 the mutation is even more striking, and in Figures 5 and 6, though different, it is still quite evident.

It has been suggested that the film on costal breathing best serves for a pathological interpretation of tuberculosis. This supposition, however, is not supported by any known facts. Moreover, from the foregoing it is obvious that numerous transitions may be obtained in the mutations here illustrated, by regulating the extent of participation of the costal and diaphragmatic elements during the inspiratory act.

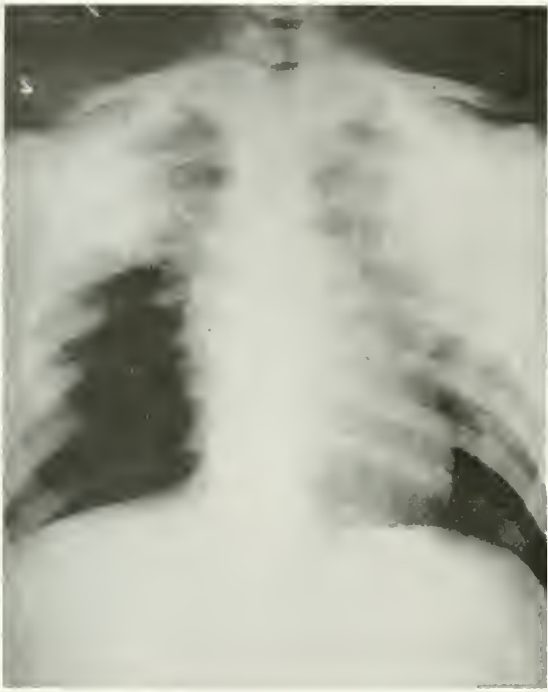


Fig. 3. Costal breathing. Case 6746. Note particularly the dense uniform shadow occupying the outer two-thirds of the second, third and fourth interspaces on the right side, internally fusing with the hilum shadow.

Fig. 4. Abdominal breathing. Case 6746. Note the remarkable change in the location, distribution and appearance of the pulmonary shadows in the upper right lung field. The difference in the outline of the chest on costal and diaphragmatic breathing indicates the difficulty of forming an opinion of the shape of the thorax from the roentgenogram.

The causal factor of these mutations cannot reasonably be attributed to pathological changes within the lung, since the time interval between the *x*-ray exposures was well within a minute. Nor can the difference between the respective volumes of air intake on costal and diaphragmatic breathing be regarded as an important contributory factor, inasmuch as the air intake as registered by the spirometer varied only from 12 to 20 per cent in favor of costal breathing. That the mutations are associated with the type of respiration was apparently established when it was discovered that the accompanying films could all be readily duplicated by governing the type of respiration. Their presence probably can best be explained by the attempting to determine the effect of tuberculin injections on the pulmonary lesion, or the progress and distribution of the disease by serial roentgenograms. Their occurrence, however, is especially to be remembered in studies devoted to the correlation of the roentgenography and pathology of tuberculosis.

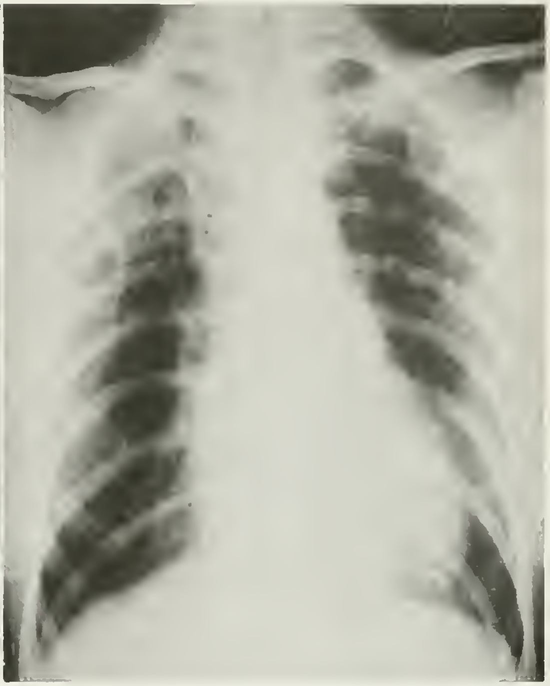


Fig. 5. Costal Breathing. Case 6667.

Fig. 6. Abdominal Breathing. Case 6667.

Figures 5 and 6 are further examples of mutations of shadows due to type of breathing, and in certain respects contrast with the mutations noted in the other figures.

theory that the *x*-rays impinge on lesions, which, in common with the rest of the lung, have changed their shape with the type of breathing.

A knowledge of the shadow mutations here referred to will prove helpful when

From the foregoing it would seem inadvisable to employ a strictly pathological nomenclature in interpreting pulmonary shadows. It would perhaps be better, at least for the present, to use a terminology descriptive of the pulmonary shadows.

THE ROENTGENOLOGIST AND THE UROLOGIST IN THE DIAGNOSIS OF RENAL DISEASE*

BY E. GRANVILLE CRABTREE, M.D., AND WILLIAM M. SHEDDEN, M.D.

Massachusetts General Hospital

BOSTON, MASSACHUSETTS

GENERAL CONSIDERATIONS

WITH the rapid development of cystoscopy and the roentgen ray, large burdens in diagnosis have been placed on the roentgenologist. Unfortunately for him, he does not have at his command all the clinical facts that exist, to enable him to make the best possible diagnosis. With the urologist, who has the roentgen-ray findings, clinical symptoms and the facts obtained by cystoscopy, the matter is somewhat easier.

Many cases with pathological kidneys are not sent to the urologist early in the investigation. This is as it should be. When they do arrive, frequently gastro-intestinal and complete medical examinations have been made and the renal diagnosis has been not only the last thing to be established, but may even be the last thing suspected. For this reason the roentgenologist is in much closer contact with the general practitioner, whose case is being investigated, and if his knowledge is broad he is the one man in position to give valuable advice, based on his plates, to guide investigation of any particular case. Patients are, I believe, most often sent to the roentgenologist for pain. We all know that in many instances negative roentgen-ray report for stone is interpreted by patients and frequently by the physician as equivalent to no renal disease. Stone is, of course, but one of a number of surgical renal conditions which give symptoms. It has been my experience that the more finished and well-trained the roentgenologist the more careful is his report to the physician on the degree of positiveness or negativeness of the roentgen-ray findings. I would not be surprised if Dr. Holmes' aim in having me, an urologist, address the New England Society of Roentgenologists is not only that a better understanding of the renal problem may result to both of us from a discussion of an urological subject, but, what is more important, benefit accrue to the man who sends in cases for diagnosis. That the patient will benefit to a corresponding degree is a necessary sequence.

What I have said regarding the guidance which roentgenography may give to the general practitioner is not intended in any way to detract from the general man. All of us recognize how simple a difficult diagnosis is, once it is made. We also recognize that a busy practitioner's problems are not those of a special man. His work is essentially made up of many short visits and a great deal of night work, and it is done under surroundings in which there is neither time nor equipment at hand for a thorough study of each case which is presented to him. Medicine is now so complex that he cannot be expected to keep posted on all the possibilities in every branch of medicine, surgery and the specialties. The roentgenologist is in a position to make to these men many valuable suggestions in the diagnosis of renal conditions, and these suggestions are gratefully received.

Routine examinations of the kidney and ureter regions have two essential purposes, one, to show suspicious densities which, from the roentgenologist's experience, he is led to believe lie within the region of the kidneys and the ureters. He is certainly entitled to make a statement as to whether he thinks these are stone, tubercular calcifications, calcified mesenteric glands and phleboliths. Yet all these conditions may be absent and the kidney still be pathological. This means that he is entitled also to make estimate as to the normalness of the kidney in size and position. On this depend many diagnoses. It is my aim to discuss the group of kidney diseases in order that the roentgenologist may better

* Read before The New England Roentgen Ray Society, Boston, Mass., February 18, 1922.

judge of the possibility of abnormalities from the data shown by roentgenograms. A roentgen-ray examination of the kidney regions is unsatisfactory if it fails to show definite outlines of the kidney shadows. This is a point of much significance, and justifies repeating the examination. False leads in diagnosis result from poor demonstration of renal outlines.

PROBLEMS OF THE UROLOGIST IN WHICH X-RAY OF THE KIDNEY IS CONCERNED

Briefly, the clinical pathology of the kidney comprises tumors, stones, infections, stasis or any combinations of these four.

TUMOR

To the urologist as well as to the roentgenologist, tumor must be considered to mean the differential diagnosis of masses occupying the sites of one or other of the kidneys. From these the urologist with the help of the roentgenogram sorts out the true renal tumors and frequently gives valuable aid in the diagnosis of spleens, liver abscess, psoas abscess, fatty retroperitoneal tumors, etc. True renal tumor, usually hypernephroma, is of course recognized by enlargement of the kidney shadow if enlargement exists, and deformity, by pressure of the pelvis of the kidney as shown by pyelogram. This deformity follows no set rule other than that it is the demonstration of a new growth encroaching upon some portion of the pelvis. It must be remembered that the tumor may arise from the extreme upper or lower pole of the kidney, and may increase to great size without deforming the kidney more than in the upper or lower calices against which the tumor presses. Papillomatous growths of the renal pelvis are more difficult to diagnose, particularly when bleeding occurs, giving rise to retained blood clot. Other forms of tumor in the region of the kidney, particularly retroperitoneal growths, are apt to carry the kidney and ureter out of position either toward or away from the midline. In all these conditions the position of the kidney and ureter can be made a landmark for differential diagnosis.

In polycystic kidney the characteristic renal deformity is elongation of the pelves and calices due to occurrence of multiple cysts, among which, by the growth of the cysts, the normal calyx is drawn out as well as pressed upon. Compression of the kidney from enlargement of Riedl's lobe of the liver may actually deform the pelves of the kidney in such a way as to make it extremely difficult to differentiate between that and true tumor of the kidney. Cystoscopic examination usually will show this pelvis to be normal in capacity.

FIG. 1. Diagram of an injection of the pelvis in which a line (3) connects the tips of the pyramids. Abnormalities in outline of the pyelogram beyond this line are usually due to inflammatory processes in the kidney substance. Tuberculosis and staphylococcus type of abscesses may appear in this area.

STONE

The demonstration of large stones in the kidney has at this stage of roentgen-ray diagnosis become easy. It cannot be too frequently emphasized to the medical profession at large and especially to some surgeons, that the kidney is the important thing, not the stone. I mention this merely to indicate that the demonstration of large stones in the kidney is not a complete diagnosis of a kidney condition. It is important to know whether the kidney is worth preserving, or, if it should be extirpated, whether its fellow is capable of supporting life. The nature and extent of dilatation associated with stone is a guide to subsequent usefulness of that kidney. It is also important to have these facts determined *before* operation. One discouraging feature of urological work which still persists is that cases are still sent to us for diagnosis *after* the operation has already been performed for the supposed condition. It is also important to have generally recognized the fact that a kidney which is worth saving if its stones

FIG. 2. Hydronephrotic kidney with bacilluria indicating pyelitis, almost no pus, and high temperature on that account. Pyelogram showed a triangular area in the cortex which suggested cortical suppuration. Four days following the pyelography, patient voided on three occasions bloody, pussy urine, which contained large numbers of staphylococcus aureus after which the urine cleared up except for the pyelitis. The temperature dropped to normal and the patient quickly recovered. I believe there has been a focus of suppuration in the kidney, at the point indicated in the illustration, which produced an abscess that ruptured into the pelvis and produced satisfactory drainage.

are removed, often has not proved so in the end, because of failure properly to clean up the pelvis which has recently harbored a stone in order to free it from pus and put it back into shape to perform the work expected of it. At this date it is unpardonable surgery to do nephrectomies and removal of calculi by pyelotomy and nephrotomy without having at hand full data regarding the condition of the kidney which harbors the stone. It is equally unpardonable to remove a stone and to leave an embarrassed kidney with active infection, alkaline urine and stasis, all conditions which contribute to recurrence of stone, and part of which conditions can be removed by proper postoperative treatment, thus considerably diminishing the chance of recurrence. There are patients now living comfortably on kidneys which at the time of operation seemed hopeless. These patients have later been forced to depend entirely upon a damaged kidney, because, subsequent to operation, stone and severe infections have completely

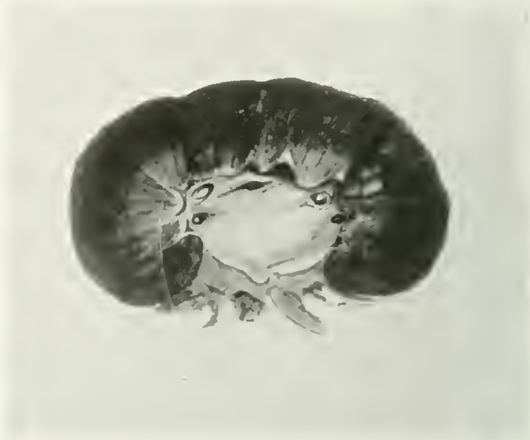


FIG. 3. Illustration of a kidney with multiple staphylococcus abscess in the cortex. Two of these are well down in the papillae and deformed the neighboring calices. One of these abscesses eroded through an arcuate artery producing serious hemorrhage for which nephrectomy was done. These two areas showed as pyramidal pale areas similar to that shown in Figure 2, and were in exactly the positions of the two abscess areas mentioned.

destroyed what was previously the sound kidney. The ability of these kidneys to return to function is nothing short of marvellous. Yet, if leaving them must mean recurrent stones and repeated operation (which it does not), it places too great a burden upon the patient.

The one place where diagnosis of stone still remains difficult is in the demonstration of large or small stones which, because of their composition, fail to show in the roentgenogram, and of small stones, either within the pelvis or the ureter, which, because of their size and the size of the patient, are shown with difficulty. We have come to discover that there are a few cases of slight dilatation of kidney pelvis or ureter with or without infection and negative roentgenograms for stone, in which there is no demonstrable cause for dilatation of the pelvis. These dilatations are sometimes due to a small stone which we can either stain by injecting the pelvis, or show as a rarified area in the pelvis, or demonstrate in the ureter by blocking of the ureter. The wax-tipped catheter is most useful, of course, in the ureter. In many instances symptoms will guide us in suspecting the presence of these stones. The wax-tip is not of such great reliability in the pelvis where stones may exist in the calices and be unrecognizable by this method.

INFECTIONS

Within the past two years some advance in our conception of the significance and of the treatment of infections has taken place. I prefer to consider infection under three classes: 1. The pyelitis type, which is usually due to the colon bacillus. 2. The staphylococcus type, commonly and erroneously known as "hematogenous infection," in which abscess development takes place. (This type includes perinephritic abscess because of the renal origin of perinephritis.) 3. Tuberculosis. Roentgenogram and pyelogram can be made to play an important part in the diagnosis of all these three types of renal infection. Recent investigations tend to show that persistent pyelitis is a persistent infection because of renal damage of some form, usually malformations of the kidney or acquired damage from obstruction. For this reason an infection which has persisted for two or more years either as recurrent attacks or as a persistent pyuria can be suspected to be due to some form of renal pathology in addition to simple pyelitis. The cause may be stricture, aberrant vessels, congenital malformations, or, commonest of all, sagging kidneys which have obstruction to the free outflow of urine, particularly during periods when the patient is in an upright position. In these cases roentgen-ray demonstration of the position of the kidney in full inspiration or when standing, is of great value in determining whether further investigation is apt to divulge something of importance in that kidney. Not all sagging kidneys produce symptoms or have stasis in the pelvis. It is the problem of urologists to study this type of case and determine whether or not stasis exists. Cure of these cases is possible, sometimes by operative procedures, in many instances by proper cystoscopic and other measures. It must be recognized that the cystoscope is an instrument for treatment as well as for diagnosis.

I do not recognize any definite peculiarity in the pyelograms in pyelitis which seem to me infallible for determining from pyelogram alone whether the pelvis of the kidney is the seat of infection. In some instances there is broadening of the calices in long-standing infections of the pelvis, but I have seen long-standing pyelitis where there is normal cupping of the calices of all portions of the pelvis.

Fig. 4. Ureterogram with catheter in the ureter demonstrating a uric acid stone in the ureter. The stone appears as a rarefied area in the injection fluid.

Urologists now are on the watch to recognize mixed infections with pyelitis symptoms in which the kidney shows a true pyelitis and, in addition, cortical sepsis with abscess formation. These cases, on pathological examination, show the abscess to be due to pyogenic types of bacteria and not to B. coli. We have studied the so-called "hematogenous kidney" pyelograms to determine whether it is possible to recognize abscesses in the cortex or the pyramids of the kidney. The result has not been totally satisfactory. It is possible, however, to recognize in some cases definite areas in which the injection material in the neighborhood of the calices is either flattened or extends into the cortical substance. These abnormalities have been proved to be the sites of abscesses usually situated in the pyramids. I believe in great measure the success of pyelography in these cases outside of the line of the calices above referred to. Irregular granular calcification in the kidney should lead one to suspect tuberculosis in these cases. There is an occasional cortical stone formed within the substance of the kidney, often in a malformed pelvis or calyx, which must be differentiated because it lies outside the

FIG. 5. Pyelogram of a kidney with the catheter in place. Kinking is almost entirely absent. There is a suggestion of an irregularity at the junction of the pelvis and ureter. In this instance the stiff ureter catheter has almost completely obliterated the kinks in the ureter.

FIG. 6. The same case as that shown in Figure 5, showing kinking of the ureter on full inspiration. This kidney has definite stasis as determined by cystoscopy.

depends on one of two things; either upon the presence of an abscess cavity which can be filled with injection material, or a swollen papilla which encroaches upon and flattens the neighboring calyx. These areas of necessity lie in a portion of the kidney outside of a line including the tips of the calices, when seen in the pyelogram.

In tuberculosis actual calcification of a portion or the whole kidney may show in the roentgenogram. Most tubercular kidneys do not have calcification. In those the pyelogram is apt to be of help in diagnosis by showing irregular extensions of the injection material into the kidney line of the calices. Usually differentiation is easy because of the clean-cut dense shadow which the stone shows. In perinephritic abscess, if large, the pyelogram may be of help, although usually it is not needed. A normal kidney pelvis and ureter will be pushed either toward or away from the midline by the mass of pus near the kidney.

STASIS

We believe that something can be gained in our conception of pelvic dilatations by classification of stasis into four types, namely, acute stasis, subacute stasis, intermittent stasis and what, for want of a better term, I shall refer to as relative stasis. Acute stasis means acute obstruction to the outflow of urine from the kidney from swelling, as in severe pyelonephritis, obstruction from a stone passing down the ureter or, not uncommonly, from a blood clot which fills the ureter and pelvis. These cases are more apt to be seen by the urologist than the roentgenologist because they are in the nature of emergencies. The important thing to be considered is, however, that the obstruction is acute and if relieved, results in no damage to the kidney. The second form of obstruction is that of weeks' or months' duration, due to obstruction to the outflow of urine from the kidney from obstruction to the ureter. The commonest form of this obstruction is renal back pressure in pregnancy and slow-moving stone. The urologist recognizes in these types of obstruction a condition which if relieved is apt to be followed by a return of the kidney to almost if not completely its previous condition. For example, a pyelitis of pregnancy with a 350 c.c. pelvic capacity determined during the pregnancy, is apt at the termination of pregnancy to decrease to 15 c.c. or even to normal.

The third type, intermittent stasis, is perhaps commonest and most difficult to diagnose. The usual occurrence is in the sagging kidney. The amount of damage which results to the kidney is not great. Dilatation takes place, but occurs slowly because obstruction does not persist throughout the twenty-four hours. Recognition of this type of obstruction depends chiefly upon the cystoscope to demonstrate stasis, and upon the pyelogram to show what is the nature of the obstruction. Inasmuch as these cases are accompanied by slow dilatation of the pelvis with persistence of pelvic and ureteral peristalsis, they are not often large, but can be considered to account for a great number of the painful kidneys. These pelves may or may not be the seat of pyelitis in addition. By correction of these we may both relieve pain, and cure long-standing infections. I feel like repeating the statement which I have already made, that because a kidney is low and the course of its ureter is not straight, that kidney must not be considered to have stasis until it is proved so through cystoscopy. Another type of intermittent stasis in the kidney is that in which there is a ball-valve stone which drops into the ureteral orifice for a time, and becomes dislodged, only to drop back again at a later date. The fourth type of stasis, which we call relative stasis, is not so clear in its explanation or etiology. By this term I refer to those kidneys which apparently show little or no effects of back pressure through flattening of pyramids, yet in which the pelvis and the whole of the ureter as well as the ureteral orifice are dilated. This dilatation is, as far as I know, totally unexplained. Unless the kidneys are infected the symptoms are negative. When infection takes place they are difficult and unsatisfactory to treat.

GENERAL CONSIDERATIONS IN THE PRODUCTION OF GOOD ROENTGENOLOGICAL RESULTS

There are certain pitfalls to diagnosis, both from the point of view of the urologist and the roentgenologist. The common ones you all recognize and they need not be mentioned here. There are a few general points which I wish to mention because of their bearing on diagnosis of renal conditions.

One of these is frequent bilateral dilatation of kidneys or hydronephrosis where only one kidney gives symptoms. So common has been this finding since the introduction of bilateral pyelography as a routine at the Massachusetts General Hospital, that the urologist hesitates to do radical operations on a kidney for hydronephrosis without bilateral pyelography. The probable reason for this is that conditions which produce hydronephrosis on one side, whether congenital or acquired, are apt to be reproduced on the other side. In many instances the acutely painful kidney is the smaller of these hydronephroses and is apt to be the one which is undergoing a dilatation similar to the spreading hernia ring, and is painful. The other one, which has dilated to such an extent that peristalses are lost, does not produce pain at all.

Another point is that from examination of a great number of roentgenograms, I expect to find that there is a similarity of design and arrangement of calices of the pelvis in the two kidneys. I mean by that, that if one kidney has an extrarenal type of pelvis, the other probably has an extrarenal type also, or a bilateral intrarenal pelvic combination exists. I do not remember having seen an intrarenal pelvis on one side and an extrarenal pelvis on the other.

I have already mentioned the significance of the failure of a kidney shadow to appear in a good plate. If a kidney shadow is persistently absent in clear plates, one of four possibilities must be suspected: nephrectomy, congenitally small kidney, congenitally malposed kidney or hydronephrosis. The hydronephrotic kidney is particularly apt to show indistinctly or not at all, because the cortical substance is extremely thin as a result of prolonged back pressure.

I have already referred on several occasions to the value of the cystoscopic estimation of capacity of the pelvis. This is simply done and has a bearing on diagnosis. Hydronephrosis and congenitally small kidneys are easily recognized.

In addition, it is possible to recognize stasis in these cases of sagging kidneys already mentioned, by determining whether or not the pelvis is filled to capacity at the time cystoscopy is done. A small kidney pelvis of 15–20 c.c. capacity when full to its capacity at the time of cystoscopy, is just as definite an instance of stasis as when a large hydronephrosis is found with many times the same amount of urine in it.

Where double ureters exist and enter the bladder it seems to be a rule that the lower orifice, as seen by the cystoscope, enters the upper pelvis of the kidney and the upper orifice in the bladder connects with the lower pelvis in the kidney. In instances in which a small pelvis is seen to occupy a half of a normal-sized kidney shadow, and in which one ureter is found entering the bladder, the roentgenologist is entitled to ask the urologist for an ureteral injection, because it is probable that a Y ureter exists, only one branch of which has been catheterized.

In gastrointestinal roentgenograms instances are found in which no definite kidney shadow is seen, but in which the intestines full of bismuth seem to be pushed well away from the kidney region. One should suspect large hydronephrosis in these cases.

Occasionally the persistent presence of gas in the intestines over one kidney region will give a lead as to renal pathology. In inflamed condition of the kidney the persistence of gas over the affected area on repeated examinations is sometimes seen.

It is unsafe to consider a pyelogram negative for kinking of the ureter when the pyelogram is made with a stiff catheter passed into the pelvis of the kidney. A stiff catheter will straighten out kinks in some instances to such an extent that they will be hardly recognizable. If a portion of the injection fluid is withdrawn from the pelvis and the catheter pulled down to the brim of the bony pelvis the ureter can then be injected and any kinks demonstrated. Ureterograms for the demonstration of kinks should be taken with the kidney in complete downward excursion produced by a full inspiration, or by standing the patient upright. The ureter catheter is obstructed in the ureter by kink as well as by stone. The cystoscopist suspects kink in those cases in which the ureter catheter is gradually moved by manipulation through certain portions of the ureter.

Reports from the roentgenologist to the general practitioner as to the normal appearance of pyelogram in the sagging kidneys should be given out with some hesitation when the symptoms for which the examination was made are pain or infection. In these cases cystoscopic evidence of the presence or absence of stasis is necessary for diagnosis.

Ureterograms are made with less discomfort to the patient if the pelvis is emptied of fluid by suction before the catheter is drawn down into the ureter. The ureter can then be injected without overdistention of the pelvis.

I have not had experience with pneumoperitoneum and air injection of the pelvis and ureter in renal investigations, sufficient to allow me to discuss their value. The error of diagnosis in renal conditions under the procedures by which we work is less than 2 per cent.

SERIAL ROENTGENOGRAPHIC OBSERVATIONS OF CHRONIC PULMONARY TUBERCULOSIS*

BY J. BURNS AMBERSON, JR., M.D.

Loomis Sanatorium

LOOMIS, NEW YORK

TODAY the roentgen ray is an indispensable aid and guide in the intelligent study, diagnosis and management of pulmonary tuberculosis. This is a truism, but many repetitions will be required before an unjustified though much too prevalent skepticism will give way to its unanimous recognition. It is proper occasionally to take time to appraise the various modes of examination at our disposal, but it is fruitless to enter into hairsplitting debates on the relative merits, for instance, of two such diverse methods as auscultation and roentgenography; it is much more profitable to appreciate their interdependability. Once we have acquired a clear conception of the limitations of roentgen-ray findings, the distinctly unique advantages of these findings, and their wide applicability as a supplement to other clinical, physical and laboratory data, we shall have surely struck the path of progress. There is much to be said about roentgenography and roentgenoscopy in the early diagnosis and the differential diagnosis of pulmonary tuberculosis, but this discussion will be confined to a consideration of structural changes in established lesions and of certain inferences that can be drawn from the observation by serial roentgenograms of these changes. There is no problem which roentgenologist and clinician can attack jointly to greater mutual profit. The phases of the problem are manifold. It is of utmost interest simply to trace the evolution of the tuberculous lesion through its varying periods of progression and retrogression; such a study alone divulges much information that the pathologist for generations longed for but did not find. But it is even of more value to correlate anatomical mutations with clinical symptoms. If the day comes—and I believe it will—when we can state with a fair degree of accuracy what clinical manifestations should accompany a given anatomical change, we shall have gone a long way toward surmounting obstacles that now beset our course. If it is admitted that cellular as well as humoral reactions play their part in tuberculo-immunity, it becomes self-evident that the roentgen ray must play an essential rôle in depicting gross anatomical alterations that accompany the ebb and flow of that ill-defined element called resistance. Tuberculosis most often attacks the lungs and, fortunately, it is here that a combination of physical properties enables us to study anatomical reactions more closely than in any other body tissue.

At the Loomis Sanatorium our investigations of structural changes in the lesions of pulmonary tuberculosis have thus far been to us most fruitful. The field is vast, and should tempt the roentgenologist to join hands with the clinician in further research.

In the present stage of our knowledge it will serve no purpose to speculate on the roentgenographic characteristics of pulmonary tuberculosis in its true incipiency. Certainly there is a transitional stage between a slight lymph-node involvement and gross parenchymatous lesion, in which stage the roentgenogram cannot be expected to decide whether or not there exists the beginning of clinical disease; it never will decide, because the truly incipient change is microscopic. Passing, therefore, to the definitely recognizable early parenchymatous lesion, certain characteristic shadows present themselves. The appearance is variously described as mottling, cirrose clouding or cotton ball shadow. Its center is its densest part, and its periphery is hazy and indefinite, shading off imperceptibly into normal lung markings; the peripheral haze may be narrow or it may extend through a wide

* Read before the New England Roentgen Ray Society, Boston, Mass., March 11, 1922.

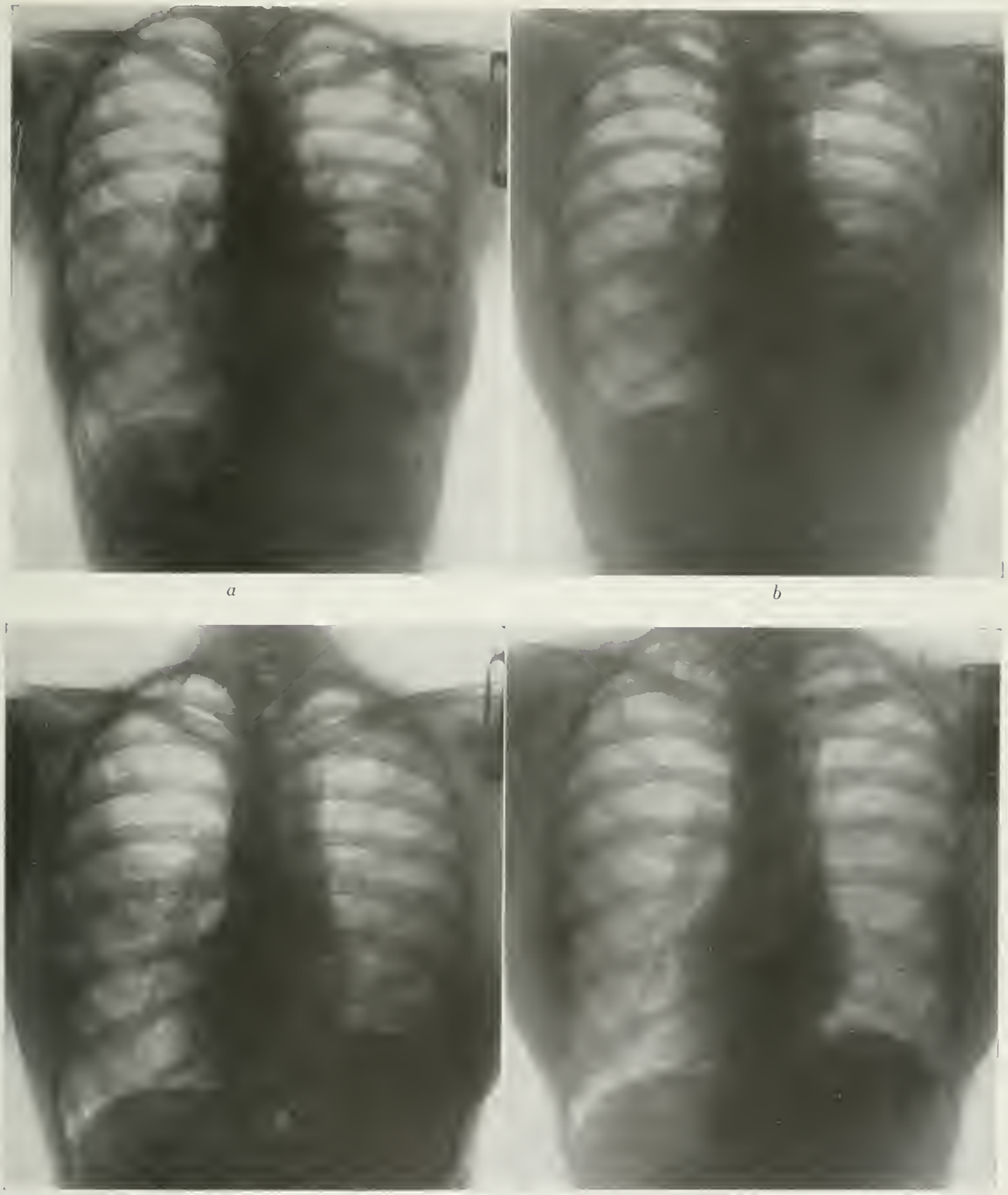
area. These are the fundamental earmarks of the conglomerate tubercle with its collateral inflammation. I would stress collateral inflammation because it is usually the unique accompaniment of tubercle that is chronic.

Here we may pause to establish clearly in our minds the concept that chronic tuberculosis of the adult represents disease developing, not in virgin soil, but in a soil the reactions of which are altered by some previous sensitizing dose or doses of bacilli. Moderate or massive infection of an experimental animal that has previously developed a relative immunity through a nonlethal dose of bacilli is always attended by a rapid inflammatory reaction characterized by more or less grave constitutional symptoms and the pouring out of inflammatory products—cells, serum and fibrin—about the focus of infection. Krause has repeatedly emphasized that this response is not elicited by a moderate initial infection of a healthy animal; it is distinctly a response of allergic tissue. In the human adult the exudative reaction has been variously described as collateral inflammation, perifocal pneumonia and collateral hyperemia; the term collateral inflammation or perifocal inflammation is preferable because the reaction is not specifically pulmonary, but occurs wherever the bacillus is implanted in allergic tissue. This is the reaction that underlies the perifocal or collateral haziness in the roentgenogram. On the basis of this concept it is readily understood why the haziness may be of greater or less extent, varying with the intensity of the allergic response.

In this early stage there may appear changes in distant structures, notably the hilum. Its outline may become indistinct and hazy and accentuated trunks may lead to it from the pathological focus. This is to be explained by the fact that the hilum is the point of confluence of the pulmonary lymphatics and its lymph-nodes react with the same perifocal inflammation as they filter out the products of disease that surely drain through them. Our previous studies have indicated that the hilum is often a dependable index of the state of activity of the pulmonary process; as this process advances the hilum becomes progressively more puffed up and indefinite in outline, and as healing follows, the structure regains much of its original contour and sharpness of definition. The process is more striking when the mottling has not encroached upon the hilum.

In the literature and elsewhere much discussion centers on the diagnosis of activity of pulmonary tuberculosis by means of the roentgenogram. From a single observation one can often offer the opinion, "disease probably active or recently active" or "disease probably stationary or retrogressive," but for him who from such an observation positively diagnoses activity or inactivity there lies ahead an inevitable and humiliating disillusionment. From the roentgenographic point of view there is only one sure criterion of activity, and that is the demonstration by serial roentgenograms of an actual progression of the pulmonary mottling with or without increased rarefaction, interpreted as advancing cavitation. To be sure, this is merely an anatomical change, but I have never seen such a change without clinical manifestations. If we could be absolutely sure that all technical and physical factors were constant, it would be possible to depend on an increase in perifocal haziness as an indication of focal activity, but without this condition such a criterion can be deceptive.

Progressive destruction by chronic pulmonary tuberculosis consists in an increase and a coalescence of the mottling, advancing usually from apex toward base and from periphery toward hilum. Increasing density implies caseation with or without fibrosis, and in chronic progressive disease it is usually only a question of time until the dense shadows of caseation acquire a moth-eaten appearance implying beginning cavitation. These small areas of rarefaction gradually merge with one another, forming one or more large cavities. The older the cavity, the cleaner and less ragged it looks, and the more likely it is to assume the form of a sphere or a closely allied geometrical figure. Rarefaction typically begins in an upper lobe near the periphery and, like mottling, advances downward and inward. Destruction may be slow, when it is almost always associated with progressive fibrosis,



a *b* *c* *d*

Fig. 1. Time interval between *a* and *b*, 5 months; between *b* and *c*, 9.5 months; between *c* and *d*, 24.2 months; total, 38.7 months.

(*a*) Heavy infiltration, mostly perihilar in lower half of right lung; lighter infiltration on left. Patient had symptoms of active tuberculosis, including fever; sputum, 136 grams daily; numerous tubercle bacilli present. (*b*) Process more marked in both lungs with possibility of small pleural effusion on right. Between *a* and *b* symptoms of activity persisted with gradually lessening severity; tubercle bacilli still present in sputum. (*c*) Clearing of mottling with pleural thickening and beginning fibrosis on right. Symptoms between *b* and *c* improved uninterruptedly; sputum scant; tubercle bacilli disappeared from sputum two months before roentgenogram *c* was made. (*d*) Continued anatomical repair; remarkable clearing with restoration of definite hilum outline and only a few residual deposits in the lungs. Patient remained well; occasional scanty morning sputum, negative for tubercle bacilli.

or it may be rapid, when fibrosis is not demonstrable, mottling is densely confluent, collateral haziness is heavy and rarefaction is multiple, thin-walled and ragged. In the rapid type, the patient usually is overwhelmed by toxemia and dies with considerable intact lung tissue; with slowly progressive disease and less toxemia life may last when the roentgenogram reveals surprisingly little sound tissue. In the latter type, as might be expected, the patient may suffer severe dyspnea in spite of feeling otherwise fairly well. With progressive mottling without rarefaction the sputum is usually scant and may be negative for tubercle bacilli for months; when rarefaction of previously dense mottling appears and progresses the sputum increases in quantity and tubercle bacilli are almost always found. In both instances symptoms of toxemia sooner or later appear in definite form. Anatomical repair may become initiated at any stage of the disease, but is less likely to ensue when serial roentgenograms demonstrate the rapidly destructive lesions described above.

The first phase of repair is clearing of mottling; and by this is meant the disappearance of perifocal inflammation. The explanation has its basis in the concept of allergic reaction to which we have already referred. In the experimental animal that survives the initial exudative reaction following infection, the anatomical products of inflammation disappear, a sharply defined tubercle appears and the animal passes into a chronic, slowly progressive type of disease. In the lung of the human relatively immune adult, therefore, it is to be anticipated that repair will start with a similar resorption of perifocal inflammation to be detected roentgenographically by a clearing of perifocal haziness. In some cases this clearing can be discerned within a period of three or four weeks, and in many it is quite pronounced at the expiration of two or three months. Shadows, the outlines of which seemed previously to be obscured by a more or less dense fog, now stand out clearly as if the fog had been blown away. In many instances the conglomerate tubercles appear with such clarity that

a b

FIG. 2. Time interval between *a* and *b*, 13.7 months.
(*a*) Moderate disseminated infiltration of right lung, most marked about the hilum; light perihilar deposits on left. Patient recovering from recent symptoms of active tuberculosis including hemoptyses and fever; sputum, 41 grams daily; numerous tubercle bacilli present. (*b*) Clearing of mottling with restoration of definite hilum outline. Patient free of symptoms except for scant expectoration; tubercle bacilli absent for 7 months.

they can be counted under the stereoscope. Haziness, clouding and poor definition give way to discreteness, compactness and discernible delimitation. If there is no complicating involvement, tuberculous or nontuberculous, of any other organ or tissue, the patient practically always shows clinical improvement with gain in weight, lessened toxemia and decreasing cough and expectoration. The presence of cavitation longer be described as mottling or cirrose clouding, but its characteristics are probably best conveyed in the term discrete uneven clouding. Occasionally one loses all trace of the shrinking tubercle; from the roentgenographic point of view it has been entirely resorbed. But it is a rare tubercle that does not leave behind some slight vestige in the form of a little uneven clouding with or without a thin, sharp, dense

a *b*

Fig. 3. Time interval between *a* and *b*, 12 months.

(*a*) Heavy infiltration upper part of right lung; limited below by band of fibrosis, partly interlobar. Vague constitutional symptoms including malaise and malnutrition; no sputum (tubercle bacilli present in sputum 4 months previously). (*b*) Clearing of mottling with upward contraction of the affected region, secondary to fibrosis; deflection of mediastinum. Progressive improvement in constitutional condition; no local symptoms, except for slight dyspnea on exertion.

may alter conditions considerably, and of this I shall speak presently.

Once the perifocal haziness has cleared, we assume that the residual shadow represents the conglomerate tubercle proper, divested of its initial enveloping inflammation, and that healing from this stage proceeds by the deposit of fibrous tissue. Within two to six months this deposit can often be found in serial roentgenograms. Gradually, through the next one or two years the individual conglomerations are seen to shrink and their granular texture is replaced by a homogeneous cloud with sharply defined edges. The shadow can no line extending from it to the hilum. At this point the markings may be permanent; I have observed these fibrotic densities unchanged after a lapse of eight years.

If there is one roentgenographic feature of healing pulmonary tuberculosis more prominent than another it is localization. Often a series of pictures will vividly portray nature's effort to seal off from sound tissue the pathological focus. Along the course of fuzzy, poorly defined, accentuated trunks radiating from the hilum this change can best be traced. Slowly the trunks become more compact and sharply defined until they are transformed into wiry rays most prominent at the lower border of the upper lobe lesion. Coincidentally a network of tangled striations becomes interwoven with these fibrotic trunks, and over all a light cloud of diffuse fibrosis is thrown. If healing continues from this point, contraction of the lesion is inevitable, and it is not uncommon to see the process sharply confined above the first or second intercostal space where, one or two years previously, its ill-defined lower margins reached the third or fourth.

The presence of cavity in the healing lesions influences conditions anatomically and clinically. It has been indicated that, beyond certain limits, the older the cavity the less ragged and the better formed it is, implying, of course, that its wall is more or less fibrotic. The progress of excavation is retarded only when the roentgenogram shows the formation of enveloping fibrosis. Otherwise, it usually continues in its course of unbridled destruction. Caught in the meshes of striations described above and overlain with fibrotic cloud, the cavity usually shrinks, and occasionally it becomes completely obliterated. Even as shrinkage proceeds there may be a coalescence of multiple areas of rarefaction, and we visualize a twofold healing process, a cleaning within and a contraction without. As might be expected, contraction of cavity is not seen until fibrosis is fairly well developed; consequently it requires a long time.

Healing by fibrosis of the lesion in which cavitation cannot be diagnosed in the roentgenogram always is accompanied by improvement in the clinical condition, provided other complications do not interfere. Weight is gained, temperature and pulse become stabilized, cough and expectoration disappear and tubercle bacilli, if they have been present in the sputum, are usually no longer demonstrable. From this class come the bulk of the patients who are discharged from treatment with "disease arrested." When a solitary cavity becomes obliterated similar symptomatic improvement can be expected. But when cavity persists, even though contracted, conditions are usually altered; constitutional improvement may be marked, but in a majority of instances expectoration, though reduced in quantity, will continue to appear and it will be positive for tubercle bacilli. To such patients we often say, "Your disease is quiescent and healing, but for years to come, perhaps for the remainder of your life, you will likely have a little sputum containing tubercle bacilli." There is also an extra hazard in such cases in the liability to small or large hemoptyses, often resulting in a bronchogenic dissemination of the disease with fatal issue. Aside from this potential danger it must be remembered that persisting cavity is usually a constant source of bacilli-laden exudate, capable at any time of infecting other parts of the lungs and possibly responsible for more remote complications such as laryngeal and intestinal tuberculosis. As a matter of fact, our serial roentgenographic studies indicate that tuberculous complications are by all odds most frequent where infiltration with cavitation is progressive. They are less frequent in the cases showing progressive healing of the pulmonary lesion, but an outstanding observation is that complications in this group are more likely to occur where cavitation remains patent even though partially contracted.

Little need be said about calcificaton, because it plays only a small part in the healing of chronic pulmonary tuberculosis of adults. Opie, in his recent work, has considered caseation or calcification within the lung accompanied by similar deposits in the regional lymph-nodes as presumable evidence of primary focal tuberculosis of childhood, and he apparently believes that calcareous infiltration of the regional lymph-nodes never plays a part in the secondary disease of later life. Our observations substantially corroborate his latter view, although there is an occasional exception. In a very few adult cases I have seen what appeared to be the development of a small calcareous deposit at the hilum where there were also pre-existing similar deposits. There are many more instances where a pre-existing calcific nodule shows in the roentgenogram only after a heavy perifocal haziness has cleared away, and unless caution is practiced it may be erroneously considered as having a part in the current healing process. In our cases—even in those observed over periods of six or seven years—progressive healing by calcification in any part of the lung has seldom been demonstrated. For practical purposes, therefore, calcification participates to a slight extent or not at all in the repair of this type of disease, and it will be a profitless task for any roentgenologist to look through a series of pictures with the hope of discovering such tangible effects of calcium medication. There may be some other rational indication for such therapeusis, but it apparently cannot be founded on the supposition that the mineral salts usually densely infiltrate the caseous focus as they do in puerile tuberculosis.

Tuberculosis is a chronic relapsing disease. The assertion is trite, but for this very reason the phenomenon is baffling. Serial roentgenograms testify as eloquently as anything else to this fact and, a l too often, we see strikingly portrayed the thwarting of nature's devices to save the lung from destruction. At any stage, a picture of progressive repair may be transformed into one of unchecked devastation. The pathologist has shown that firm and relatively intact scar tissue may become thickly infiltrated with tubercles, and it is in this circumstance that we find the explanation for many roentgenographic mutations. Not uncommonly the dense, contracted shadow of fibrosis relaxes and melts down, perifocal inflammation again asserts itself, apparently obliterated cavities reopen and new areas of rarefaction appear to render the prognosis more gloomy. Again, the advance of the disease may be halted by reinforced anatomical repair, and another longer or shorter respite ensues. So we can graphically trace the alternating sway of opposing forces, meanwhile wondering all the more about the underlying cause of this most mystifying feature of the d sease.

With the interchange of anatomical progression and retrogression goes a corresponding fluctuation of clinical symptoms. Were it possible to express serial roentgenray findings in the terms of a geometrical curve, we would find the undulations of the roentgen-ray curve closely paralleling those of the toxemic curve. And if it is ever possible to construct a dependable serological curve, it is certain that, from the three, valuable conclusions will be drawn.

No mention has been made of extrapulmonary changes. These are often mechanical and self-explanatory. One apparently reflex phenomenon that may be noted in passing is the unilateral inhibition of the diaphragm. This fixation commonly fluctuates with the intensity of the inflammatory reaction within the lung or pleura; when perifocal haziness is heavy, diaphragmatic inhibition is maximum; when c earing is observed, normal position is approached or entirely regained.

Pleural annular shadows are most interesting. At the Trudeau Sanatorium they were observed in 11.8 per cent of 423 cases; at the Loomis Sanatorium I have seen them in as many as 20 out of 100 consecutive cases. Formerly they were not distinguished from cavity, but today we feel reasonably certain that they are an entirely different thing. By some they are thought to be due to small localized pneumothoraces secondary to rupture of the visceral pleura, but for reasons outlined elsewhere* I have been led to the belief that the underlying lesion is a simple localized pleurisy with or without separation of the pleural layers; in the latter event a small effusion is often present. In many instances, especially if the shadow is situated in one of the interlobar fissures, it is impossible to state definitely whether the appearance is that of a cavity or something else. Serial roentgenograms often decide the question. When a sizable annular shadow disappears in the space of a few weeks, and there is no increased mottling or clouding, it certainly was not a cavity. Likewise, when the shadow rapidly enlarges without the rarefaction of surrounding confluent mottling, and without an increase in the patient's sputum, it is fairly safe to say that it is not a cavity. The rapid fluctuations in size are the most striking characteristics. Our recent investigation indicates that the shadows increase in size when the underlying pulmonary lesion is active, and decrease and disappear when such lesion becomes retrogressive. I shall not discuss the phenomenon at further length

* *Amer. Rev. Tuberc.*, Nov., 1921, v. 723.

except to express the hope that roentgenologists will look for these shadows and follow them to autopsy where their exact nature will finally be established. On first thought it may appear strange that postmortem studies have not already been sufficiently elaborate to decide the point; the explanation is that the structure will be entirely destroyed or overlooked in removing the lungs and tearing adhesions unless the pathologist makes a careful examination *in situ* of the area involved. The shadows appear most distinctly where the disease is not dense and extensive; such cases, of course, are not often seen at autopsy.

In this review of anatomical mutations no effort has been made to consider the atypical and the unusual. Our studies are by no means completed; in fact, it will require much work before all the possibilities of serial roentgenography of pulmonary tuberculosis can be appreciated. I have attempted to indicate some of these possibilities in the hope that the method will be more widely applied. Certainly a serial roentgenographic record portrays structural changes in the living subject much better than any other means at our disposal. It is hardly necessary to point out that a current record of any kind is of far more value in a disease like chronic tuberculosis than one or two isolated observations. The distinctive advantage of current stereoscopic roentgenographic data resides in the fact that it is much more accurate than the only other method we have for following detailed structural changes; I refer to physical signs. Physical examination, essential as it may be, cannot possibly convey certain very definite impressions that we get from the roentgenogram. For instance, in some cases there may be little or no change in the character or extent of dulness, altered breathing and râles, while serial pictures show progressive clearing and a slowly developing tracery of fibrosis. In such cases, symptomatic observation may be even more definitely informative than physical signs. This need not depreciate physical signs; it merely emphasizes one of their limitations and, by contrast, demonstrates in greater relief certain superiorities as well as certain limitations of the roentgen ray. Inferentially, this brings up one of my original points; namely, that the methods should be employed to supplement one another. The roentgenologist who would study tuberculosis can no more detach himself from the clinician than the latter can get along without the roentgen ray. Cooperative endeavor is the master word. Tuberculosis will constitute a simpler problem once we amass sequential and correlated data established by methods of dependability. Roentgenography of tuberculosis, within its limitations, is dependable.

THE EFFECTS OF THE X-RAYS AND RADIUM ON THE BLOOD AND GENERAL HEALTH OF RADIOLOGISTS*

BY GEORGE E. PFAHLER, M.D.

Professor of Radiology, Graduate School of Medicine, University of Pennsylvania

PHILADELPHIA, PENNSYLVANIA

THE report of 5 deaths from aplastic anemia, due directly or indirectly to the radiations of radium or *x*-rays, is of deep personal interest to every radiologist. Even though these deaths are not fully accepted as being due directly to the radiations, still it has seemed to me advisable that we, as American radiologists, should take account of our present status. If we are in such danger, it is clearly evident that we must take sufficient additional precautions to avoid these accidents. Even if, as a whole, we are sufficiently protected and sufficiently cautious, there may be individual workers who are taking unnecessary risks.

If we are not running any such grave risks, we must not add further to the unjust prejudice against us on the part of life insurance companies, which is apt to form as a result of these reports. Some companies actually refuse to issue insurance to those engaged in radiological practice, because of the accidental deaths which have occurred in those who were exposed excessively in the early days of roentgenology, when the dangers were unknown, and the means of protection undeveloped.

The insurance companies should realize that they have not actually lost money because of these deaths. The development of every powerful agent for good leads to the sacrifice of some lives, but the saving and prolongation of other lives compensate a hundredfold for these losses. Some pioneers in radiology sacrificed their lives in the development of this branch of medical science, but I am sure I can say truthfully that for every death more than a thousand lives have been saved, and many thousand prolonged, because of the benefits which have come from the aid given in diagnosis and treatment. I believe no one will dispute this. Then the insurance companies have gained in actual cash, because of the prolongation of premium paying, and the prolonged use of the money invested. Therefore, instead of their prejudice, there should be an everlasting debt of gratitude.

Preceding these 5 cases referred to above, the deaths of radiologists from excessive radiation have been due to the development of malignant disease secondary to the chronic irritation of the skin. This skin irritation has been practically eliminated, or at least the means and knowledge are at hand to give protection against such effects. Those entering the field of roentgenology or radiation therapy during recent years should be free from all such effects. For this second reason, present-day prejudice of insurance companies against radiologists is unjustified.

As the amount of radium used in medical practice increases, and as the *x*-rays are being made more powerful, we may be facing new dangers. It is better that we investigate now.

The deaths of 3 workers at the Radium Institute of London have been attributed to their occupation. The first death[1] occurred in December, 1916, in a worker who was seen by several eminent specialists, and whose death was ascribed by them to pernicious anemia. The second death occurred in January, 1920, in a nurse, and was due to infective endocarditis, but it is admitted that the radium had unquestionably affected her, though it was not from this alone that she died. The third death occurred in February, 1921, in a man, aged forty-seven, and was due to acute pneumonia. Each case is claimed to have been due to a definite disease apart from the effects of radium, but the Institute Committee consider it highly probable that the work of these persons weakened the power of resistance to the diseases from which they suffered.

* Read at the Twenty-Third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Cal., Sept. 12–16, 1922.

Larkin[2] reports a fourth case in which the disease was ascribed to the effects of the *x*-rays. A male, aged forty-three, had been working at radiography for fifteen to eighteen years. He was of excellent physique, and for eighteen months had been putting on weight; his general health had never been better. His complexion had always been sallow, a fact which unfortunately masked the onset of the fatal anemia. In October, 1920, a blood examination, casually made, showed Reds, 4,200,000; Whites, 7,200; Hb., 85 per cent; Diff. L., 38 per cent; P., 60; E., 1.7 per cent. This was three months before he complained of symptoms, and five months before death. In January the patient's color changed to a lemon yellowish tinge, and he complained of dyspnea and loss of appetite. He still kept on working at high pressure, and refused to consult any one. On Feb. 4, 1921, however, he gave in. His temperature at this time was 100.6°F. at night, pulse 90. He had backache. Blood pressure was 110. Blood count now was Reds, 2,700,000; Whites, 1,600; Hb. 54 per cent, L., 76 per cent; P., 20 per cent; E., 3 per cent. This showed a serious drop in both red and white corpuscles and a complete inversion of the ordinary percentage relation of lymphocytes to polymorphonuclears. No poikilocytosis, no nucleated reds, and no variation in the size of the red cells were to be seen. Urine showed nothing. He had a hemic murmur, but no evidence of endocarditis. Bacteriological examination of the blood on two separate occasions gave negative results. He grew progressively worse and died March 21, 1921.

I am referring to this case in a little more detail because the radium cases have received a little more publicity, and some roentgenologists assume that only radium workers need be concerned. In this case there seems to have been no other associated disease. Dr. Larkin remarks that this radiographer had recently changed over from soft to hard tubes for the greater part of the work, and he warns us that the protection that we used for soft tubes is insufficient for hard tubes.

Foveau de Courmelles[3] refers to a fifth case, Dr. Emilio Tiraboschi, radiologist for fourteen years at the large hospital in Bergamo, making use of hard tubes without precautions, who died in January 1914, "in a state of profound anemia. At autopsy upon his body considerable changes were found in the blood, advanced glandular atrophy, and the well-known lesions of extreme exhaustion."

After the deaths in the Radium Institute in London, Dr. J. C. Mottram was appointed to make a special investigation[5] of the effects of radium on the staff of the institute. For a year he made examinations of the blood of every worker, from the superintendent down to the hall porters. He found definite changes in the red and white corpuscles, due to exposure to radium. He showed that radium workers are subject to widely different amounts of irradiation according to the period of exposure. Laboratory workers who prepare and measure applicators containing emanation and radium, and clinical workers who attach screens to the applicators and subsequently apply them to patients, are especially exposed. Other workers, down to the servants of the institution, are subject to only small quantities of the gamma radiation which pervades the whole building. The polymorphonuclear and lymphocytic blood count of radium workers was found decidedly lower than that of normal persons. As a result, an extremely thorough protective system has been established.[4,5]

On Aug. 3, 1920, before the Pathological Society of Great Britain and Ireland, Mottram[6] made a report of the red-cell blood content of those handling radium for therapeutic purposes. He gathered material from outside the institution as well, and found that clinical and laboratory workers present, on the whole, a diminution in the number of red cells as compared with the unexposed workers. However, they fell within normal limits with five exceptions, three male and two female clinical workers. The three males (4.15, 4.2 and 4.3 millions per c.mm.) are a little below the lowest male found by Bing[7] (4.4 millions). The two females (3.3 and 3.4) were, however, very much below Bing's lowest female (4 millions). The color index was high.

Mottram then refers to three fatal cases, accompanied by anemia, which have occurred among radium workers. Apparently two of these occurred in the Radium Institute, and are probably the same cases referred to above and reported by Pinch.[1] The third was a case occurring in France, (it may be the same as the case referred to by Foveau de Courmelles,[3]) or it may, possibly, be the sixth on record. "Case C., aged about fifty years, had worked with radium for ten years. Previous to this his blood presented some anomalies, notably a mast-cell leucocytosis. His illness was of short duration, and was diagnosed as aplastic pernicious anemia. No post-mortem examination was made.

"Reviewing these three cases, and taking into account the great rarity of aplastic pernicious anemia, it might reasonably be concluded that exposure to radium was the important etiological factor. When, however, the blood examinations of other workers is also taken into account, the above conclusion becomes hardly open to doubt. The anemia found was of exactly the same type, only less profound. Add to these facts the constant occurrence of a marked leukopenia, and a complete absence of signs of regeneration, and it is clear that the hematopoietic system of these workers is seriously damaged. The aplastic pernicious anemia found differs from the rare disease of young women in being accompanied by a leukopenia instead of a leucocytosis. In this respect it is similar to certain anemias produced by poisons, as for instance, trinitrotolnol."

A definite improvement in the blood picture was noted after the workers had been away from radium exposure for several months. Yet, it will be noted in the history of two of the fatal cases, that their symptoms developed after vacations of several months.

Experiments on animals[8] show that the bone-marrow is less affected by *x*-rays than are the lymphoid tissues. Warthin[9] found an inhibition of white cell productions and a preponderance of senile over young forms.

Regaud[10] says operators and attendants can protect themselves by forming the habit of: (1) Taking judicious advantage of the law of distance (especially through the use of special tongs in performing manipulations) and (2) interposing between the operator's body and any source of radiation leaden screens several cm. thick and impervious to penetrating rays. The few accidents that have occurred up to the present time have been the results of ignorance of the danger and lack of precautions.

Tuffier[11] collected information from various sources and found some complaints of cutaneous lesions, rarely menstrual disorders, azoospermia, and a reduction of polymorphonuclear elements and an increase of lymphocytes in the blood.

Portis,[12] in recording the result of blood studies made of a number of roentgen workers during a year, says, "There has not been a uniform blood picture. The majority, however, show a diminution of the total number of leucocytes which, in some cases, has been progressive. The lymphocytes were commonly relatively increased, and, at times, this was the most pronounced finding. A closer examination of the lymphocytes showed abnormal varieties described by some as unripe forms and by others as irritation forms. Myelocytes were found in three cases in small number. The red corpuscles and platelets were not affected, and the hemoglobin only slightly reduced.

Fortunately, the further investigations by Mottram[13] upon the effect of increased protection give us much encouragement. He says: "Increased protection has now been in operation for six months. As will be seen, this has resulted, with few exceptions, in a return of the blood conditions to normal." He gives a description of the methods of protection: "It is, however, not enough to provide protections; the workers must know how to take advantage of them. One has heard of a case of a nurse who was accustomed to carry radium each morning from one room to another. She suddenly developed a bad radium burn of the hand, which was accounted for by discovering that some days previously she had had a long conversation with a friend in the passage between the two rooms."

More recently Mottram[13] has collected 40 blood counts from healthy adults, 20 in radium workers and 18 in roentgen-ray workers, showing the lymphocytes and polynuclear distribution to be abnormally low, particularly in the radium workers. Observations should be made on workers before they are subjected to exposure and then periodic blood examinations should be made. Under these conditions a fall, followed by a sustained low level, would indicate that insufficient protection was being provided. The red cells are not as sensitive to radiation as are the leucocytes, so they make a less delicate indicator. For this reason an anemia must be looked upon as a grave departure from the normal and will indicate a serious overexposure. Red cells are diminished in numbers in radium workers although the color index is high, probably indicative of interference with the production of red cells and polynuclears in the bone-marrow; and observations on the bone-marrow of rats exposed to gamma rays are confirmatory. The penetrating gamma rays of radium react and injure the bone-marrow, whereas the less penetrating roentgen rays exhibit their effects chiefly upon lymphocytes and lymphoid tissues which are not protected by a covering of bone.

EXPERIMENTAL WORK

A considerable amount of experimental work has been done in the study of the effects of radium and *x*-rays upon the blood, especially by Russ[14,15,16] and his co-workers. In 1919, they showed that the lymphocytes in the blood of the rat are extremely vulnerable to small doses of *x*-rays. In his recent paper[16] he states that the cells are more delicate indicators of *x*-rays than is an ordinary *x*-ray plate; and then refers to the experiment which he believed demonstrated it. A rat, the blood-count of which had been taken, was exposed to *x*-rays for 1/40 of a second; 1 hour later a blood-count showed a reduction of 20 per cent in the number of lymphocytes. An *x*-ray plate was then placed in the position previously occupied by the rat and a similar exposure given. The plate, on development, showed no visible photographic action. A normal rat exposed for 12 seconds to *x*-rays, and examined 1 hour later, showed a reduction of about 50 per cent in the circulating lymphocytes; the time of exposure may be considerably increased or decreased without any appreciable change in this percentage. He then raises the question of the possibility of a group of sensitive lymphocytes which, when once destroyed, cannot be quickly replenished, and no further reduction occurs.

Taylor, Witherbee and Murphy[17] found that *x*-rays in large doses affect the lymphocytes before any of the other circulating cells. There is a sharp fall in the total number of circulating lymphocytes, which is complete forty-eight hours after treatment. Following the immediate decrease there is a primary rise, followed by another fall, which in turn is followed by a permanent rise of these cells to normal. Various animals were used in these experiments.

Levin[18] conducted experiments on the turtle and the normal frog, and found a marked reduction in the lymphocytes within twenty-four hours.

Leitch,[19] in a brilliant paper, makes a very timely criticism upon animal experiments and seems to have eliminated errors in his technique of handling the animals. He says: "We know that the numbers of lymphocytes in the blood vary within considerable limits from time to time, and even (a fact which is not generally appreciated) from hour to hour, but we can fix a maximum limit which they do not normally exceed. The compensating mechanism whereby this limit is kept has baffled explanation until quite recently. A few months ago, Bunting and Huston[20] showed that there is a continual loss of lymphocytes through the intestines. In sections they can be seen traversing the bowel epithelium, and they can be found in large numbers in the fluid contents. We may suppose that they discharge some digestive function in the lumen of the bowel, and that their numbers correspond with the local demands; indeed, it is probable that exceptional local stimuli induce unusually large emigrations of the lymphocytes from the blood-vessels into the contents of the gut. There are only two ways in which Russ's reduction can be explained; either the normal addition of new lymphocytes from the lymphatic channels is inhibited, or the loss through the intestines is increased. The latter seems to me to be the more probable occurrence. We need not invoke the supposititious differences of lymphocytes to explain the decrease.

"I may be allowed to say that the evidence in favor of a defence being set up by the lymphocytes in cancer is anything but conclusive; it is very questionable. Secondly, it is a risky thing to argue from one animal to another of a different species; the human being does not necessarily react in the same way as a rat. In order to settle this point we examined the blood of a few patients taken at random. The material for complete blood counts was taken immediately before, and again from one and a half to three and a half hours after the end of the *x*-ray sitting.

"It will be seen from the table that in the first three cases there was no diminution in the number of the lymphocytes; they had actually increased in the interval. The increase in the first two cases is of no moment; the differences in the figures are such as one would expect from random samplings; they are quite within the narrowest limits of experimental error. The blood-corpuscles are not so uniformly distributed that one drop contains exactly the same number as another drop; even if, by chance, we got the same numbers of white corpuscles in two drops we could not expect the same proportions between the different varieties of leucocytes; and, in actual practice, no two people would arrive exactly at the same figures if they examined the same preparations. We reckon on a certain amount of latitude. The third case shows a still greater increase in the lymphocytes, and the increase is beyond what we should usually allow for errors of random sampling. It is, however, quite a normal physiological variation, recognized as such by pathologists. The fourth case shows a diminution of lymphocytes, in spite of a total leucocytic increase, of no great degree, and is still a normal variation. In the last case it will be seen that, though the total number of leucocytes has increased, the lymphocytes have fallen by 26 per cent. This case might be cited as supporting Russ's thesis. Still, one swallow does not make a summer. It may quite well be a normal variation, but the following particulars are not without significance. The patient was a woman of fifty who had her breast removed four years before for cancer. She had no recurrence of the disease and had merely come to the hospital to report progress. She consented, after much persuasion, to allow me to examine her blood, and to undergo a few minutes' exposure to *x*-rays. So nervous was she that it required a nurse to hold her hand and another to hold her head while the drop or two of blood was being taken, and when she returned two hours after the *x*-ray application she was still trembling. If we dismiss the explanation that the decrease in lymphocytes in this instance was a normal variation, we cannot overlook the only other factor present in her case, and absent in the others, namely, fright. Everyone knows how fright or nervous excitement affects the intestinal apparatus, and it is very probable that under such stimuli the normal loss of lymphocytes by the intestines is correspondingly exaggerated. These few experiments are sufficient to show that Russ's conclusions, arrived at from experiments on rats, are not applicable to human beings." Note the following experiments on rats:

Treatment	Leucocytes			Lymphocytes		
	Before	After	Difference	Before	After	Difference
1. Lead screen interposed....	14,800	9,800	−34%	7,962	4,860	−39%
2. X-ray tube cut out.......	19,900	14,900	−25%	15,840	11,533	−28%
3. X-rays, 4 minutes.........	13,300	5,100	−62%	10,640	3,315	−69%
4. X-ray tube cut out.......	14,200	13,800	− 3%	8,350	3,616	−57%
5. Docile rat, tube cut out..	12,500	13,000	+ 4%	10,325	8,736	−15%
6. Nervous rat, *x*-rays, 2 minutes.........	22,000	9,500	−57%	16,544	6,593	−64%
7. Same rat as No. 5, *x*-rays, 2 minutes....	20,400	13,000	−33%	17,748	10,816	−39%
8. Same rat as No. 6 . .	8,800	0,000	+ 4%	7,286	3,021	−59%

BLOOD STUDIES OF AMERICAN RADIOLOGISTS

In November, 1921, at one of the regular meetings of the Philadelphia Roentgen Society, I proposed that we make a study of our blood. I was then appointed to make these investigations. I decided later to enlarge this plan and solicit the cooperation, if possible, of all radiological workers in America. A blank was prepared, with the cooperation of Dr. John Kolmer, Professor of Pathology, making the following queries:

CLINICAL RECORD FOR BLOOD STUDIES OF RADIOLOGISTS

Name. Age { Physician, Nurse, Technician
Address. { Stenographer, General Assistant
Name of laboratory.
Began work.

	Hours Each Day	Days per Week	Years
Amount of work			
Roentgentherapy			
Roentgenography			
Roentgenoscopy			

Amount of radium handled.
Do you prepare the specimens? How?
Do you apply the radium? How?
Describe your protection against the roentgen rays.
Describe your protection against radium.
What was your occupation previously?
Describe your general health before any exposure to rays.
Describe your general health or any present symptoms.
Mention any causes of present symptoms that occur to you.
Record blood pressure. S. D. PP.
Record any previous blood pressure tests.
Carry a dental film in your pocket for two weeks, marked with a lead number, and mail to me promptly in a tin box, without developing.
Record here the results of any blood examinations previously made.
Please have a blood examination made as follows at least two hours after previous meal.

	Date	Date	Date	Date
Total erythrocytes				
Total leucocytes				
Hemoglobin				
Differential leucocyte count				
Small lymphocytes				
Large lymphocytes				
Transitionals				
Polymorphonuclear				
Eosinophiles				
Basophiles				
Abnormal erythrocytes				
Abnormal leucocytes				
Blood clotting time				

Examined by
Remarks.

One thousand of these blanks were distributed in December, and by request several hundred more were sent out later. Yet only 338 were returned. Probably the most valuable contribution is that made by the medical director of one of our leading Radium Producing Companies. While he requests that his name be withheld, I take the liberty of quoting his "General Summary of Health Conditions in Radium Workers:"

"Since the establishment of the laboratories that have produced 85 gm. of radium (estimated to be upwards of 60 per cent of all the radium ever refined) there have been no deaths among the laboratory workers. One of the workers, with a continuous service of ten years, had lobar pneumonia in 1919 with a rapid and complete recovery. Another, also with ten years' continuous service, had a general infection (never positively diagnosed) with complete recovery. Five members of the staff, who have had constantly to handle radium tubes and needles, are suffering from radium effects on the thumb, index and middle fingers of both hands, produced in the very early history of the laboratory. Since the establishment of regulations that radium must be handled with instruments, this local condition has not progressed in any one of the cases.

"The general health of the laboratory workers is, I believe, above the average. Absence from duty on account of illness is very infrequent. During the 1918 epidemic of influenza, the entire staff escaped almost entirely, there being only one case.

"The general exposure at any one time has amounted to from 200 to 1,000 mgm. of radium in process of crystallization (emanation exposure), and from 100 to 2,000 mgm. of the finished product (gamma ray exposure). Members of the staff, represented in charts numbered 1, 2, 3, 4 and 5 have received the greatest amount of gamma radiation.

"The average blood count for members of the staff having had the greatest amount of exposure for a longer period than five years, is as follows:

R.B.C.	W.B.C.	Poly.
5,027,500	5,296	63.6 per cent

S. L.	L.L.	Trans.	Hemo.
12.6	22.3	2.5	94 per cent

Since this tabulation has been recorded, an additional count has been made which in no way differs from the individual counts recorded and tabulated.

"In addition to the above, one of the officers, not directly exposed to radium in the laboratories, has received during the past eight years, 90,450 mgm. hours of gamma ray exposure to a pathological lesion. Treatment consists in the use of from 50 to 200 mgm. of radium used either directly on or buried in the growth. This officer is at the present time in good health, and presents the following blood count:

R.B.C.	W.B.C.	Hemo.
4,250,000	6,200	90 per cent

The case is quoted as being, perhaps, the largest radium dose on record."

This report was based upon repeated blood studies which had been made independently during a year, and the study of the individual charts is most interesting. No. 1 and No. 2 had been exposed for ten years, had damaged fingers, and had been exposed to about 85 gm. of radium, yet the blood studies made four times during 1921 showed a normal condition. The lymphocytes were at the low normal level. No. 3, which had nearly the same amount of exposure, showed a variable condition, but in March, July and September there was a moderate leukopenia, and a distinct relative lymphocytosis.

Male—Age 35 years—Married—No children.
Continuous Service—10 years (absent during war period).
Amount Handled—70 gm.
Special Duties—Gamma ray measuring.
Visible Effects—None.
General Health—Very good. Never been ill.

Date	3 28 21	5 20 21	7 27 21	9/30/21	11/29/21
R.B.C.	4,980,000	5,080,000	4,810,000	5,730,000	5,790,000
W.B.C.	3,800	5,000	5,050	4,200	5,800
Poly	48%	68%	44%	54%	64%
S.L.	10	....	26	16	22
L.L.	40	32	28	24	12
Trans	....		1	4	2
Baso	2	...	1	2	....
Eosin	....	.....		....	....
Hemo	....	....		97%	85%

No. 4 showed a constant leukopenia, and a relative lymphocytosis. No. 5 was normal yet had been in service eight years, working at gamma ray measuring and tracing lost radium, and suffered with effect on fingers, (not progressive since radium is handled with instruments), yet the blood remained normal. Nos. 6 and 7 remained normal. No. 8 showed a relative decrease in polynuclears, and an increase in lymphocytes.

Male—Age 41—Single.
Continuous Service—1 year.
Special Duties—Emanation measuring (samples).
Amount Handled—Cannot estimate.
Visible Effects—None.
General Health—Good.

Date	3 28 21	4 25 21	7 27 21	9 30 21	11 29 21
R.B.C.	4,980,000	4,380,000	4,390,000	4,560,000	4,610,000
W.B.C.	9,200	5,650	6,430	7,000	4,450
Poly	40%	32%	50%	40%	. .
S.L.	8	16	6	18	.
L.L.	52	50	42	40	. .
Trans	.	2	2	.	.
Baso		.	....	2	
Eosin			... . .	....	....
Hemo		.	.. ...	90%	82%

No. 14 and 17 showed similar conditions. No. 17 was a stenographer and received only short exposures to large amounts of radium. No. 18 showed a marked leukopenia, and a relative lymphocytosis, and yet was only the porter, handled no radium, and his general health was good.

Male—Age 29—Married—4 children prior to radium work.
Continuous Service—6 months.
Special Duties—Porter of laboratories.
Amount Handled—None
Visible Effect—None.
General Health—Good.

R.B.C.	W.B.C.	Poly.	S.L.
6,210,000	3,450	34	14

L.L.	Trans.	Baso.	Myelo.	Eosin.	Hemo.
36	2	2	—	12	92%

Unfortunately none of these reports were accompanied by the dental films carried for two weeks.

DENTAL FILM VALUES

In order to form some idea of the relative amount of exposure that each worker got, I requested that each carry a dental film for two weeks. To get gradation values, I took the time necessary to produce an erythema dose, which with one of my machines requires 4 minutes (240 seconds) at 8 inches with a 9-inch spark gap and 5 ma. through 2 mm. Al. filter. At 80 inches' distance, this time becomes 2,400 seconds, according to the law of inverse squares. At this distance, exposure of ten of the standard (Eastman) dental films from 10 up to 100 seconds will show ten gradations from the faintest shadow to the darkest shade possible. Each of these shades will then measure from 1/2,400 to 10/2,400 of an erythema dose. In my own institute, of the 10 workers only 2 showed any fog, and these 2 who handled the radium and *x*-rays most, clinically, received in two weeks about 1/2,400 of an erythema dose.

The majority of the films sent in showed no more, but many were entirely black; and since the film will only record a certain maximum shade of blackness, these people are probably dangerously exposed. I would suggest that any one whose film, carried for two weeks, shows definite blackening, should increase the protection. This makes a simple practical test, which will give warning long before changes in the blood can be noted.

Among the other blanks returned were those of 175 physicians, 55 nurses, 62 technicians, 25 stenographers, and 16 general assistants. The stenographers were all normal, or at least had no symptoms or blood changes to suggest radiation effect. Therefore, the general radiation effect in our American laboratories can be ignored.

I found that the nurses, technicians, and general assistants all did more or less radiological work, and can therefore be classed together (159). Of this group there were only 10 which showed any abnormal symptoms, or blood change, or excessive exposure on the dental films. One of these showed 53 per cent lymphocytes, 38 per cent polymorphonuclears, and about 6,000 total leucocytes.

One of the correspondents remarks: "I am very well generally, much better in many ways than when I began *x*-ray work; but most of the time, after I leave the work for the day, I find myself completely exhausted, and it requires about nine hours' sleep to put me in good condition again. A peculiar thing about this feeling of exhaustion is, I do not notice it while around the *x*-rays. (She is supposed to have had Bright's disease preceding *x*-ray work.) She worked five and one-half days, five hours, at roentgenotherapy, for five and one-half years. Her blood was normal. Her film showed about $\frac{5}{24,000}$ of an erythema dose. One nurse noticed menstrual irregularity. Several showed an excess of exposure on the dental films.

The physicians showed most change, as might be expected. They do the fluoroscopic work, and most of the radium and roentgenotherapy. In general, they have been doing radiation work over a longer period and working more intensely. Those who work with radium or with the high voltage *x*-ray machines, showed an excess exposure on the dental films. I would therefore urge that these workers increase their protection until they can carry a dental film (face outward) for two weeks with little or no fogging.

The blood studies, if reduced to averages, would undoubtedly come entirely within the normal limits. In general, there is a tendency to a reduction in leucocytes, and a relative increase in lymphocytes, with a marked increase in eosinophiles, in a few cases. In most instances, these changes are only slightly beyond the normal limits, but when taken as a whole, and when compared with similar observations made by other authors, even though on a smaller scale, they are probably significant of excessive radiation and should be interpreted as danger signals.

The five worst blood records sent to me were as follows:

Total erythrocytes	4,900,000	5,080,000	5,140,000	5,210,000	4,600,000
Total leucocytes	5,900	4,400	8,100	7,200	6,600
Hemoglobin	95%	80%	100%	94	103
Differential leucocyte count:					
Small lymphocytes	31	42	42%	39	45
Large lymphocytes	14	7	1	8	....
Transitionals	5	1	1	0	2.5
Polymorphonuclear	42	48	52.5	52	49
Eosinophiles	8	2	3	0	2
Basophiles	....	....	5	1	1

All these have occurred in physicians who have been at the work only a comparatively short time. Four of the five had black dental films. The fifth had only a faint fog on his dental film. These blood changes may be caused by some other conditions than radiation, but if due to radiation, then we must conclude that some of the younger men are not giving as much attention to protection as are the older workers. It is indeed surprising to find the blood of the older radiologists in such good condition.

The Blood-Clotting Time. Accepting three to five minutes as the normal, there were only twelve reports of abnormal clotting time. These were respectively, 10, 7, 7, 9, 14½, 7½, 9½, 10, 7, 5, 7, 7, or a delayed clotting time in 3½ per cent. There was no abnormally rapid clotting reported. The one who had a nine minute clotting time had an eosinophilia of 12 per cent, for which he could give no cause. In other respects his general health and his blood were normal. The one who had a clotting time of fourteen and one-half minutes, had a systolic blood pressure 11 points below normal, but in all other respects he seemed to be normal.

Blood-Pressure. Accepting 120 mm. as normal for the age of twenty years, and adding 1 mm. for each two years above twenty as normal, there has been a general decrease in the systolic blood pressure. This has been the most constant abnormality found in these studies. The reduction varied from 5 to 38 points. In general there has been a reduction in systolic pressure of 10 to 15 points below normal. In only one marked case was there associated abnormal blood. In this one there was a 44 per cent lymphocytosis, and a 50 per cent polynuclear count, while the total leucocytes were 8,120. The low blood-pressure is too common to be ignored, but I believe that it is not caused by the radiation, because there are no other radiation effects corresponding, and it does not bear any relation to the amount of exposure, or the duration of service. It is most likely caused by the high tension electric effects.

General Symptoms. Only 11 out of 338 report any general symptoms which they attribute to, or which seem to be associated with, the occupation. This, it seems to me, is a fair percentage of health, and should not lead a diagnostician to attach great importance to the occupation as an etiological factor in general symptoms.

Sinusitis is reported by two. One simply says that the ozone from treatments irritates. The second reports "a steadily advancing pansinusitis (pyogenic) and a steadily decreasing resistance, sixteen carbuncles in 1920, thirteen abscesses in 1921, with loss of 'pep.' From a health viewpoint, I was considered A No. 1, until 1916—three years after entering *x*-ray work." Since then he has had several sinus operations and has quit *x*-ray work. He is recovering. It would seem unwise to attach much importance to the radiation in this case, since similar cases are not uncommon in people who are in no way exposed to the rays.

One physician reports a troublesome pruritis. Another reports duodenal ulcer, and says he knows of six radiologists who have duodenal ulcer.

Several report fatigue at the end of the day, and desire for a long night's rest. From my own experience and observance of other radiologists, all of whom work long hours and with great intensity, I am led to believe that a similar amount of work in any other line would probably cause similar fatigue. Though two or three seem to associate the fatigue with much roentgenotherapy, one associates it with much fluoroscopy, and lack of fresh air.

One radiologist reports as follows: "Four years ago, when commonly handling 500 mg. of radium, with lack of precautions, such as standing three to four hours daily near radium, unprotected, I found myself running an extremely low systolic B.P., 100 to 105. Three months later I developed what was diagnosed as degenerative changes in the heart wall. With this there came rapidly structural changes in the liver, phlebitis of severe type affecting both lower extremities. After treatment for six months I returned to guarded radium application, with complete recovery from all symptoms, including the myocardial. Blood: R. 5,100,000; W. 8,700; H. 85."

CONCLUSIONS

1. Undue exposure to the *x*-rays or radium is associated at times with a moderate leukopenia, a relative lymphocytosis, a relative polycynthemia, and occasionally an eosinophilia.

2. A low blood-pressure is quite common in radiological workers, which does not seem to be associated with any other definite symptoms.

3. The asthenia, sometimes noted, can probably be accounted for by strenuous work, caused by the great interest and also by the desire to meet the heavy "overhead" charges which must be carried by the radiologist. These symptoms are also

probably caused by close confinement, lack of fresh air, and lack of recreation.

4. The skin changes found in the earlier workers are not increasing, and are being avoided entirely by the younger ones, because of the increased knowledge and increased protection.

5. Complete protection can undoubtedly be obtained. It requires not only the means, but continual caution on the part of the individual.

6. Increased protection is needed by those who are working with the gamma rays, or with the higher voltage x-rays.

7. A dental film carried in the pocket for two weeks, will give a quick index of excessive exposure. If definitely fogged or blackened, protection should be increased.

8. Shortening the hours of work and increasing the amount of fresh air and recreation will probably remove symptoms, and prevent future trouble.

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CARCINOMA OF THE UTERUS WITH PREGNANCY INTERVENING TREATED SUCCESSFULLY BY RADIUM FOLLOWED BY DELIVERY OF A NORMAL CHILD*

BY C. EVERETT FIELD, M.D.

Radium Institute of New York

NEW YORK CITY

FEMALE, aged thirty-nine years, married. American born, of Irish and English parents. Mother luetic, died at seventy-four years of age of a chronic myocarditis. Father a sailor, died as a result of an accident at sea. Has one brother, well; no sisters. Has had diseases of childhood. Was married at nineteen years of age.

History of Pregnancies. First, at twenty, normal, and normal child now living. Second, at twenty-two, resulted in miscarriage. Third, at about thirty. In seventh month developed growth of inferior maxilla, which broke down leaving large scar. Child born blind, and died at age of two weeks of congenital disease. Fourth, normal, child normal, died at six months of marasmus. Fifth, resulted in stillbirth at fifth month. Pathological examination of fetus and placenta showed evidence of leus. Stillbirth occurred in May, 1914. Sixth: In view of the previous stillbirth, patient was advised a Wassermann test, but refused to have it made. She was therefore put on mixed treatment, and had normal pregnancy and childbirth. The child later developed marasmus, but was put on specific treatment, and is now normal. Was born May 15, 1917. As a result of this labor, there was considerable laceration with a great deal of induration. Patient was ordered to hospital for repair or amputation of cervix, but refused treatment. For a full year patient complained of a foul vaginal discharge.

Seventh pregnancy, normal to fourth month, when the present illness was ushered in on December 24, 1918, with a marked hemorrhage from vagina. The patient was found in a semi-comatose, pulseless, and serious condition. She had not menstruated in four months. Vaginal examination showed that the blood was not coming from within the uterus. The cervix was not dilated, but the fundus was the size of a four months' uterus. The cervix showed a cauliflower growth of the size of a large egg, and blood was coming from the edge of the cervix. Bleeding subsided and the patient was removed to a hospital, where a diagnosis of incomplete abortion was made, with the placenta in the cervix. The diagnosis was later changed to cancer of the cervix, and this was confirmed by two consultants. Cauterization was advised, but the patient refused it. She remained in the hospital about two weeks and went home. There was a continuation of the bleeding and she was later removed to a private hospital. After consultation, it was decided that surgical intervention would result in the death of both mother and child, and radium was resorted to.

The case was referred on March 1, 1919, by Dr. Lee Wilson Thomas of Brooklyn, to the Radium Institute of New York, under the author's service. Examination at this time showed the cervix to be the center of a cauliflower growth of about 7 cm. diameter, with an extension upward along the posterior wall of the uterus and along the anterior surface of the rectum. Pressure symptoms on the bladder were prominent, but there were no signs of malignant involvement. The patient was in a state of extreme exhaustion. The blood count showed red corpuscles 3,200,000; whites, 6,000.

Treatment. Radium application, March 3, 1919, consisted of 100 mgm. radium element introduced within the cervix (screen 1 mm. gold and brass; 0.5 mm. rubber) for a period of eight hours; crossfiring from a sacral pad containing 300 mgm., screened with $1\frac{1}{2}$ cm. felt, $1\frac{1}{2}$ mm. rubber and $\frac{1}{2}$

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

mm. metal, for a period of sixteen hours. The second radium treatment, instituted March 11th, consisted of a postcervical bomb of 140 mgm., screened with 1½ mm. brass and 1½ mm. hard rubber for eight hours. The third radiation, March 26, 1922, consisted of 100 mgm. radium element, standard screen applied within the cervix for six hours. The total radiation utilized consisted of 7,320 mgm. hours.

The clinical observation showed a control of all hemorrhage ten days following the first radiation, together with a marked general improvement in the patient's physical condition.

On April 12th, the patient reported for examination, about five weeks after the institution of the radium treatment. The malignant mass involving the cervix was practically gone and but a trace of the vaginal wall lesion was to be found.

Although all arrangements had been made to deliver the woman by an abdominal operation, the case proceeded uneventfully until April 26th, when a normal labor attended with but little pain, brought a four-pound girl baby. There was no serious hemorrhage or laceration. The patient returned home after two weeks and resumed her housework.

On September 14, 1919, she was returned to the Institute for treatment of a recurrence in the cervix. One treatment was given, consisting of 100 mgm. in the cervix for eight hours, and 125 mgm. packed against the cervix posteriorly for the same period. The patient apparently improved and kept at her duties until April, 1920, when she developed a metastasis in the liver and died June 17, 1920.

The child is now three years old, of a healthy and beautiful type.

THE TREATMENT OF BENIGN CONDITIONS OF THE PELVIS WITH RADIUM*

BY LEDA J. STACY, M.D.

Section on Medicine, Mayo Clinic

ROCHESTER, MINNESOTA

THE efficacy of radium in the treatment of operable carcinoma and myoma of the uterus is still a moot question. In reviewing the literature of the last two years on the treatment of benign tumors of the uterus, however, it is evident that radium is becoming more universally recognized as "an adjunct of surgery and not its competitor." The majority of writers recognize the fact that in certain groups of cases surgery is the more conservative treatment; for example, myomectomy in a woman under thirty-five with multiple fibromyomas; and even hysterectomy if necessary, as the function of the ovaries may be less disturbed by this than by repeated large doses of radium given to reduce the size of a large tumor. Again, in the young woman without demonstrable tumor of the uterus and with menorrhagia which has not been controlled by medical treatment or curettement, abdominal hysterotomy is indicated rather than radium. In such cases, a small intra-uterine fibromyoma or a polyp which has been missed by the curettement is often found, and its removal relieves the symptoms. Pregnancy may occur following the use of radium, but only in a small percentage of cases. In our series of 1,013 patients treated with radium in the Mayo Clinic since 1915, four women have each had a living child, three gave birth to dead fetuses, one had two miscarriages, and one was pregnant at the time of the report. In a series of 741 myomectomies, thirty-three women later raised one child and eleven raised two or more children.[7] Sterility following the use of radium may be due to two factors; the destruction of the graafian follicle by the

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radium rays, and connective tissue infiltration of the endometrium which interferes with implantation of the ovum.

FIBROMYOMAS

Most writers consider that tumors larger than a four months' pregnancy are best treated by surgery unless it is definitely contraindicated. A history of pelvic infection within three to four years, evidence of pelvic infection at the time of examination, and ovarian tumors are definite contraindications to the use of radium. Submucous fibromyomas presenting at the cervix and rapidly growing tumors of the uterus should be removed. The fact that carcinoma of the fundus may develop after radium application should be carefully considered in the subsequent course of these patients. Carcinoma has occurred in three of the series of 1,013 patients. I reported one case in 1920, and the other two have occurred since then. One was in a woman aged fifty-five years who came to the Clinic in March, 1920, complaining of irregular menstruation. She had had a Watkins-Wertheim's operation for prolapsus six and one-half years before. Because of the difficulty of performing hysterectomy fo lowing the interposition operation, it was thought advisable to use radium. One intra-uterine irradiation of 600 mgm. hours was given. Bleeding did not occur for six months, and then there was a return of the occasional bloody discharge without odor. In January, 1921, another treatment of 700 mgm. hours was given; this did not stop the bleeding. Five months later, another 700 mgm. hours of radium and roentgen-ray treatments over the abdomen were given. The patient returned in January, 1922, and said that she had had a great deal of lower abdominal pain, especially when she was on her feet, and bloody discharge occasionally. The uterus was large, firm and tender. Another series of deep roentgen-ray treatments was given, which did not entirely control the bloody discharge, and a month later hysterectomy was advised. At operation an extensive adenocarcinoma of the fundus was found. The third patient came to the Clinic in 1919 with a diagnosis of fibromyoma of the uterus. Her menstrual periods were irregular, but there was no unusual leukorrhea or metrorrhagia. The uterus was large and fibrous. The systolic blood pressure was 186, and diastolic, 120. One intra-uterine treatment of 500 mgm. hours of radium was given. The patient had two normal menstrual periods following this and then no discharge for two years when there was once a slight flow for a few hours, and a slight leukorrhea which she had "had always." Six months later, the leukorrhea became watery and occasionally bloody, and there was considerable low abdominal pain. This had continued for three weeks when she returned for examination in November, 1921. The uterus was then found to be about twice normal size, firm, and freely movable. A diagnosis of probable carcinoma of the fundus was made and abdominal hysterectomy advised. At operation, an extensive carcinoma of the fundus which had extended to the pelvic peritoneum was found. The malignancy was much more extensive than the history of the case indicated.

Radium may not have been an etiological factor in these three cases, but it should be taken into consideration in all cases of recurrence of bleeding after a period of one year or more of amenorrhea following radium treatment.

Delbert quotes Mornard as reporting 3 cases of particularly rapidly growing cancer developing after radium treatment, although he says that there is no basis for supposing that the radiotherapy was the cause of the cancer. He emphasizes the need, however, of careful diagnosis before radium treatment is instituted. Jacobs also reports instances of malignancy following the use of radium.

If the history is suggestive of malignancy, hysterectomy is advisable although the findings on curettement are negative.

Results from radium therapy given during the last two years at the Mayo Clinic are given in Table I. Between October 1, 1919 and July 1, 1921, 413 patients have been given intra-uterine radium treatments for menorrhagia and benign tumors of the uterus. Of the 305 who were aged thirty-eight years or more, 198 (96.59 per cent of those heard from) had

had cessation or lessening of profuse flow. Menstruation had ceased in 151 (64.25 per cent). Of the 108 who were less than thirty-eight years, 62 (91.17 per cent) had had cessation or lessening of profuse flow. Menstruation had ceased after treatment in 9 (13.23 per cent). Four patients had hysterectomy following radium treatment; one, eight months after treatment because of dysmenorrhea which had increased after the radium treatment; the second, sixteen months after treatment, with 363 mgm. hours, because of continued profuse flow and increase in size of the uterus. The third was operated on elsewhere thirteen months after treatment; the fourth two months after treatment, because of persistent menorrhagia.

ADENOMYOMAS

The location of adenomyomas or their adhesions to the surrounding structures are often such that removal may not only be difficult but may necessitate extensive dissection. This is particularly true if the tumor is in the rectovaginal septum or at the juncture of the fundus and the cervix. In this group of cases, radium has been of distinct value. Twenty-two cases of adenomyoma of the uterus have been treated at the Clinic since 1915. Pathologic diagnosis was made in 14. The youngest patient in the series was aged twenty-five years, the oldest fifty-two. Eleven patients have been heard from or recently re-examined. The tumors of 6 had definitely reduced in size; the tumor of one had disappeared. In 2 instances the tumor was not mentioned; two patients are dead.

Seven of the tumors were located in the rectovaginal septum; 5 in the posterior vaginal fornix, one of which was apparently a broad ligament tumor adherent to the posterior vaginal mucous membrane; one was at the juncture of the fundus and cervix; 3 apparently were in the broad ligament; 2 were single adenomyomas of the uterus projecting through the cervical canal and were removed by vaginal myomectomy; one radium treatment was applied after operation in each case. There was one case of single pedunculated adenomyoma growing from the cervical canal. Two patients of this series are dead. One presents an interesting history. She was first examined at the Clinic in 1907. At that time, there was a hard nodular growth in the right posterior vaginal wall which was diagnosed clinically as cancer of the vagina. She was not operated on at that time, and returned to the Clinic nine months later, but apparently there had been no change in the tumor. She was examined again in February, 1920, when she was having attacks of hematuria without pain. The original tumor had apparently not increased in size, but there were several small nodules scattered over the wall of the vagina. She was given 2,386 mgm. hours of irradiation by vagina and rectum. Examination a year later disclosed slight induration extending from the introitus to the vault of the vagina on the right side. The growth projected into the rectum, but there was no ulceration of the rectal mucous membrane. The patient's general health was good, and treatment was not given at this time. She died one year later, after an illness of two months, and it is a question whether death was due to the original trouble. One patient on whom myomectomy was performed had an adenomyoma on the posterior wall of the uterus, adherent to the sigmoid and culdesac, and apparently not encapsulated. A specimen was removed for diagnosis, and during convalescence the patient was given one intra-uterine and one vaginal treatment with radium. This patient died subsequently, but cause and time of death are unknown.

Two patients, each of whom had had one intra-uterine treatment with radium for menorrhagia, were operated on five and eight months later respectively; one, because of continued bleeding and the other, because of a profuse foul vaginal discharge suggesting malignancy of the fundus, although bleeding had ceased after radium treatment. At hysterectomy, diffuse adenomyoma of the uterus was found in each.

Another patient had a large adenomyoma, about 13 cm. in diameter, in a ventrofixed uterus adherent to the abdominal wall. An exploratory incision showed the tumor to be adherent to all surrounding tissues; total removal was not attempted. Radium was applied over the abdomen and into the uterus. A month later, examination revealed that the tumor was reduced to a small ridge about 2 cm. in diameter.

The technique employed varies according to the location and size of the tumor; the emanation needles are inserted into the growth, if it is located in the rectovaginal septum, or the radium is used in the vaginal pack and rectal applicator. If the growth is high in the posterior fornix at the cervicofundal juncture, the vaginal pack is used combined with radium inserted into the cervical canal. Between 1,600 and 2,400 mgm. hours has been the average total dosage, given in two or three doses, using 50 mgm. at each dose for fourteen hours in the vagina and 50 mgm. for two hours in the rectum in two doses, although as much as 6,000 mgm. hours has been used in a case of a large fixed tumor in the posterior fornix adherent to the vaginal mucous membrane and to the rectum.

Table I

RESULTS OF INTRA-UTERINE RADIUM THERAPY FOR NONMALIGNANT CONDITIONS

October 1, 1919, to July 1, 1921

	Number	Per Cent
Patients treated	413	
Single	29	
Married	384	
Heard from	309	
Patients aged thirty-eight years or more (Average age 46.08 years)	305	
Patients heard from	235	77.0 of 305
Fibrous uterus	78	
Definite fibromyomas	110	
Questionable fibromyomas or fibrous uterus	47	
Profuse flow before treatment	205	87.23 of 235
Cessation or lessening of profuse flow after treatment	198	96.59 of 205
No cessation or lessening of profuse flow after treatment	7	3.4 of 205
(Average dose to cause cessation of profuse flow 734.55 mg. hours)		
Two treatments	12	
Three treatments at long intervals	1	
Cessation of menstruation	151	64.25 of 235
Hysterectomy performed later in an average of 8.75 months after radium treatment	8	3.4 of 235
Patients less than thirty-eight years of age	108	
(Average age 32 years)		
Patients heard from	74	
Definite fibromyomas	31	
Fibrous uterus	32	
Questionable fibromyomas or fibrous uterus	11	
Profuse flow before treatment	68	91.89 of 74
Cessation or lessening of profuse flow after treatment	62	91.17 of 68
No cessation or lessening of profuse flow after treatment	6	8.8 of 68
Cessation of menstruation	9	13.23 of 68
(Average dose to cause cessation of menstruation 397.66 mg. hours)		
Hysterectomies after radium treatment	4	
Eight months after treatment because of dysmenorrhea which had increased after radium treatment	1	
Sixteen months after treatment with 363 mgm. hours irradiation because of continued profuse flow and increase in the size of the uterus	1	
Operated on elsewhere thirteen months after treatment	1	
Operated on elsewhere two months after treatment with 340 mgm. hours irradiation because of continued profuse flow	1	

ENDOCERVICITIS, PRURITUS, AND KRAUROSIS

The series of cases at the Clinic of endocervicitis treated with radium has been too small to admit of a definite conclusion regarding its efficacy, although a cervical discharge, persisting after abdominal hysterectomy, has ceased after one or two treatments of 700 mgm. hours of radium. Curtis, in 1920, reported satisfactory results without resulting amenorrhea or atresia of the cervix in his series.

In our experience, pruritus vulvae has been more satisfactorily treated by roentgen rays than by radium, although radium has given relief in many instances. In cases of kraurosis with pruritus, short treatments with unprotected radium have given a great deal of relief by controlling the pruritus, but apparently do not influence the kraurosis, although, according to theory, radium should stimulate the superficial circulation and overcome the atrophy.

CONCLUSIONS

1. Radium, then, is the treatment of choice in cases of menorrhagia of menopause associated with fibromyomas not exceeding in size a four months' pregnancy, or of a fibrous uterus, in which the possibility of malignancy is eliminated by the history, or by a curettement. Small doses of radium are indicated in a few carefully selected cases of menorrhagia in young women of the child-bearing age.

2. A history or evidence of pelvic infection is a contraindication to the use of radium.

3. In adenomyomas which are adherent and difficult to remove, the use of radium is preferable to surgery.

4. Treatment with radium relieves the symptoms in certain cases of pruritus vulvae and in kraurosis associated with pruritus.

5. Endocervicitis continuing after an abdominal hysterectomy responds satis-

factorily to one or two treatments of radium.

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TECHNIQUE AND STATISTICS IN THE TREATMENT OF CARCINOMA OF THE UTERUS AND CONTIGUOUS ORGANS WITH THE COMBINED USE OF RADIUM AND X-RAYS*

BY HENRY SCHMITZ, M.D.

CHICAGO, ILLINOIS

At the last annual meeting of the society I presented a review of the investigations of Friedrich and Glasser[1] on the determination of isodoses or equal intensity curves of radium capsules. The outstanding facts of these researches were: (1) The calculation of the distribution of the dose from the laws of distance and absorption in the intratumoral treatment of cancer with radium is incorrect, as the secondary and scattered rays arising in the tissues and the geometrical form of the radium capsules have not been taken into account in such calculations. (2) The value of the secondary radiation is so great that it not only equals the loss by absorption, but results in higher values for the total dose. (3) The curves of equal intensities, designated "isodoses," do not take a course parallel to the circumference of the radium capsule, but evince a course deviating quite markedly from that of the surface of the capsule.

The capsules furnished by American purveyors of radium have a different construction from those employed by Friedrich and Glasser in their investigations. Therefore it appeared advisable to determine the equal intensity curves of some of the radium capsules in my possession. The results of these labors carried on in association with Huth[2] are shown in Figure 1. Knowing the equal intensity curves, it became necessary to determine

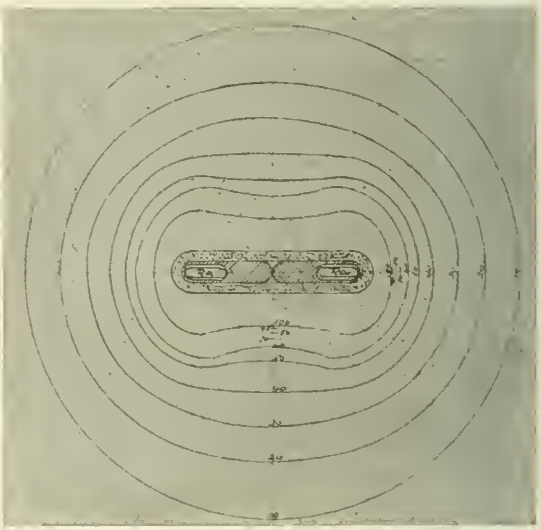

Fig. 1. Equal intensity curves of 50 mgm. element.

the time duration of the application of the 50 mgm. of radium element arranged and screened, as seen in Figure 1, to determine the biological unit of dose. For this purpose we chose the isodoses 60, 40, 20, 10

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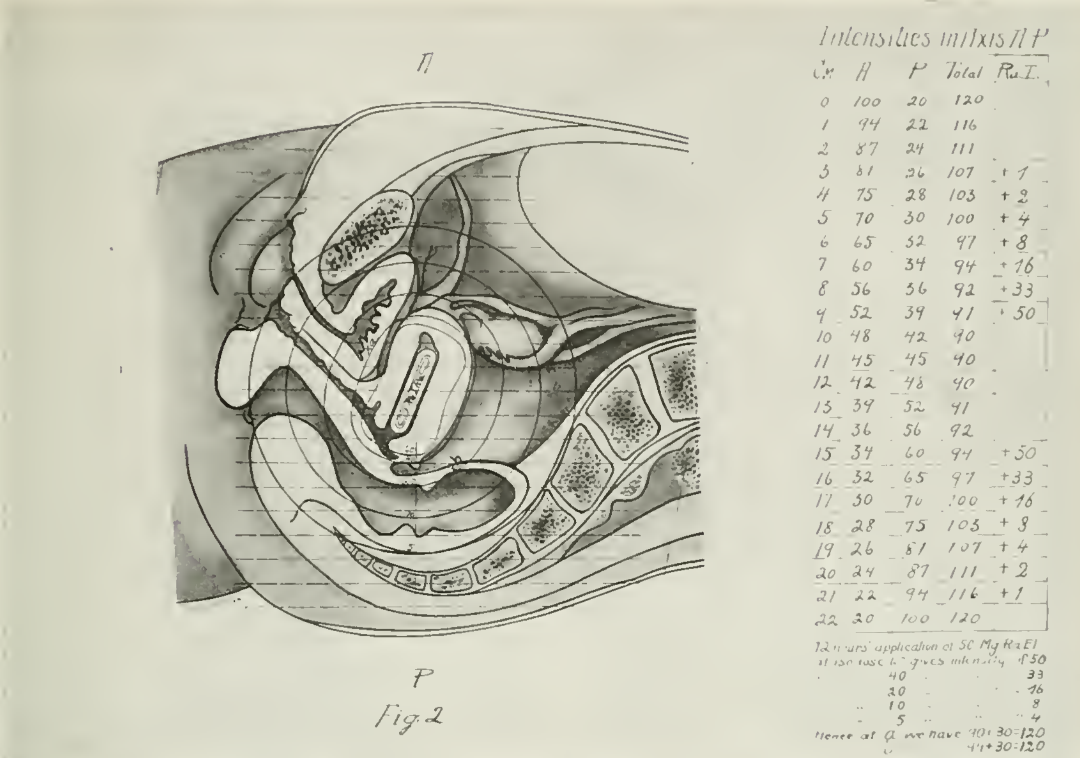


Fig. 2. Median longitudinal section of a female pelvis with equal intensity curves and intensities of x-rays.

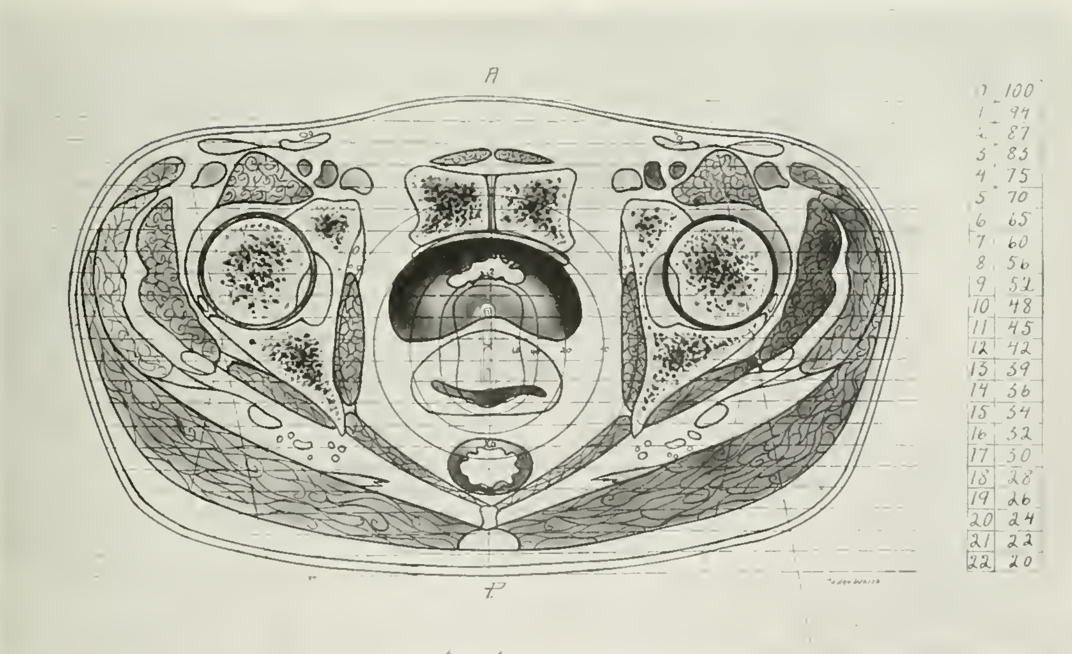


Fig. 3. Transverse section through cervix with equal intensity curves of radium and intensities of x-rays.

and 5, which are about 1, 2, 3, 4 and 5 cm. distant from the surface of the filter in the line vertical to the center of the longitudinal axis. The time duration of an application of 50 mgm. radium element within water at isodose 60 to obtain an erythema or epilation skin dose is about twenty-four hours, or 1,200 mgm. el. hrs.; at isodose 40 it is thirty-six hours, or 1,800 mgm. el. hrs.; at isodose 20 it is seventy-two hours, or 3,600 mgm. el. hrs.; at isodose 10 it is one hundred and forty-four hours, or 7,200 mgm. el. hrs.; and at isodose 5 it is two hundred and eighty-eight hours, or 14,400 mgm. el. hrs.

If an epilation skin dose of 1,800 mgm. el. hrs. has been applied to the equal intensity curve 40, then an intensity of 2,700 mgm. el. hrs. is attained at isodose 60; of 900 mgm. el. hrs. at isodose 20; of 450 mgm. el. hrs. at isodose 10, and of 225 mgm. el. hrs. at isodose 5. Since the epilation skin dose of 1,800 mgm. el. hrs. represents 100 per cent, Ep. S. D., isodose 60 receives 150, isodose 20 receives 50, isodose 10 receives 25 and isodose 5 receives 12.5 per cent of an Ep. S. D.

TECHNIQUE

The practical application of these investigations consists in drawing median longitudinal and transverse sections of the pelvis of the patient to be treated, as shown by Opitz and Friedrich.[3] The sections must be made from actual measurements of the patient (Figs. 2 and 3). The radium capsules are arranged in filters, as shown in Figure 1, and placed intrauterine on this drawing. The equal intensity curves 60, 40, 20, 10 and 5 are entered, using the patterns seen in Figure 4 which were made from the isodoses of Figure 1. We are now able to determine the exact intensities of radium rays in any part of the pelvis, provided we consider the time duration of the application of the radium which must be arranged and screened as shown above.

The intensity of rays to produce an epilation skin dose has been arbitrarily placed at 100. This represents the biological standard, or unit of a radiation dose. Reactions of tissues to radiations differ, depending on the intensity applied. Intensity varies with the amount of gamma rays, their geometrical distribution, the thickness and kind of filter, the focus skin distance, and the time of application. We distinguish the following reactions for normal epithelial cells:[4] (1) The maximal skin dose for healthy skin. It stops just short of a visible reaction. (2) The erythema or epilation skin dose produces a burn

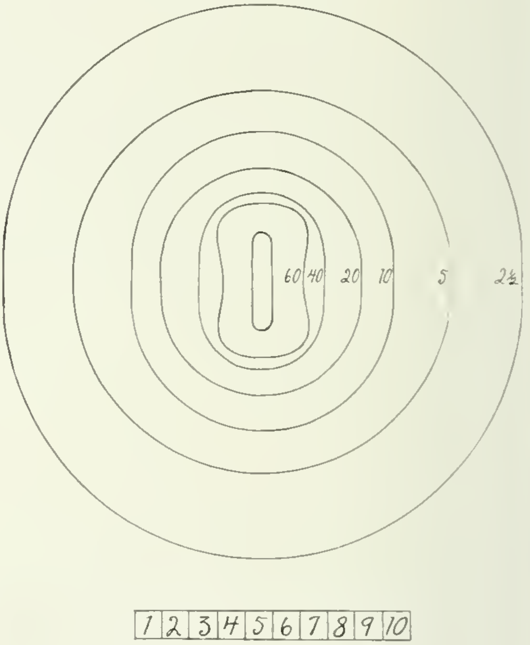


FIG. 4. Patterns of equal intensity curves of radium at 60, 40, 20, 10 and 5 per cent.

of the first degree. It is characterized by a reddish discoloration usually appearing at about the tenth to the fourteenth day after radiation, followed by a desquamation of the most superficial layers of the skin within about fourteen to twenty-eight days, and a loss of hair from about the twenty-eighth to the forty-second day. The skin recovers completely without any latent changes except a brownish discoloration which may last from six to eight months. (3) The estal skin dose is characterized by burns of the second degree accompanied by the formation of blisters. The latter heal promptly within six to eight weeks, leaving a white discoloration behind, in the area of which marked telangiectases appear in the course of a few months. (4) The lethal skin dose which causes a third degree burn. It is characterized by a deep ulceration and subsequent necrosis, which may hea by aseptic methods of treatment or wil persist, necessitating finally excision and grafting with a pedicled flap of skin.

The maximal skin dose is attained at a distance of 1 cm. or isodose 60 in water with 50 mgm. radium element arranged and screened as shown in Figure 1 with an application of about eighteen hours; the epilation skin dose at twenty-four hours; the *aestal* skin dose at about thirty-two hours; and the lethal skin dose at about forty-eight hours. The lethal carcinoma dose is practically the same as the dose producing an epilation skin dose. Exceptions form the squamous cell carcinomata which respond to an estal skin dose. Carcinoma cells therefore are twice as sensitive to radiations as normal epithelial cells.[5]

The object of the treatment of cancer of the uterus with radiations is to degenerate or destroy all the cancer cells without permanent injury of the neighboring vital organs. The latter are the bladder and rectum. We may expose the epithelial cells of the posterior bladder mucosa and the anterior rectal mucosa to an intensity of 130 per cent. This is the highest intensity that we dare use. Higher intensities would bring these organs within the range of the lethal epithelial dose. The mucosae of the posterior bladder and anterior rectal walls are from 2 to 2½ cm. distant from the cervical canal. Hence, if we wish to avoid permanent injury or destruction of these regions we cannot extend the application of 50 mgm. radium element beyond thirty-six hours at 2 cm. and forty-eight hours at 2½ cm. The area within which this lethal cancer dose is attained is an ellipse about 4 cm. wide and 6 cm. long, namely, the isodose 40 Cancer cells beyond this ellipse are therefore not destroyed and beyond the isodose of 20 are actually stimulated to an increased mitosis, hence rapid growth.

The insertion of radium into the parametria through trochars, or the needling through a laparotomy incision have been tried by us in a number of cases.[6] The results did not warrant a continuation of the methods. Five laparotomies were performed for needling. Not a single patient appeared to be benefited. Only one patient, in whom radium was thrust into the parametrium through the vaginal fornix was apparently benefited.

The investigations of the determination of the equal intensity curves and the clinical observations on the reaction of gamma rays have convinced us that gamma rays are indicated when a local intensive effect suffices. As the majority of pelvic cancers have invaded the regional lymph-nodes, which are mostly 6 cm. distant from the cervical canal, we cannot reach all of the cancer cells with radium rays because we must avoid irreparable injuries to the normal tissues. We therefore studied the feasibility of combining radium therapy with x-rays. The latter are indicated where an extensive area must be subjected to radiations.[9]

Two types of transformers at our disposition have an output of 140 and 300 kv. respectively. The intensity of the x-rays depends on the proper determination of the following factors: The kilovoltage, the filter, the focus skin distance, the size of the field of entrance, the milliampèrage, the time duration of the application, and the roentgen-ray tube used. The tube employed with the 140 kv. transformer was a standard Coolidge tube with a bulb of a diameter of 18 cm.; while the one used with the 300 kv. transformer was the new therapy tube, the bulb measuring 21 cm. in diameter.

Two methods of measuring intensities of x-rays exist, the direct and the indirect. An example of the direct measurement is the Bachem electroscope. Indirect methods are the iontoquantimeter of Friedrich,[7] the measuring bench of Wintz and the electroscope of Schmitz. The Friedrich and Wintz instruments are modifications of Szillard's electrometer which was designed for the direct measuring of quantities of gamma rays of radioactive substances. We are using all the methods, as thereby we can control each instrument and thus be sure of the exactness of the measurements of radiation intensities. The introduction of these methods of determining radiation intensities has enabled the physician to solve the problem of a correct radiation therapy. The physician can now state whether the diseased area is traversed by a practically homogeneous radiation. We can enter the *x*-ray intensities on the median longitudinal section. Figure 5 represents the intensities of the *x*-rays. The intensities of the 200 kv. *x*-rays are entered on the median section, seen in Figure 2, and by simple addition the physician may now determine the combined intensities necessary to destroy a pelvic carcinoma. Referring to Figure 2 we observe that the anteroposterior diameter is 22 cm. Two ports of entry are

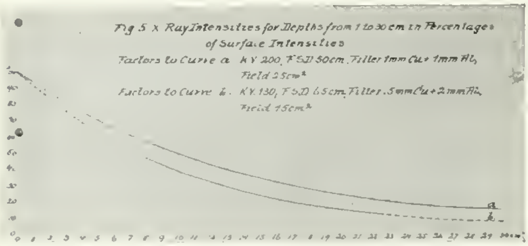


FIG. 5. X-ray intensity graphs with the chief factors.

used: A is the anterior and P the posterior port. The fields are 20 cm. square. The intensities of the *x*-rays for each cm. are read off from the graph *a* in Figure 5. They are shown in Figure 2 in the columns to the right of the section. By an addition of the gamma and *x*-ray intensities applied at the anterior rectal wall and posterior bladder wall, indicated by stars at *a* and *b*, the intensities to the right of the columns are attained. In this instance a 12 hours' application of gamma rays suffices. Should the combined intensities at either the bladder and rectal wall or on the skin amount to more than 130 occurring in patients with an anteroposterior diameter of less than 20 cm. we must reduce the application time of the gamma rays or *x*-rays or both. Should the intensities be less than 100 seen in patients with an anteroposterior diameter of more than 24 cm. we must increase the application of either the gamma rays or *x*-rays or both.

Figure 6 shows the application of the 140 kv. *x*-rays. Four fields are used: An anterior one of 20 cm. square, a posterior of 15 cm. square and left lateral and right lateral fields of 15 cm. square each. The last two fields are applied with the patient in either the right lateral or left lateral position, as seen in Figure 7. The axis of the lateral field is placed directly over the cervix. Attention must be given to leave a wide margin of skin between these lateral fields and the anterior and posterior fields. Points 1, 2, 3, 4 and 5 are now placed, as well as 6, 7, 8, 9, 10 and 11. The former present the anterior, posterior and lateral periphery and the center of the true pelvis; the latter, the skin regions where several *x*-ray beams cross each other. The last points are the danger points on the skin. The use of the Dessauer tables is particularly helpful with the 140 kv. *x*-rays.[8]

The preceding paragraphs represent the technique we employ in the treatment of carcinoma of the pelvic organs. The method with the 140 kv. *x*-rays and radium has been in use since 1919, while that of the 200 kv. *x*-rays and radium has been instituted since November, 1921. It is obvious that the statistics which follow do not as yet enable us to prove whether results will be improved by the newer method of radiation therapy.

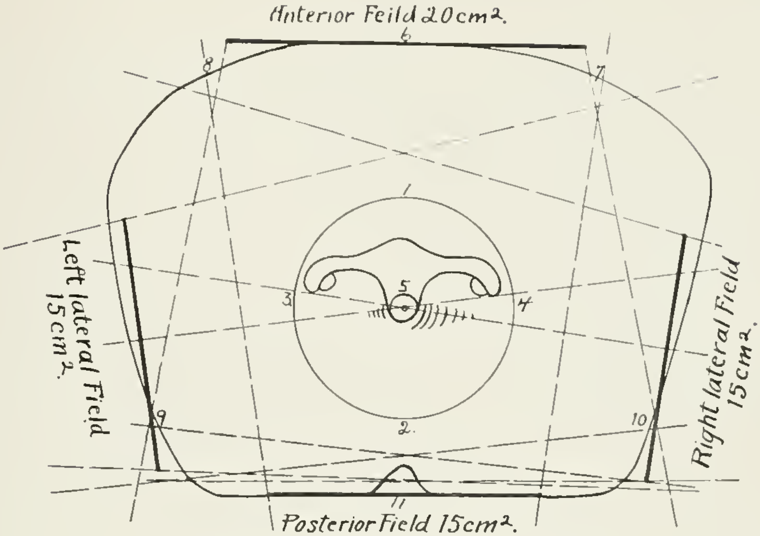
STATISTICS

The total number of cases of cancers of the female urogenital organs admitted and treated between the years 1914 and 1921 inclusive is 423. According to location and years they are divided as follows:

TABLE I

	1914	1915	1916	1917	1918	1919	1920	1921	Total	Per Cent
Vulva		..	2	.	.	4	2	2	10	2 3
Urethra		..	4	2	1	..	1	.	8	1 9
Bladder	3	4	..	4	6	9	5	6	37	8.6
Vagina	.	1	..	1	1	1	.	6	10	2.3
Cervix	12	31	42	24	38	45	60	51	303	72 0
Corpus	2	1	..	2	5	5	3	7	25	5 9
Ovaries	1	2	3	2	3	6	3	10	30	7 0
Total for each year	18	39	51	35	54	70	74	82	423	...

We did not refuse to treat a single case. However, the treatment varied, depending on whether the patient could be safely subjected to a curative application of the rays or not. As our experience grew, we also observed that clearly localized and borderline carcinomata offered a much better prognosis to radiation therapy than the clearly inoperable, recurrent and ad-



Intensities obtained at points marked.

Field	1	2	3	4	5	6	7	8	9	10	11
Ant.	40	13.5	25	25	22.5	100	80	80	12	12	10.5
L lat.	65	20	58	9	19.5				100		
R lat.	65	20	9	58	19.5					100	
Post	25	48	19.5	19.5	40	13	13	13			100
Total	98	101	111	111	105	113	93	93	112	112	110.5

Factors: 65cm F.S.D, 0.5mm Cu + 6 mm Leather + 1mm Al. Filter; 130 K.V. max., 5 mamp, Coolidge tube 18cm; Time Duration of application to each Field i.e. Full Epilation Skin Dose 1050 M.amp. min.

Fig. 6. Transverse section of a female pelvis with four fields of entry for application of x-rays obtained with 130 kv. max. The factors are seen in Figure 5.

vanced cases.[9] For these reasons we divided the patients into five groups, namely: (1) The clearly localized cancer (2) the doubtfully localized cancer, (3) the inoperable cancer with invasion of the adjacent tissues or organs, the regional lymph-nodes or both, (4) the advanced case characterized by a "frozen pelvis" and grave cachexia, (5) the recurrent cancer, recurring after a surgical eradication. Table II represents the grouping of all the cases; the number of patients alive and well today are indicated in parentheses.

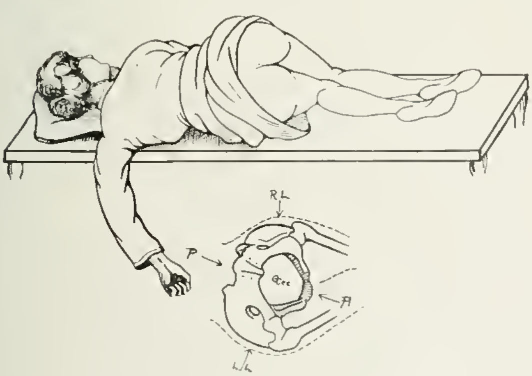


Fig. 7. A patient in left lateral position showing application of side fields.

We have tabulated all the cases that presented themselves. If the case refused treatment or did not complete the course of treatment, it was classed with the known dead. If inquiry remained unanswered, the case was added to those known to be dead. We therefore have applied the strictest rule to the statistics.

TABLE II

VULVA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized.		....	1 (1)	....	....	1 (1)	....	....	2 (2)
Borderline		....	....	....	....	....	....	....	....
Inoperable		....	....	....	....	....	2 (2)	2 (2)	4 (4)
Advanced		....	....	....	....	1	....	....	1
Recurrent		....	1	....	....	2	....	....	3
Total	....	....	2 (1)	....	....	4 (1)	2 (2)	2 (2)	10 (6)

URETHRA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized		....	1 (1)	1 (1)	....	....	1 (1)	....	3 (3)
Borderline		....	....	....	....	....	....	....	....
Inoperable		....	3	1	1 (1)	....	....	....	5 (1)
Terminal Advanced		....	....	....	....	....	....	....	....
Recurrent		....	....	....	....	....	....	....	....
Total		....	4 (1)	2 (1)	1 (1)	....	1 (1)	....	8 (4)

VESICA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized		1 (1)	....	....	1 (1)	....	....	....	2 (2)
Borderline		....	....	....	....	....	....	....	....
Inoperable		....	....	....	3	7 (1)	2	1 (1)	13 (2)
Advanced or Terminal	2	....	....	3	2	1	2	3 (1)	13 (1)
Recurrent	1	3	....	1	....	1	1	2 (2)	9 (2)
Total	3	4 (1)	....	4	6 (1)	9 (1)	5	6 (4)	37 (7)

VAGINA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized.		....	....	1 (1)	....	....	....	....	1 (1)
Borderline.		....	....	....		1	....	....	1
Inoperable		1	....	....		....	....	4 (3)	5 (3)
Terminal.		....	....	....	....	....	....	2	2
Recurrent		....	....	....	1 (1)	....	....	....	1 (1)
Total		1	....	1 (1)	1 (1)	1	....	6 (3)	10 (5)

CERVIX

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	1 (1)	1 (1)	....	1	2 (2)	4 (3)	4 (4)	13 (11)
Borderline	1	4 (1)	5 (3)	2	4 (2)	2 (1)	4 (3)	4 (4)	26 (14
Inoperable	7	15	10 (1)	13 (4)	14 (2)	18 (5)	20 (7)	17 (12)	114 (31)
Terminal	....	4	9	6	8	10 (1)	21 (2)	17 (7)	75 (10)
Recurrent	4	7	17 (1)	3	11 (1)	13 (1)	11 (3)	9 (5)	75 (11)
Total	12	31 (2)	42 (6)	24 (4)	38 (5)	45 (10)	60 (18)	51 (32)	303 (77)

CORPUS

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	1 (1)	....	....	1	3 (3)	1 (1)	1 (1)	1 (1)	8 (7)
Borderline	....	....	....	....	1 (1)	....	....	3 (2)	4 (3)
Inoperable	1	....	....	1	1	1	....	....	4 ....
Terminal	....	1	....	....	....	1	1	2 (1)	5 (1)
Recurrent	....	....	....	....	....	2	1 (1)	1	4 (1)
Total	2 (1)	1	....	2	5 (4)	5 (1)	3 (2)	7 (4)	25 (12)

OVARIES

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	....	....	....	....	....	....	....	....
Borderline	....	....	....	....	....	....	....	....	....
Inoperable	1	....	1	1	2 (1)	3 (2)	3	6 (4)	17 (7)
Terminal	....	....	....	....	....	....	....	1	1
Recurrent	....	2	2	1	1	3	....	3 (1)	12 (1)
Total	1	2	3	2	3 (1)	6 (2)	3	10 (5)	30 (8)

In Table III the cases are tabulated that have passed the five-year limit, namely, those from 1914 to 1917 inclusive.

If only the operable and borderline cases of all the locations are considered, we have 25 cases with 12 absolute recoveries, namely, 48 per cent.

Considering only the cervical cancer we have a total of 109 with 12 five-year cures, namely, 11.1 per cent. The localized and borderline cervix cases with a five-year cure number 14 with 6 survivors, namely, 42.8 per cent.

Table III

Location	Group	1914	1915	1916	1917	Total	Per Cent
Vulva	Localized			1 (1)			100
	Recurrent			1			0
Urethra	Localized			1 (1)	1 (1)		100
	Inoperable			3	1		0
	Localized		1 (1)				100
Vesicae	Terminal	2			3		0
	Recurrent	1	3		1		0
Vagina	Localized				1 (1)		100
	Inoperable		1				0
	Localized		1 (1)	1 (1)		2 (2)	100
	Borderline	1	4 (1)	5 (3)	2	12 (4)	33.3
Cervix	Inoperable	7	15	10 (1)	13 (4)	45 (5)	0
	Terminal		4	9	6	19	0
	Recurrent	4	7	17 (1)	3	31	3.5
	Total	12	31 (2)	42 (6)	24 (4)	109 (12)	11.1
Corpus	Localized	1 (1)			1	2 (1)	50
	Inoperable	1	1		1	3	0
Ovaries	Inoperable	1		1	1		0
	Recurrent		2	2	1		0

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THE EFFECT OF THE SIZE OF RADIUM APPLICATORS ON SKIN DOSES*

BY EDITH H. QUIMBY, M.A.

Radium Research Laboratory, Memorial Hospital

NEW YORK CITY

FOR a point source of radiant energy, it is a well-known physical law that radiation varies inversely as the square of the distance from the source. When the source is not a point, this is not strictly true, and when it is a fairly large surface it is not even approximately so, for distances comparable to the size of the source.

In radium therapy the applicators used frequently have areas of several square centimeters, and are used close to the skin. For purposes of dosage it is desirable to compare the intensity of radiation delivered by different applicators at different distances. The inverse square law offers only a first approximation in this case. Therefore the tables included in this paper have been worked out, so that doses may be compared directly, for the applicators and distances considered. Furthermore, by means of the curves, the comparison may be made for any practical applicators and any distances. Also, if the dose is known for one applicator, under a given set of conditions of distance and filtration, it may be obtained for any other applicator, under any conditions of application.

If we consider a line, which is the simplest departure from a point source, and which corresponds for all practical purposes to a tube applicator, we have the situation shown in Figure 1.

AB is the source of radiation, and we wish to find the intensity at P, which is at a distance d units from its center. If the source of strength Q_0, were concentrated at S, the intensity at P would be $\frac{kQ_0}{d^2}$, where k is a constant depending on the units adopted.

But the radioactive source is uniformly distributed over AB, and every point of AB except its center is at a greater distance than d units from P. Therefore, as we would expect, the intensity at P is less in this case than in the case of the point source. We may consider any tube to be divided into a definite number of point sources of equal intensity, for instance, ten. Then the intensity due to each point source can be calculated according to the inverse square law, and the sum of all these will be the intensity for the tube. To simplify the calculations, this was done in the present case. For a tube of length a units, ten points were taken, at distances of $0.05a$, $0.15a$, $0.25a$, $0.35a$, and $0.45a$ units on either side of the center, as

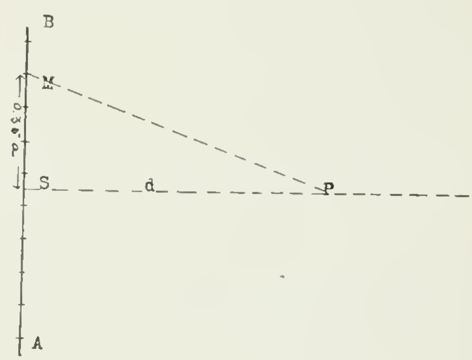


FIG. 1.

indicated in the figure. The intensity of radiation at P due to any one of these sources is determined directly by the inverse square law. For instance, for the point M, which is at a distance $0.35a$ units from S, the intensity is $\frac{1}{10}\frac{kQ_0}{(MP)^2}$ which is equal to $\frac{1}{10}\frac{kQ_0}{(0.35a)^2 + d^2}$. The sum of the intensities at P due to the ten point sources is, for all practical purposes, the same as the intensity due to a line source.

For a flat circular applicator of diameter a units, one hundred points were considered instead of ten. Circles were drawn at distances $0.05a$, $0.15a$, $0.25a$, $0.35a$, $0.45a$ units from the center, and the points equally spaced on these. Then all the points on any one circle are at the same

* This article was received for publication in November, 1921.

distance from the point at which we are measuring the intensity. The intensity of radiation due to a point source on each circle was determined in the manner previously explained; this was multiplied by the number of points on that circle, and the sum of all these products taken as the intensity for the circular applicator. In the case of the square and rectangular applicators a similar method was used.

If a filter is introduced between the source and the point P, the radiation suffers an additional decrease due to absorption

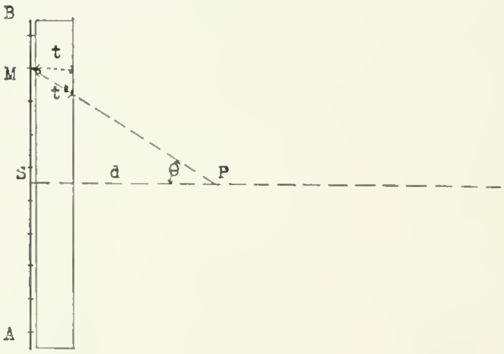


Fig. 2.

in the material of the filter. In order to find the intensity due to a point source, when a filter is interposed, we may simply take that fraction of the unfiltered radiation which is transmitted by the given thickness of material. But in the case of a distributed source, the thickness of filter traversed by radiation from different parts is not the same. That from a point near the edge passes through a greater thickness of material than that from a point near the center. This is shown in Figure 2, from which we see that t′, the actual thickness traversed, will be equal to $\frac{t}{\cos\theta}$. Therefore in determining the intensity due to any one of the individual points we must include a factor $R_{t'}$, the fraction of the initial radiation transmitted by this thickness of filter, e.g., the intensity at P due to the point M is equal to $\frac{1}{10}\frac{kQ_0R_{t'}}{(0.35a)^2+d^2}$. If we have an absorption curve for the metal of the filter, showing the percentage of the transmitted radiation relative to the unfiltered source, for different thicknesses of metal, the values of $R_{t'}$ may be read directly from it. Such curves have been published in a previous paper.[1] These curves are, however, based on physical data, that is, measurements of the ionization produced by the filtered radiation. Since the applications of the present paper are to biological effects, it is best to use as a basis for calculations, a curve obtained by finding, for different filters, the amount of radiation which produced a definite biological result. Therefore the number of millicurie-hours necessary to produce an "average erythema"[2] was determined, for a number of different thicknesses of brass. For the same number of millicuries, the time required to produce the erythema is inversely proportional to the amount of radiation transmitted by the filter. Hence, the reciprocals of the times, plotted against the corresponding thicknesses of filter, give a curve which is better for determining doses than one based on ionization measurements. This is given in Figure 3. The doses from which it is plotted are shown in Table I.

Table I

Curve showing intensities of radiation required to produce erythema, for different filters, in terms of intensity from unfiltered source. Radium applied at distance of 2 cm. from skin

Total Filter in Addition to Glass Tube	Dose, Mc.-hr.	$\frac{1}{\text{Dose}}$	Percentage
None	7.5	0.1333	100.0
0.16 mm. brass / 1.2 mm. rubber	30.0	0.0333	40.0
0.32 mm. brass / 1.2 mm. rubber	100.0	0.0100	7.50
0.50 mm. brass / 1.2 mm. rubber	250.0	0.0040	3.00
0.75 mm. brass / 2.4 mm. rubber	475.0	0.0021	1.57
1.0 mm. brass / 2.4 mm. rubber	630.0	0.0016	1.20
2.0 mm. brass / 2.4 mm. rubber	830.0	0.0012	0.90

[1] The Effect of Different Filters on Radium Radiations. Am. J. of Roentgenol., September, 1920.

[2] An "average erythema" is defined as the erythema produced on the skin of the average patient by a dose of 7.5 millicurie-hours of unfiltered radiation, applied at a distance of 2 cm. By unfiltered radiation is meant the radiation from the emanation in the capillary glass tube, with no additional covering.

Note. For unfiltered radiation, the integral calculus offers a convenient method of attacking this problem. The expression for the tube is

$$I_p = 2\int_0^{\frac{a}{2}} \frac{KQ_0dx}{p^2 + x^2} = \frac{2K}{p}\tan^{-1}\frac{x}{p}.$$

This formula has been used by Wood and Prime (Action of Radiation on Transplanted Tumors in Animals. *Ann. of Surg.*, Dec., 1915).

But when the term for the filter is introduced, the expression becomes

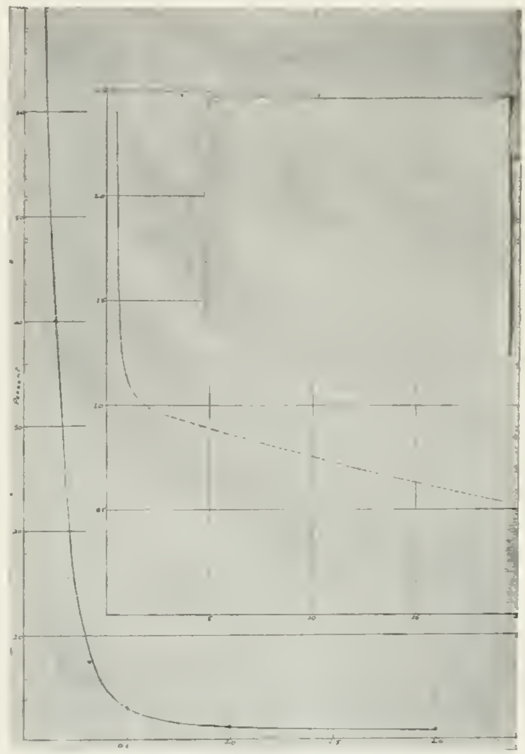
$$I_p = 2\int_0^{\frac{a}{2}} KQ_0C^{-\mu d \sec\theta} d\theta$$

which is not readily integrated. In any case the method is not applicable for filters less than 2 mm. of brass. In order to integrate the expression, μ, the absorption coefficient must be regarded as constant. But this is not the case unless the absorption follows an exponential law. It has been shown that a filtration of at least 2 mm. of brass is necessary in order for this condition to be fulfilled. (Failla. The absorption of radium radiations by tissue, Am. J. Roentgenol., May, 1921.)

The term cos θ, which appears in expressions for the intensity of light, is omitted in these expressions. What we are really interested in is not the intensity, but the energy density per small unit volume, and this does not depend on the angle.

In order to obtain results which could be used for applicators of various sizes, the unit adopted for measuring all distances was an arbitrary constant a, which represents the length of the tube, the diameter of the circle, the side of the square, or the shorter side of the rectangle (the longer side being $1.5a$) as the case may be. All calculations were made in terms of this unit, so that the curves are general. The filters considered were: Bare applicators,[3] Figure 4; 0.16 mm. brass, Figure 5; 0.50 mm. brass, Figure 6; 0.75 mm. brass, Figure 7; and 2.0 mm. brass, Figure 8. In each chart, separate curves are given for the tube, circle, square, and rectangle. The horizontal distances denote distance from applicator to skin, the vertical distances give the intensity of radiation from the given applicator, in percentage of the intensity from a point source of the same strength at the same distance. Since the effect due to the point source is easily calculated by the inverse square law, it will be seen that when we have obtained a relation between a given applicator and the point source, we can readily find the effect due to the applicator. For any given applicator at a definite distance, it is necessary to express the distance in terms of a for that applicator. This then enables us to read from the curve the effect due to that applicator at the specified distance, relative to that from a point source at the same distance. Having calculated the effect of the point source at this distance, we have only to take the percentage of it indicated by the reading on the curve.

[3] A "bare applicator" is one having no additional filter beyond the glass of the emanation tube.



Millimeters Brass.

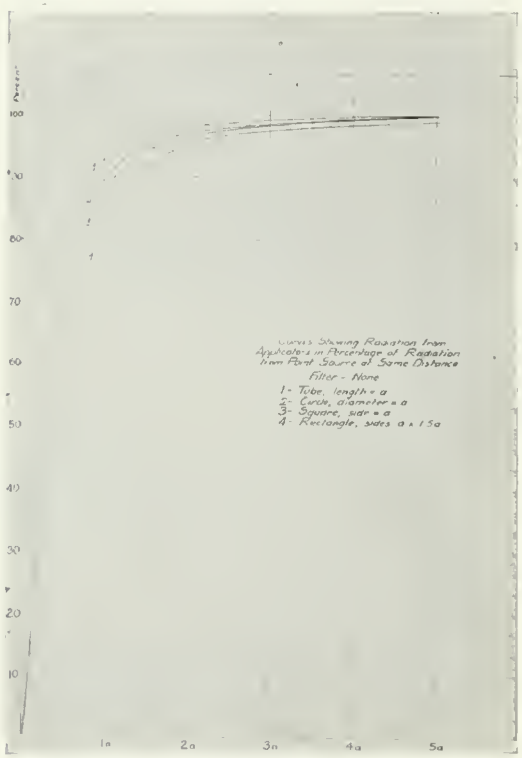
Fig. 3. Curve showing intensities of radiation required to produce erythema, for different filters, in terms of intensity from unfiltered sources. Dotted curve shows portion near bend much enlarged.

It should be noted that the intensity obtained is that at a point on the axis of the applicator. Except for a few special cases, which will be mentioned later, intensities at other points have not been calculated. The one given is evidently the maximum, since the average distance to it from all points on the applicator is less than from any other. If it is a question of how much radiation can be applied without causing injury, it is this maximum effect which must be known.

Let us consider some examples of the use of the curves; 1. What is the effect due to an applicator 4 cm. square, at a distance of 3 cm. from the skin, the filter being 2 mm. of brass and 2.4 mm. of rubber? *a* is 4 cm., hence the distance, 3 cm., is 0.75*a*. For a filter a 2 mm. of brass we refer to Figure 8. The effect due to a square at a distance of 0.75*a* is 77.3 per cent of that for a point source at the same distance. So if we had attempted to use this applicator and calculate the dose by the inverse square law alone, we would have given 100 − 77.3 = 22.7 per cent too small a dose of radiation.

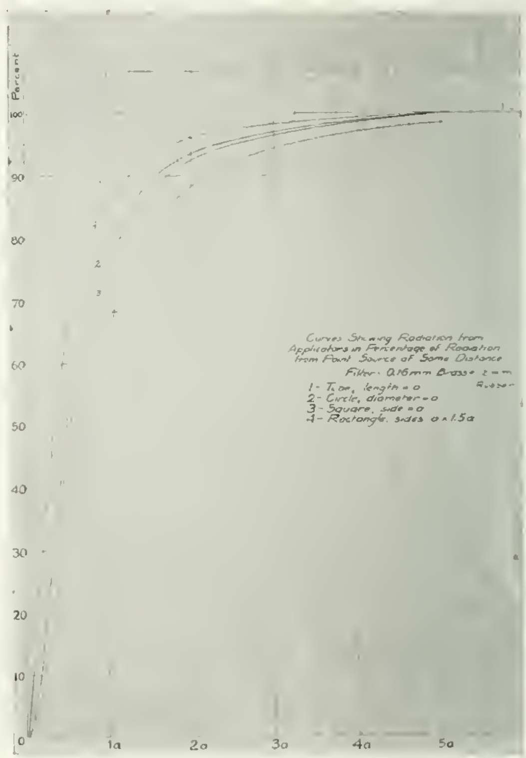
2. Suppose we have an applicator which does not fit any one curve, for instance, a rectangle whose dimensions are not *a* x 1.5*a*. It is possible to interpolate between two curves. What is the effect due to a rectangle 6 x 8 cm. at a distance of 5 cm., the filter being 0.75 mm. of brass and 2.4 mm. of rubber? In curves 7 we have the square *a* x *a*, and the rectangle, *a* x 1.5*a*, and our applicator falls between the two. *a* is 6 cm., the distance (5 cm.) is 0.83*a*. For the square at this distance the value is 75.1 per cent, and for the rectangle 66.3 per cent of that from the point source. For the applicator under consideration, if we take the mean of these two, 70.7 per cent, we will not be far wrong.

3. How do the effects due to the following two applicators compare:—(a) a circle 5 cm. in diameter, at a distance of 3 cm., and (b) a rectangle 6 x 8 cm., at a distance of 6 cm; the filter in each case being 2 mm. of brass and 2.4 mm. of rubber, and the quantity of radium, and the time used in each case being the same? The proper curves for this case are Figure 8. For the circle *a* is 5 cm., the distance (3 cm.) is 0.6*a*, the value for the circle at this distance is 75.3 per cent of that from the point at the same distance. For the rectangle, *a* is 6 cm. and the distance (6 cm.) is *a*. The value in this case is 81.0 per cent that of the point source at



Distance from skin.

FIG. 4.



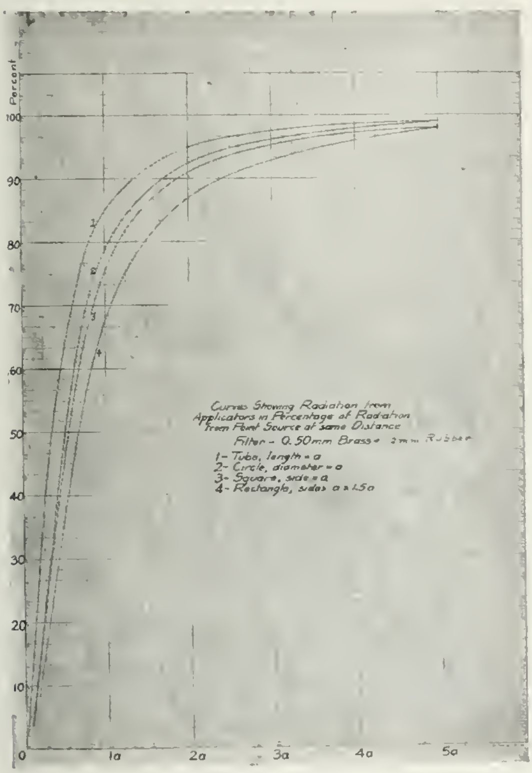
Distance from skin.

FIG. 5.

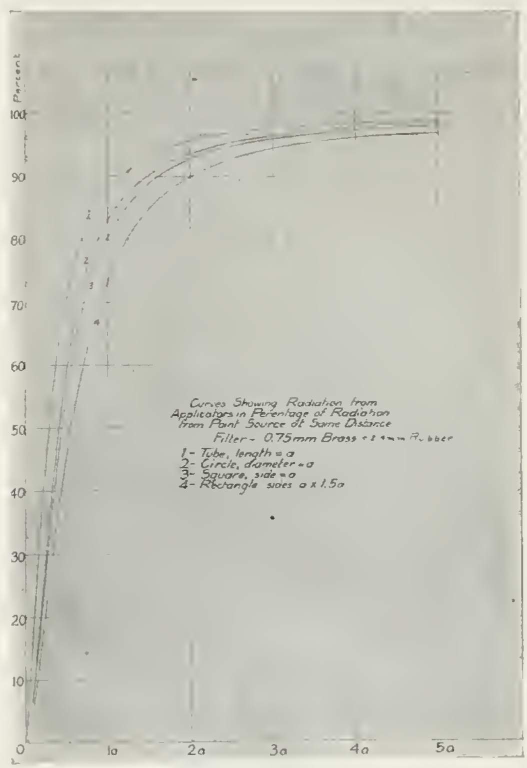
the same distance. But the intensity of radiation due to the point source at 3 cm. is $\frac{1}{9}$ that at 1 cm., and at 6 cm. $\frac{1}{36}$ that at 1 cm., according to the inverse square law. So if we adopt the effect due to the point at 1 cm. as a unit, the circle at 3 cm. will give $\frac{1}{9} \times 75.3$ per cent $= 8.39$ per cent, and the rectangle at 6 cm. will give $\frac{1}{36} \times 81.0$ per cent $= 2.25$ per cent.

Table II

Filter	Filtration Factor
None (glass capillary)	1.00
0.16 mm. brass + 1.2 mm. rubber	0.40
0.50 mm. brass + 1.2 mm. rubber	0.030
0.75 mm. brass + 2.4 mm. rubber	0.0157
2.0 mm. brass + 2.4 mm. rubber	0.0090



Distance from skin.
Fig. 6.



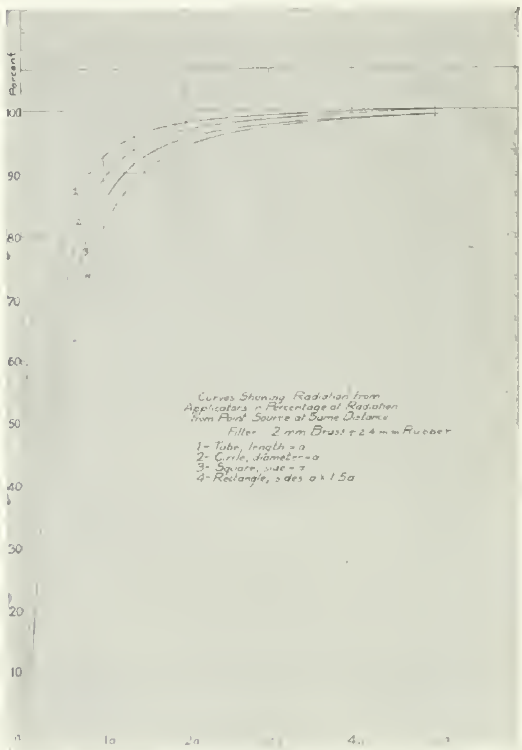
Distance from skin.
Fig. 7.

Whence, of our two applicators, the circle gives $\frac{8.41}{2.25} = 3.8$ times as much radiation at the given distance.

Values from 2 sets of curves are not comparable, since each set is based upon a different value for 100 per cent, namely the effect due to the point source with the same filter as for that set of applicators. However, with the aid of the following filtration factors, values from the various curves may be compared by multiplying each by its proper factor:

4. For instance, what is the difference in the intensity of radiation from a 2 x 2 cm. applicator having a filter of 0.16 mm. brass and 1.2 mm. of rubber, at a distance of 2 cm., and from one 4 x 6 cm., having a filter of 0.50 mm. brass and 1.2 mm. of rubber at a distance of 4 cm.? For the first, we use Figure 5, and for the second, Figure 6. For the square, $a = 2$, the distance is a, the value from the curve is 76.0 per cent that of the point at the same distance. At 2 cm. the value for the point is $\frac{1}{4}$ that at 1 cm. Therefore the value for

the square is $\frac{1}{4}$ x 76.0 or 19.0 per cent that of the point at 1 cm. Multiplying by the filtration factor from Table II, 0.40, we have 7.6 per cent. For the rectangle, a = 4, the distance is a, the value is 67.7 per cent that of the point at the same distance, and $\frac{1}{16}$ as much, or 4.23 per cent that of the point at 1 cm. Multiplying by the factor from Table II, 0.030, we have 0.127



Distance from skin.
FIG. 8.

per cent. Whence, for these applicators and distances the square with 0.16 mm. brass gives $\frac{7.6}{0.127}$ or 60 times as much radiation as the rectangle with 0.50 mm. brass.

5. By means of these curves, if the dose for one applicator is known, that for another can be found. Suppose that, for a circular applicator 3 cm. in diameter, at a distance of 3 cm., filter 0.75 mm. brass + 2.4 mm. rubber, the dose is 700 millicurie-hours. What is it for a rectangle 4 x 6 cm., at a distance of 4 cm., the filter being the same? Comparing the two applicators in the manner outlined in example 4, we find the effect due to the rectangle to be 0.5 that due to the circle. Therefore in order to produce the same effect, it is necessary to double the dose in millicurie-hours in the case of the rectangle.

6. If a tube 1.4 cm. long, placed 2 cm. from the skin, with a filter of 0.5 mm. brass and 1.2 mm. of rubber, produces an erythema with a dose of 250 millicurie-hours, what dose will be necessary to produce the same effect with a circular applicator 3 cm. in diameter at a distance of 2 cm., the filter being 0.16 mm. brass and 1.2 mm. rubber? In this case it is again necessary to use the factors of Table II. The value for the tube, (a = 1.4 cm., distance = 1.43a) is 91.0 per cent x $\frac{1}{4}$ x 0.030, or 0.682 per cent. For the circle (a = 3 cm., distance = 0.67a), it is 64.3 per cent x $\frac{1}{4}$ x 0.40 or 6.43. Therefore the value from the circle is $\frac{6.43}{0.682}$ = 9.4 times that from the tube; the dose to produce the same effect is $\frac{250}{9.4}$ or 26.6 millicurie-hours.

Since it is frequently desired to compare doses, and the operation here outlined is rather complicated, it was thought desirable to calculate from these curves tables for certain definite applicators and definite distances, so that a comparison might be made directly. These are given in Table III. The effect due to the point source of unit strength, without filter, at a distance of 1 cm. is called 100, and all the other values are in terms of this standard. Therefore they are all directly comparable. It will be seen that in each case the calculations have been carried out for practical distances for the given applicator.

Now if we take example 4, and look in Table V for a 2 x 2 cm. square, filter 0.16 cm. brass + 1.2 mm. rubber, distance 2 cm., we find a value of 7.6; for a 4 x 6 cm. rectangle, filter 0.50 mm. brass, + 1.2 mm. rubber, distance 4 cm., we find a value of 0.126, which are just what we found previously from the curves.

Similarly, with Example 6: The value for the tube 1.4 cm. long would be about halfway between that of one 1.0 cm. long and one 2.0 cm. long. For a filter of 0.5 mm. brass and 1.2 mm. rubber, at a distance of

Table III

INTENSITIES OF RADIATION FROM DEFINITE APPLICATORS AT DEFINITE DISTANCES; POINT SOURCE, WITH SAME FILTER, AT DISTANCE OF 1 CM. = 100 UNITS IN EACH OF THE FOLLOWING SUBDIVISIONS

A—*Applicators without filter*

Distance, cm.	Point	*Tubes*—Length		*Circles*—Diameter					
		1 Cm.	1.5 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
0.25	1,600.0	890.0	672.0	656.0	283.0	106.0	57.6	41.6	25.8
0.50	400.0	314.0	262.0	279.0	164.0	70.8	40.0	26.4	19.9
0.75	178.0	157.0	140.0	148.0	103.0	52.8	31.5	21.4	15.3
1.0	100.0	92.8	89.3	89.6	69.7	41.0	25.6	17.7	13.3
1.5	44.4	43.2	41.2	42.4	37.1	25.7	18.2	13.1	10.0
2.0	25.0	24.5	23.9	24.3	22.4	17.4	13.3	10.2	8.02
3.0	11.1	11.0	10.9	10.9	10.6	9.27	7.74	6.42	5.45

Squares—Lengths of Side

	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.			
0.25	606.0	261.0	96.0	52.8	40.0	24.4	.....	.....	.....
0.50	265.0	152.0	65.2	36.0	24.0	18.5	.....	.....	.....
0.75	145.0	97.0	48.4	29.0	19.4	13.9	.....	.....	.....
1.0	87.5	66.2	37.9	23.6	16.3	12.2	.....	.....	.....
1.5	42.0	36.2	24.2	16.8	12.1	9.24	.....	.....	.....
2.0	24.1	21.9	16.6	12.4	9.48	7.38	.....	.....	.....
3.0	10.9	10.5	9.06	7.35	6.05	5.04	.....	.....	.....

Rectangles—Lengths of Sides

	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 8 Cm.	8 × 12 Cm.	10 × 15 Cm.			
0.25	478.0	195.0	70.5	35.2	20.8	15.0	.....	.....	.....
0.50	227.0	119.0	48.8	26.8	17.2	12.1	.....	.....	.....
0.75	130.0	79.5	37.8	21.7	14.2	10.3	.....	.....	.....
1.0	82.0	56.8	29.8	18.0	12.2	8.62	.....	.....	.....
1.5	40.4	32.4	19.8	13.2	9.40	6.68	.....	.....	.....
2.0	23.8	20.5	14.2	10.0	7.45	5.52	.....	.....	.....
3.0	10.8	10.1	8.10	6.30	4.95	4.01	.....	.....	.....

2 cm., this factor is 0.685. The factor for the circle 3 cm. in diameter at a distance of 2 cm., filter 0.16 mm. brass and 1.2 mm. of rubber, is 6.42. Therefore for the same dose the circle would produce $\frac{6.42}{0.685}$ or 9.4 times the effect. But since the same effect is desired, we must decrease the dose from the circle; it should be $\frac{250}{9.4}$ or 26.6 millicurie-hours.

Suppose we wish to compare the intensity of radiation on the skin from a dose of 500 millicurie-hours given with a circular applicator 3 cm. in diameter, filter 0.5 mm. brass and 1.2 mm. rubber, distance 2 cm. with that from a dose of 2000 millicurie-hours from a rectangular applicator 4 x 6 cm., filter 2.0 mm. brass and 2.4 mm. rubber, distance 4 cm. The factor for the first is 0.48 (assuming the 3 cm. applicator to have the average of the 2 and 4 cm. ones). Since this is per unit of dose,

Table III

B—Applicators with filter of 0.16 mm. brass, and 1.2 mm. rubber

Distance, Cm.	Point	*Tubes*—Length			*Circles*—Diameter					
		1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
0.25	640.0	235.0	132.0	51.2	126.0	34.6	10.2	5.76	3.20	1.07
0.50	160.0	103.0	57.2	33.0	80.8	31.4	8.64	4.00	2.56	1.78
0.75	71.2	55.6	37.2	20.5	49.2	25.7	8.40	3.85	2.35	1.50
1.0	40.0	34.6	25.8	14.7	31.2	20.2	7.84	3.72	2.16	1.40
1.5	17.8	16.6	13.9	9.28	15.8	12.3	6.24	3.48	2.10	1.37
2.0	10.0	9.62	8.56	6.44	9.36	7.80	5.04	3.04	1.96	1.33
3.0	4.44	4.38	4.12	3.48	4.31	3.91	3.08	2.24	1.44	1.15
	Squares—Length of Side									
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.				
0.25	114.0	36.0	9.60	5.76	3.20	1.05	....	....	....	....
0.50	74.0	28.5	8.00	3.68	2.40	1.74	....	....	....	....
0.75	46.4	23.4	7.60	3.59	2.06	1.35	....	....	....	....
1.0	30.4	18.5	7.12	3.40	2.00	1.32	....	....	....	....
1.5	15.5	11.6	5.84	3.16	1.90	1.21	....	....	....	....
2.0	9.24	7.60	4.64	2.76	1.78	1.20	....	....	....	....
3.0	4.28	3.87	2.91	2.05	1.46	1.06	....	....	....	....
	Rectangles—Lengths of Sides									
	Cm. 1 × 1.5	Cm. 2 × 4	Cm. 4 × 6	Cm. 6 × 9	Cm. 8 × 12	Cm. 10 × 15				
0.25	76.0	20.5	5.44	1.92	1.28	0.56	....	....	....	....
0.50	56.8	19.1	5.12	2.40	1.44	0.92	....	....	....	....
0.75	38.4	17.3	4.92	2.28	1.32	0.86	....	....	....	....
1.0	26.9	14.2	4.76	2.20	1.28	0.80	....	....	....	....
1.5	14.4	9.60	4.32	2.11	1.22	0.78	....	....	....	....
2.0	8.84	6.72	3.54	2.03	1.10	0.78	....	....	....	....
3.0	4.20	3.60	2.40	1.57	1.08	0.77	....	....	....	....

or, in other words, per millicurie-hour, this must be multiplied by the dose: 0.48 x 500 = 240. Similarly, for the rectangle the factor is 0.045. Multiplying this by the dose we have 90.0. Therefore the first applicator would give $\frac{240}{90}$ or 2.7 times as intense radiation on the skin as the second.

It should be noted that in these curves and tables the decrease in intensity of radiation given is due to increase in distance alone. If it is desired to consider the effect within the body, then the decrease due to absorption by tissue enters, and proper allowance must be made for this. At the present time, however, we do not know with any degree of accuracy the amount of radiation which reaches the deep layers of tissue.

According to the method outlined in Example 6, using the clinical doses given at Memorial Hospital as a basis for the calculations, a table (Table IV) of the dose.

TABLE III

C—*Applicators with filter of 0.50 mm. brass, and 1.2 mm. rubber*

Distance, Cm.	Point	*Tubes*—Length			*Circles*—Diameter					
		1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
0.50	12.0	7.60	4.68	2.28	5.34	3.68	1.03	0.52	0.32	0.24
0.75	5.34	4.17	2.83	1.62	3.66	1.94	0.82	0.46	0.28	0.19
1.0	3.00	2.60	1.90	1.17	2.36	1.49	0.70	0.39	0.26	0.18
1.5	1.33	1.22	1.04	0.71	1.17	0.91	0.48	0.30	0.20	0.15
2.0	0.75	0.71	0.64	0.47	0.69	0.59	0.37	0.24	0.17	0.13
3.0	0.333	0.32	0.30	0.20	0.32	0.29	0.23	0.16	0.12	0.09

Squares—Length of Side

Distance, Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.				
0.50	5.52	2.52	0.97	0.48	0.29	0.23	..			....
0.75	3.54	1.84	0.77	0.43	0.26	0.18	..			....
1.0	2.26	1.38	0.63	0.37	0.24	0.16				....
1.5	1.15	0.88	0.46	0.28	0.19	0.14				...
2.0	0.68	0.56	0.34	0.22	0.16	0.12				...
3.0	0.32	0.29	0.22	0.15	0.12	0.09			...	....

Rectangles—Lengths of Sides

Distance, Cm.	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 9 Cm.	8 × 12 Cm.	10 × 15 Cm.
0.50	4.41	1.84	0.64	0.30	0.18	0.14
0.75	2.93	1.42	0.55	0.28	0.17	0.11
1.0	2.02	1.10	0.46	0.26	0.16	0.11
1.5	1.17	0.73	0.35	0.20	0.14	0.09
2.0	0.65	0.50	0.28	0.18	0.12	0.08
3.0	0.31	0.27	0.18	0.12	0.09	0.07

in millicurie-hours for various applicators having a filtration equivalent to two millimeters of brass has been developed.

Not all of these doses have been tested clinically, but they have been found correct at extremes of the range covered in the table.

It is of interest to note that according to these calculations in the case of the thinnest filter, 0.16 mm. brass, at first the intensity of radiation increases as we increase the distance of the applicator. This is due to the shape of the curve of Figure 3, which will be seen to be very steep for this thickness, so that a small increase in filter cuts down the radiation greatly. From Figure 2 it is evident that, for applications close to the skin, a decrease in distance increases the filtration for points near the sides of the applicator, and where the change in absorption is rapid this may counterbalance the effect of distance. For thicker filters, where the curve is not so steep, this does not occur. (This point has not yet been tested clinically.)

At the Memorial Hospital, where different types of gamma ray applicators are used for different conditions, the erythema dose has been determined clinically for each one. The following four applicators, each with filtration equal to 2 mm. of brass, are used.

Table III

D—*Applicators with filter of 2.0 mm. brass, and 2.4 mm. rubber*

Distance, Cm.	Point	*Tubes*—Length			*Circles*—Diameter					
		1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
1.0	0.900	0.832	0.700	0.490	0.800	0.617	0.355	0.225	0.153	0.112
1.5	0.400	0.385	0.352	0.274	0.378	0.330	0.225	0.157	0.115	0.086
2.0	0.225	0.220	0.208	0.175	0.218	0.198	0.154	0.115	0.089	0.078
3.0	0.100	0.099	0.096	0.088	0.098	0.094	0.082	0.068	0.053	0.047
4.0	0.056	0.056	0.055	0.052	0.056	0.054	0.050	0.044	0.038	0.033
5.0	0.036	0.036	0.036	0.034	0.036	0.035	0.033	0.031	0.028	0.025
6.0	0.025	0.025	0.024	0.024	0.025	0.025	0.024	0.022	0.021	0.019
7.5	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.015	0.014	0.013
10.0	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.008	0.008

Distance, Cm.	*Squares*—Length of Sides									
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.				
1.0	0.756	0.571	0.328	0.210	0.144	0.104	.....	.....	.....	.....
1.5	0.373	0.310	0.210	0.146	0.090	0.081	.....	.....	.....	.....
2.0	0.215	0.189	0.143	0.107	0.082	0.064	.....	.....	.....	.....
3.0	0.097	0.094	0.077	0.064	0.053	0.043	.....	.....	.....	.....
4.0	0.055	0.054	0.047	0.040	0.036	0.031	.....	.....	.....	.....
5.0	0.036	0.034	0.032	0.029	0.026	0.023	.....	.....	.....	.....
6.0	0.025	0.024	0.023	0.021	0.019	0.018	.....	.....	.....	.....
7.5	0.016	0.016	0.015	0.014	0.013	0.012	.....	.....	.....	.....
10.0	0.009	0.009	0.009	0.008	0.008	0.008	.....	.....	.....	.....

Distance, Cm.	*Rectangles*—Length of Sides									
	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 9 Cm.	8 × 12 Cm.	10 × 15 Cm.				
1.0	0.728	0.497	0.255	0.148	0.098	0.070	.....	.....	.....	.....
1.5	0.360	0.287	0.172	0.113	0.078	0.056	.....	.....	.....	.....
2.0	0.212	0.182	0.112	0.087	0.064	0.048	.....	.....	.....	.....
3.0	0.097	0.090	0.072	0.055	0.043	0.035	.....	.....	.....	.....
4.0	0.055	0.053	0.045	0.038	0.031	0.026	.....	.....	.....	.....
5.0	0.036	0.034	0.031	0.027	0.023	0.020	.....	.....	.....	.....
6.0	0.025	0.024	0.023	0.020	0.018	0.016	.....	.....	.....	.....
7.5	0.016	0.016	0.015	0.014	0.013	0.012	.....	.....	.....	.....
10.0	0.009	0.009	0.009	0.008	0.008	0.008	.....	.....	.....	.....

Note.—It should be noted that in dividing up the applicators for purposes of computation, the outermost point considered was not at the edge but .05a farther in. Therefore, when taking the dimensions of an applicator for use with this table, the scale should extend slightly beyond the radium—one-twentieth of the whole width on each side.

Table IV

DOSE IN MILLICURIE-HOURS

Applicators having filtration equivalent to 2 mm. brass, and 2.4 mm. rubber

Distance, Cm.	*Tubes*—Length			*Circles*—Diameter					
	1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
1.0	173	206	294	180	234	406	640	940	1,285
1.5	374	409	526	381	437	640	918	1,250	1,675
2.0	654	692	824	661	728	936	1,250	1,620	1,850
3.0	1,455	1,500	1,640	1,470	1,530	1,760	2,120	2,720	3,060
4.0	2,570	2,620	2,770	2,570	2,670	2,880	3,270	3,790	4,370
5.0	...	4,000	4,240	4,000	4,120	4,370	4,650	5,150	5,760
6.0	.....	.....	6,000	.....	5,760	6,000	6,550	6,860	7,580
7.5	.....	.....	9,000	.....	9,000	9,000	9,600	10,300	11,000
10.0	.....	.....	16,000	.....	16,000	16,000	16,000	18,000	18,000

Distance, Cm.	*Squares*—Length of Sides					
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
1.0	190	252	439	686	1,000	1,385
1.5	386	465	686	986	1,600	1,780
2.0	670	762	1,000	1,350	1,760	2,250
3.0	1,485	1,530	1,870	2,250	2,720	3,350
4.0	2,620	2,670	3,070	3,600	4,000	4,650
5.0	4,000	4,240	4,500	4,970	5,540	6,260
6.0	.....	6,000	6,260	6,860	7,580	8,000
7.5	.....	9,000	9,600	10,300	11,000	12,000
10.0	.....	16,000	16,000	18,000	18,000	18,000

Distance, Cm.	*Rectangles*—Length of Sides					
	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 9 Cm.	8 × 12 Cm.	10 × 15 Cm.
1.0	198	290	565	974	1,470	2,060
1.5	400	502	838	1,275	1,845	2,675
2.0	679	792	1,285	1,655	2,250	3,000
3.0	1,485	1,600	2,000	2,620	3,350	4,120
4.0	2,620	2,720	3,200	3,790	4,650	5,540
5.0	4,000	4,240	4,650	5,340	6,260	7,200
6.0	.....	6,000	6,260	7,200	8,000	9,000
7.5	.....	9,000	9,600	10,300	11,100	12,000
10.0	.....	16,000	16,000	18,000	18,000	18,000

Table V

Applicator	Size, cm.	Distance of Application, cm.	Dose, mc.-hr.
"Pack"..........	8×12	6	9,000
"Pack"..........	8×12	10	20,000
"Block".........	4×6	4	3,200
"Tray"..........	4×5	3	2,000
Tube	1.4	2	830

If these are to produce the same skin effect, the values of Table III for these applicators, multiplied by the dose in millicurie-hours,[4] in each case, should give the same result. We have

Table VI

Applicator	Factor	Dose	Product
Pack (1)...........	0.179	9,000	1,610
Pack (2)...........	0.077	20,000	1,540
Block.............	0.454	3,200	1,453
Tray..............	0.745	2,000	1,490
Tube..............	2.14	830	1,775

[4] The values in Table III are per millicurie-hour.

It will be seen that the agreement is as good as can be expected. The result for the tube is a little higher than the others, but the erythema produced in this case is more definite than for the other applicators. The erythema produced by the tube with the dose given is a faint but distinct reddening of the skin, appearing in about 24 hours. This fades away, to be followed in about two weeks by a deep cherry-red "secondary" reaction. This, in turn, fades, leaving a definite bronzing, which persists for several months. The doses specified for the other applicators do not, in general, produce a very definite reddening of the skin. A slight erythema may appear, and later a tanning, but even this is not always present. These doses for the applicators have been determined clinically by different physicians, and have been used in the hospital on many patients, so that the identity of their effects is firmly established. The slight discrepancy between the doses for these applicators taken from Table IV and the actual clinical doses is explained by the fact that Table IV is calculated from one well-known dose, the "Tray" of Table V, while the other clinical doses have been determined empirically. However, this discrepancy, from a practical point of view, is slight.

Table VII

INTENSITIES OF RADIATION AT POINTS UNDER EDGE OF APPLICATOR FOR SMALL DISTANCES

Filter Brass*	Distance	Int. Center	Int. Edge	Ratio
None	0.025a	1.52	0.78	1.95
	0.05	4.63	2.39	1.94
	0.10	12.2	6.52	1.87
	0.25	29.5	22.2	1.33
0.16 mm.	0.025a	0.164	0.082	2.00
	0.05	1.09	0.528	2.06
	0.10	3.30	1.48	2.23
	0.25	11.95	8.40	1.42
0.05 mm.	0.025a	0.528	0.266	1.98
	0.05	1.92	0.973	1.98
	0.10	5.43	2.79	1.95
	0.25	15.5	11.35	1.37
0.75 mm.	0.025a	0.894	0.432	2.06
	0.05	2.94	1.44	2.06
	0.10	8.27	4.31	1.92
	0.25	21.1	15.5	1.36
2.0 mm.	0.025a	1.147	0.552	2.08
	0.05	3.92	1.93	2.03
	0.10	11.6	5.72	2.03
	0.25	28.4	21.3	1.32

* With each thickness of brass is used the thickness of rubber indicated in Table I.

For applications close to the skin, the clinician is interested not only in the effect at the point under the center of the applicator, but in that under the edge, and at intermediate points. To obtain this for all the applicators would involve a large amount of additional computation. However, for the square it is fairly simple, and the results thus obtained offer an approximation for the other applicators. For the square, considering the effect at a point directly under the edge of the applicator, the method of attack was the same as previously outlined. Table VI shows, for different filters and small distances, the intensities of radiation at this point relative to those at the point under the center. These values correspond to those of Table I, and those for different filters are not comparable. It will be seen that, for distances up to one-tenth the side of the applicator, the point at the center receives twice as much as that at the side, and then the ratio begins to decrease; that is, the intensity of radiation at the side approaches that at the center, and this approach is quite rapid. This would indicate that, for distances greater than half the side of the applicator, the whole area under the applicator receives practically the same intensity of radiation.

When the application is to be made very close to the skin, and the whole area under the applicator is to receive a uniform radiation, it is better to express the dose in millicurie-hours per square centimeter. In this case the present work is not quite applicable. This method will be the subject of a future paper.

SUMMARY

1. A method is outlined for determining the intensity of radiation from any applicator, in terms of the intensity from a point source of the same strength.

2. General curves are given for tubular, circular, square, and rectangular applicators, for filters of 0.0, 0.16, 0.50, 0.75, and 2.0 mm. of brass.

3. Several examples are worked out to illustrate the uses of these curves.

4. A table is calculated, from the curves, for obtaining the intensities of radiation from about 100 definite applicators, at several definite distances, in terms of the intensity from a point source of the same strength at a distance of one centimeter.

5. Doses in millicurie-hours are given for applicators having a filtration equivalent to 2 mm. of brass and 2.4 mm. of rubber.

6. Doses for different applicators, clinically determined at the Memorial Hospital, are shown to check the calculations and curves of this paper.

In conclusion, the writer wishes to acknowledge her indebtedness to Mr. G. Failla, for his suggestion of the problem, and for his interest during the progress of the work; to Dr. Archie Dean, for his cooperation in determining the skin doses from which the curve of Figure 3 was plotted; and to Mr. James Sarros, for assistance in many of the computations.

PROTECTION TO THE OPERATOR FROM UNNECESSARY RADIUM RADIATION*

BY ALBERT SOILAND, M.D.

LOS ANGELES, CALIFORNIA

ONE of the most pernicious habits of the average radium worker is to fondle and play with the radium containers. If we would leave them severely alone, except when in actual preparation for a patient, and then handle them only with proper discretion and care, radium radiation would soon cease to be a source of danger to the operator. Unfortunately, habits are easily acquired, the bad more frequently than the good, and the cure is difficult, particularly in the case of the innocent-appearing little radium particles, whose potency for harm is so completely disguised.

Protective measures, to be efficient, must be painstakingly thorough, and they will naturally be subjective according to the physical type and amount of radium handled. In institutional work, where emanation apparatus is in service, the greatest caution must be exercised in relation to the larger radium body, and also the coexisting unscreened form in which the active agent appears. Most of the serious injuries which have appeared in operators to date have occurred in laboratories where large amounts of radium emanation are employed. Happily, this danger is so well recognized that stringent protective measures are generally enforced.

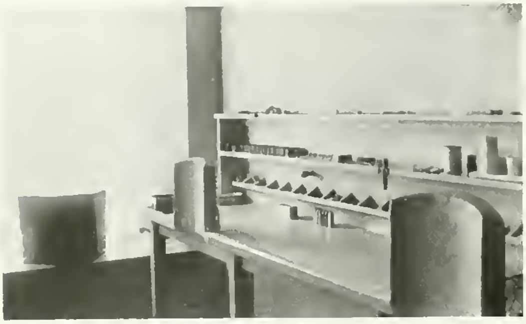
The object of these notes, therefore, is to call attention to the needs of the average radium worker, who imagines himself more or less secure from harm, because his radium element is already partially screened by metallic containers. That this is only false security, he realizes, when his fingers begin to show the characteristic trophic changes, and other constitutional disturbances become apparent, which are not accountable to other causative factors. It is to the increasing number of medical men who have qualified as radium workers, that these lines are addressed.

Adequate protection against unnecessary radium radiation is not at all difficult to obtain, and with a little care and common sense, it will soon become routine practice. The first thing to teach your operators is to maintain a respectful distance from all unscreened radiation. A few feet of air space is excellent. Next, instruct them to do all their work with long-handled forceps, and to work behind a suitable body screen, containing sufficient protective material to absorb all primary alpha, beta, and secondary beta radiation. In the writer's workroom, body screens are constructed with a curved face into which the body fits comfortably, enabling the operator to reach his radium applicators without undue muscular effort. A little practice soon accustoms the operator to the constant use of instruments, so

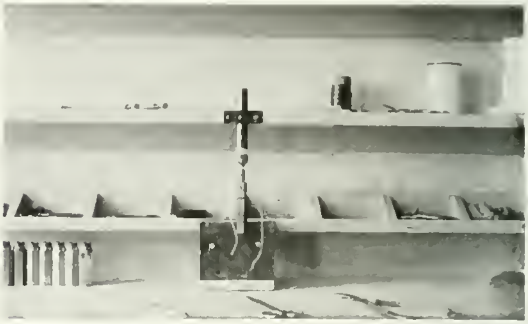
* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

that bare fingers are no longer fashionable. It is even quite possible to become so proficient in the use of the forceps that the thread binding the package is readily tied with them.

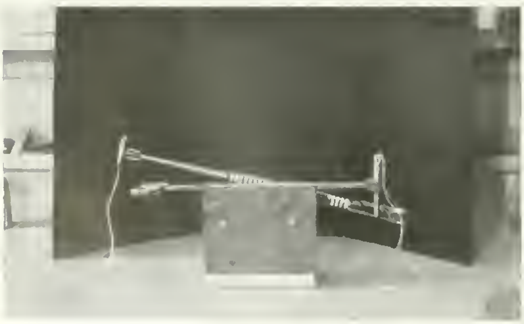
With fairly large quantities of radium in daily use, it is, of course, necessary to reckon with the accumulated gamma radiation, and to combat its influence. It is the custom in most laboratories to alternate operators, arranging for one month in the radium room and one month at other duties. A tabulated blood-count record, made at stated intervals, of all exposed to radium radiation, serves as a guide to the working time permitted in the radium room.



Showing general arrangement of radium workroom, with bench and shelving. Note protective curved body shields.



Tunnel and finger cot with attachments for preparing radium tubes, relieving fingers from contact with radium.



Extra large handled appliances for securing firm hold on radium tube or needle.

Solid lead block for housing radium needles, eye only protruding for threading.

It is a good habit, in making up radium packages, to prepare all the accessories in advance, so that the actual time period of the radium contact may be as short as possible. On removing a package from a patient where adhesive plaster is used, the time element of contact can be materially lessened by dropping the mass into a cup of benzine. This quickly releases the adhesive strips, and permits of housing the radium contents quickly.

In handling radium needles, use a lead block in which the active part of the container is safely surrounded leaving only the eye exposed for threading. This is an excellent and simple procedure for taking care of this type of applicator. In handling radium tubes, we use small tunnels, adjusted to convenient brackets in the shelf, which feed the containers into whatever receptacle fits the case, finger cots being commonly employed. The same sort of arrangement is used for the surface plaques, which are finally mounted on a flat wooden stick or metallic handle. In both cases, it is found unnecessary to use the bare hands.

Many dealers in radium are offering to the operators excellent protective devices, which have their various spheres of usefulness; and it is hoped that the day of unnecessary injury to radium workers is rapidly waning.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

DR. RUSSELL H. BOGGS: AN APPRECIATION

Dr. Russell H. Boggs, a charter member of the American Roentgen Ray Society, died suddenly at his home in Pittsburgh on the morning of June 2, 1922. He died of heart failure following a slight indisposition during which he had been confined to his house for about one week.

Dr. Boggs was born December 11, 1873, at Evans City, Pa. His family is one of the oldest in western Pennsylvania, having been here since 1763. His father was J. Walton Boggs; his mother, before her marriage, Sarah E. Johnston. He had several brothers and sisters, only two of whom reached adult life. His father died in 1896. His mother survives him.

He attended public schools in Allegheny and afterward attended the Pittsburgh Academy. He graduated in medicine from the Medical Department of the Western University of Pennsylvania in 1897. Following graduation, he opened an office in Allegheny and practiced general medicine for about a year. He then went abroad, where he became interested in dermatology and *x*-ray work. He studied at the St. Louis Hospital in Paris and at the University of Vienna, and it was there that he became interested in radiotherapy, which was later to become such an important part of his life's work. Returning to this country, he took a postgraduate course at the Skin and Cancer Hospital in New York City. He then came back to Pittsburgh and opened an office on Federal Street, Allegheny, where he installed *x*-ray equipment and began the practice of roentgenology. Two years later, he moved to the Empire Bldg. in Pittsburgh and retained offices in this building until he died. He was the first physician in Pittsburgh to make a specialty of roentgenology and to continue in that specialty. He began this work in the year 1900. His ability and enthusiasm soon gained him recognition in this new field, and we find him almost immediately a charter member in the American Roentgen Ray Society, the first large body of organized roentgenologists in this country. He was active in the Society from the first. Scarcely a year passed that he did not take part in the program. He was Secretary of the Society during the years 1904 and 1905, and Vice-President during the years 1905 and 1906. He was a regular attendant at all meetings, both annual and mid-year, and took an active interest in all the affairs of the Society.

Very early in his career, he became associated with the Allegheny General Hospital as roentgenologist. About the same time, he became Professor of Roentgenology in the Dental Department of the Western University of Pennsylvania, and was also Professor of Roentgenology in the Medical Department of the same institution in conjunction with Dr. Geo. C. Johnston of Pittsburgh. He held these positions with the Western University of Pennsylvania until it became merged into the University of Pittsburgh in 1908. He was also roentgenologist to St. Francis Hospital, Columbia Hospital and Pittsburgh Hospital, and consulting roentgenologist to Mercy Hospital. In his later years, he resigned from these hospitals one at a time until, at his death, he was connected actively only with the Pittsburgh Hospital. He was on the Staff of the Columbia Hospital as dermatologist and on the Staff of the Suburban Hospital in Bellevue, Pa. as consulting roentgenologist. At one time, he was also connected with the Sewickley Hospital.

Dr. Boggs was married first in 1899, to Blanche S. McCready of Allegheny, Pa. Mrs. Boggs died in the year 1910. He was married the second time to Etta A. Houck of Braddock, Pa., who survives him. He had no children.

He was always a voluminous writer, and appeared often before all the medical societies of which he was a member. How he ever found time to write so extensively, to do the *x*-ray work at his numerous hospitals, and to attend to a large private practice, was always a source of wonderment to his friends. The secret lay in his remarkable energy and ability to work long hours after the ordinary individual would be too fatigued to accomplish anything. His earlier work in roentgenology, like that of almost everyone else at that period, was devoted largely to the development of technique. He was one of the few roentgenologists in the country, however, who took much active interest in radiotherapy at this time. His diagnostic work was always of a superior quality, but as time went on, he became more and more interested in the therapeutic branch of his work. As soon as *x*-ray machines reached a stage of development where they could be depended upon to give uniform results, and after the invention of the Coolidge tube, he gave most of his attention to therapy, and it was after this time that his most brilliant work was done. In 1914 he began to use radium, and although he went into this work conservatively, he soon became enthusiastic and gave much of his energy to it. At the time of his death, he was one of the most expert users and one of the largest individual owners of radium in this country.

A perusal of his published writings impresses one in many ways, but I think most of all, it arouses admiration for his optimism. His enthusiasm for his work as the years went by, in the face of the disappointments which must have come to him as they come to all of us, always aroused in me great admiration. He was always enthusiastic about the work he was doing, or the work he was about to do. He had an unshaken faith in the value of radiotherapy, and in spite of all the fads and fancies which naturally come and go with the development of any science, he always stuck to his main purpose, which was the treatment of malignant disease. He held very strong views on certain points in regard to the treatment of malignancy, and seldom lost an opportunity to emphasize them in his writings, or in discussion. A few of them are mentioned here.

He believed that the treatment of malignancy should be a specialty, and that one following it should be competent to carry out any line of treatment that might be indicated in the individual case. He deplored the fact that non-medical persons were allowed to give *x*-ray treatments in medical institutions. For that matter, he was always opposed to non-medical persons doing radiographic work; and to the best of my knowledge, never employed a technician for this purpose, but had medical assistants. One of his most admirable qualities was his attitude toward young roentgenologists. He always encouraged them and did everything in his power to help them along. He took every opportunity to emphasize that incomplete operation of malignancy was worse than useless, as it always hastened metastasis and death; and that the removal of the center of a carcinomatous mass never retarded the disease, as there was a growing edge often far from the center of the lesion which was unaffected, or perhaps even had a better chance to grow after such operation. He held that the removal of adjacent lymphatic glands took away nature's barrier against invasion and did more harm than good. He had the same views about tuberculous glands. He thought that malignancy was always regional and not local when it was discovered. For that reason, the statement so often made that every cancer is curable at some stage by operation was misleading because, as a matter of fact, it was seldom or never discovered at that stage. Because cancer is a regional disease, it is useless to treat the local lesion without raying the lymphatics also. He took every occasion to emphasize the importance of raying the lymphatics of the chest in breast cancer, of the neck in cancer of the lip, and of the pelvis in cancer of the uterus. He usually used radium over the primary lesion and roentgen rays over the lymphatic distribution. He was one of the first to advocate ante-operative radiation in cancer of the breast, and he adhered to this consistently throughout his career. The last work in which he appeared to be most intensely interested was the imbedding of radium needles into the breast in inoperable cases of cancer, with radiation of the neighboring lymphatics, in the hope of making these cases operable. In his last papers he ventured the opinion that in time to come, all such cases would be so treated before operation.

In spite of the fact that he practiced roentgenology for nearly twenty-five years, and handled large quantities of radium for eight years, he never developed any serious burns. Although he had a few keratoses on his hands and some brittleness of nails, he never had any serious trouble, and could probably have practiced his specialty without hindrance from that cause for a long time to come. Probably his unusual freedom from burns was due to the fact that he never used the fluoroscope very much.

Dr. Boggs was a member of the County and State Societies, American Medical Association, Pittsburgh Academy of Medicine, American College of Physicians, The Roentgen Ray Society of Central Pennsylvania, American Roentgen Ray Society, The Radiological Society of North America and the American Radium Society. In the World War, he served as Lieutenant in the U. S. Navy.

He was a faithful attendant at the local medical societies, as well as the special societies. He was always seen at the meetings of the various Roentgen Societies and the Radium Society, and always took an active part in the program. He was interested in every new discovery and improvement in technique or apparatus, and was always among the first to adopt new ideas. One can easily see that he possessed a truly scientific mind; and this, together with his remarkable energy and enthusiasm, made of him a man of rare ability.

His wide experience will be sadly missed in the new era of radiotherapy upon which we are now entering.

A partial list of Doctor Boggs' articles is appended:

X-ray diagnosis of calculus. *Tr. Am. Roentg. Ray Soc.*, 1902.

Carcinosis of bone secondary to a growth in some epithelial organ. *N. York M. J.*, Dec. 2, 1911.

Roentgenological study of the alimentary canal. Read, Allegheny County Medical Society, 1914.

Progress made in radium and *x*-ray therapy. Read, Ohio Valley Academy of Medicine, Sept. 3, 1914.

Radium and mesothorium in conjunction with roentgen therapy. Read, American Roentgen Ray Society, Sept. 10, 1914. *N. York M. J.*, Dec. 12, 1914.

Value of radium, supplemented by cross-fire roentgen rays in treatment of malignancy. Read, Allegheny County Medical Society, Jan. 19, 1915.

Radium and mesothorium in conjunction with roentgen therapy. Am. J. Roentgenol., April, 1915.

The treatment of epithelioma by modern radiation. *N. York M. J.*, July 3, 1915. Read, Clearfield, Jefferson & Elk County Med. Soc., June 10, 1915.

The local application of radium supplemented by roentgen therapy. American Roentgen Ray Society, Atlantic City, Sept. 24, 1915.

The local application of radium supplemented by roentgen therapy. Am. J. Roentgenol., Feb., 1916.

The local application of radium supplemented by roentgen therapy. *Surg., Gynec. & Obst.*, March, 1916.

The treatment of tuberculous adenitis by roentgen rays. *N. York M. J.*, May 27, 1916. Read, Pittsburgh Academy of Medicine, Feb. 29, 1916.

The treatment of epithelioma of the lower lip. *Interstate M. J.*, 1916, xxiii, No. 5.

Treatment of leukoplakia by radium. *Texas M. J.*, Nov., 1916.

Differential roentgen diagnosis in bone diseases. *N. York M. J.*, Jan. 20, 1917.

Carcinoma of the uterus treated by a combination of radium and roentgen rays. Read, American Roentgen Ray Society, Sept. 20, 1916. Am. J. Roentgenol., May, 1917.

The treatment of malignancy by radium. *Med. & Surg.*, June, 1917.

Value of roentgen rays in diagnosis of carcinoma of the stomach. *N. York M. J.*, Aug. 25, 1917. Read, Roentgen Ray Society of Central Pa., May 26, 1917.

The treatment of epithelioma by radium. *Internat. Clin.*, 1917.

The treatment of acne by the roentgen rays. *Urol. & Cutan. Rev.*, Feb. 18, 1918.

Treatment of epithelioma of the lower lip by radium. *Urol. & Cutan. Rev.*, Feb. 18, 1918.

The treatment of carcinoma of the breast by the roentgen rays. *Interstate M. J.*, March, 1918.

The value and limitation of radiotherapy in internal medicine. *Med. Fortnightly & Lab. News*, March, 1918.

The comparative value of radium and roentgen radiation. *Penn. J. Roentgenol.*, May, 1918.

Post-roentgen treatment of carcinoma of the breast. Am. J. Roentgenol., June, 1918.

Radiation in the treatment of uterine fibroids. *Med. Council*, Dec., 1918.

Complications of influenza from the roentgenological standpoint. *Bull. Allegheny Co. Med. Soc.*, March 1, 1919.

The treatment of epithelioma by radium. *Am. J. M. Sc.*, July, 1919.
Treatment of goiter by radiation. Am. J. Roentgenol., Dec., 1919.
Radium in the treatment of carcinoma of the cervix and uterus. Eastern Section, Amer. Roent. Ray Society, Jan. 31, 1920.
Incompetent radium and roentgen treatment in malignancy. *Urol. & Cutan. Rev.*, Feb., 1920.
The value and limitations of radium and the roentgen rays in the treatment of disease. *Med. Council*, May, 1920.
The lethal dose of radium in malignancy. *N. York M. J.*, June 12, 1920.
Lethal and erythema dosage of radium in malignancy. Am. J. Roentgenol., Aug., 1920.
The treatment of carcinoma of the breast by imbedding radium supplemented by *x*-ray. Am. J. Roentgenol., Jan., 1921.
Treatment of malignant growths of the mouth and throat by radium supplemented by other methods. *J. Radiol.*, Jan., 1921.
Radium treatment of mouth and throat. *Penn. M. J.*, Dec., 1921.
Radium and deep therapy in the treatment of malignancy. *Radium*, Jan. and Feb., 1922.

In addition, the following articles have been written and published, but we are unable to secure the dates and the names of the journals in which they appeared:

Treatment of non-malignant diseases by the roentgen ray.
Physiological actions and therapeutic uses of roentgen rays.
The treatment of multiple glandular tumors.
Roentgen therapy in dermatology.
Review of roentgenology.
The treatment of malignancy in the mouth and throat.
X-ray as a means of diagnosis and therapeutic agent with report of a case.
The uses of *x*-ray in medicine and surgery.
Lethal and erythema dosage.
Protection of patient during roentgen exposure.
Treatment of cervical tuberculous lymphadenitis and tuberculous dermatosis by means of the *x*-ray.
The value of the roentgen rays in thoracic lesions.
The value of imbedding radium in addition to surface application of radium and *x*-ray in treatment of carcinoma of the breast.
Remarks on ichthyosis.
The technique of calculus diagnosis.
Tuberculous lesion illustrated by the roentgen rays.
Tuberculous adenitis and its treatment by radiotherapy.
The modern trend in the treatment of malignancy.
The value and limitation of radium in the treatment of cancer.
X-ray interpretation.
X-ray as a means of diagnosis and as a therapeutic agent, report of cases.
The radiographical examination of the gastro-intestinal tract.
Influenza.
Fibroids.
Comparative value of radium and roentgen radiation.
Differential diagnosis in bone disease.
Radium in the treatment of carcinoma of cervix and uterus.
The treatment of carcinoma of the cervix and uterus by radium supplemented by deep roentgen therapy.
The treatment of tuberculous adenitis by roentgen rays and radium.
Imbedding of radium throughout different parts of the body in malignancy.
Treatment of glandular metastases of carcinoma.
The lethal dose of radium in malignancy.
The treatment of tuberculous adenitis by roentgen rays and radium.
A comparative study of fractures of the extremities.

G. W. Grier.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page ix of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

A CHANGE IN THE NAME OF THE JOURNAL

At the last annual meeting of the American Roentgen Ray Society held at Los Angeles, California, the Executive Council unanimously decided to change the name of the Journal so as to read "The American Journal of Roentgenology and Radium Therapy." This step was thought advisable in view of the increasing prominence of radium therapy and the fact that the American Radium Society has made this Journal its official organ. This change will take effect in an early number.

Subscribers to The American Journal of Roentgenology *visiting New York City, are invited to make the office of* The Journal *(69 East 59th Street, New York) their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

Delherm and Thoyer-Rojat (Paris). Radiologic Study of the Great Vessels of the Base of the Heart. (*Gaz. d. hôp.*, May 21, 1921, xciv, 40.)

The work of the authors was performed on the cadavers of relatively young subjects, free from thoracic deformities and disease of the circulatory apparatus. The vessels of the base were first injected, for the details of which the reader is referred to Thoyer-Rojat's monograph (1919). As a result of the studies in question the authors are able to affirm that the shadow of the ascending aorta slightly overlaps the sternum to the right, and is doubled to the left by the shadow of the initial descending aorta. The pulmonary artery projects cleanly to the left of the origin of the aorta, while the left superior cava appears a little to the rear and cleanly to the right of the ascending aorta, overlapping the sternum broadly. These appearances all pertain to the frontal position; if now the cadaver is rotated 20 to 30 degrees into the right oblique position, the shadow of the ascending aorta and that of the initial descending aorta are superposed, giving the impression of the classic "glove finger." At the same time the pulmonary aorta tends to disappear behind the aorta, while up to 30 degrees of rotation the cava is projected to the left of the "glove finger" upon the vertebral column. If rotation is to 40 degrees the two aortic shadows are dissociated, the ascending passing to the right and the descending to the left of the observer, the pulmonary still behind the aorta, while the cava superior, conjointly with the ascending aorta, crosses the shadow of the descending. When rotation is carried to 50 degrees the two aortic shadows are separated, the shadow of the descending being nearly in contact with the vertebral column: the angle formed by the two branches of the aorta is quite acute. If now the cadaver is placed in the left oblique position at 30 degrees' rotation, the three portions of the aorta are cleanly dissociated, forming a figure 8; the pulmonary artery projects into the latter, while the cava superior shadow is confused with that of the descending aorta behind which it is projected.

What do these findings signify in the examination of the living? In the normal subject the descending aorta and the other large vessels escape investigation. If we wish, for example, to determine the caliber of the aorta, a special device, the beginnings of which go back to 1912, may be invoked. A framework for the support of the patient is mounted on a turntable, the axis of rotation corresponding to the posterior mediastinum. In the frontal position of the standing patient the visibility of the aorta is low, because it is so largely masked by bone shadows. Nevertheless this very absence of definition is of diagnostic value because it indicates a normal vessel. To obtain a correct idea of diameters it is necessary to use the oblique positions. Rotated 30 degrees to the right anterior oblique position, the vertebral shadow tends to dissociate itself from the cardiac shadow, the latter traveling to the observer's right and the former to his left. At 30 degrees a thin thread of light appears between the aortic shadow and the vertebral column, corresponding to the posterior mediastinum. The aortic image is now easily read. This is the optimum position, as further rotation will introduce new elements. The caliber may now be obtained by orthodiagraphic methods. As a check on the measurements the subject may now be rotated to the left anterior oblique position at an angle of from 30 to 40 degrees. The authors mention only the ascending aorta in this connection. This position is the one adapted to mensuration of the pulmonary artery. The article concludes with remarks on aortitis, aortic aneurysms and pathological states of the pulmonalis and cava, which are of sufficient interest for a separate study.

Bower, John O. Operating Cystoscope in Application of Radium to Cancer of the Rectum, following Colostomy. (*Surg., Gynecol. & Obst.*, April, 1922.)

The writer reports 3 cases of cancer of the rectum in which an operating cystoscope and a specially devised applicator were used to implant radium in the proximal portion of the growth.

Crossfire was obtained by inserting radium properly screened against the growth through the anus, by means of the following technique:

(*a*) Lower left rectus or inguinal colostomy under spinal anesthesia, the bowel being opened on the third or fourth day by thermocautery.

(*b*) On the seventh or eighth day the lower segment is flushed through a 25 F. catheter; when the fluid returns clear the cystoscope with irrigating tube attached is inserted, the obturator withdrawn, the telescope inserted and the special instrument holding the radium needle is introduced into the cystoscope. The radium needle with silk cord attached is imbedded in the growth. This is repeated until as many needles as required have been introduced. The free ends of the cord are secured by hemostat or fastened by adhesive to the patient's skin.

(c) Radium, properly screened, is inserted against the lower portion of the growth through the anus, using a rubber applicator.

The advantage of the method is maximum radiation due to accurate placing.

A. C. C.

Burrows, Arthur and Morrison, J. M. Woodburn. The Treatment of Exophthalmic Goiter by Radiations. (*Proc. Roy. M. & Chir. Soc.*, Section on Electro-Therapy, July, 1920, xiii, 132.)

The effects of *x*-rays and radium are considered by the authors, identical, and the difference in the usage of the two is taken up later.

They regard exophthalmic goiter as a well defined disease in which hyperthyroidism is definite, persistent and pathological by the time the case reaches the roentgen therapist. The cases are classified into three general types, namely, severe, medium and mild. Etiologically, three types are distinguished: (1) Cases which are pathological continuations of a physiological process such as pathological conditions following pregnancy and child-birth (these may overlap the next two classes); (2) cases following shock, which initiated the disease through the sympathetic nervous system; (3) the infective group, following pneumonia, influenza, fevers, pyorrhoea, etc. When treating any case of exophthalmic goiter by radiation of the thyroid, the writers believe it necessary to eliminate sources of chronic infection, diminish or mitigate the direct effect of shock, and, so far as possible, provide for natural mental and physical rest.

Their technique is given in detail. An endeavor is made to dose the whole of the gland and any accessory substernal thyroid at each treatment. This includes the thymus and the cervical sympathetics, but more reliance is placed on the thorough radiation of the thyroid than on these accessory areas. With the patient in the supine position, the head and shoulders slightly raised, and the head turned to one side, the whole of one lobe and a portion of the isthmus is exposed to a measured, filtered dose. Then the opposite lobe and portion of the isthmus is likewise exposed. A ten in. target skin distance is used with an oval-shaped extension tube which completely covers the lobe, reaching from just below the clavicle to a little above the upper pole of the gland, being directed upwards and inwards. Each lobe and isthmus receives an equal amount, the isthmus receiving half the amount given each lobe. The dose given each side, measured by Hampson's radiometer, after filtration, is 3H. With an alternative spark gap of 6 or 7 in. and the milliameter registering 3 ma., the time taken is from 9 to 10 minutes. The filters used are from 1 to 3 mm. of aluminum and three layers of felt. The majority of the cases from which statistics are taken received two treatments a week for three or four weeks, then one treatment a week. As the case progresses the intervals are extended first to fourteen days, then to twenty-one, then twenty-eight days, two months, three, and finally six months. When patients partially relapse, the intervals are shortened until satisfactory progress is obtained. The dosage given is approximately the same on each occasion. The cases are kept under observation after the disappearance of the symptoms so that a relapse may be detected and treated early. Most of the cases from which statistics are given have been under observation for from two to five years.

With radium, the great majority of the cases were irradiated by applying plates of the element or emanation to the skin over the enlarged gland. Plates of a strength of 2.5 mg. of the element, or 2.5 mc. of the emanation, to the sq. cm. are considered the best. The size and number used varies with the degree of severity of the case and the size of the thyroid gland. For a mild or ordinary case, 30 to 50 mg. are considered sufficient, but this is frequently increased, when necessary, to twice the amount. The plates are screened by 1.5 to 2 mm. of lead, and secondary radiation is effectually stopped by 24 to 36 layers of black photographic paper. Silver, aluminum, gold or platinum of the requisite thickness could be used as well as lead. Each piece of apparatus is inclosed in good rubber sheeting, and a piece of lint or wool may be put over the paper before the apparatus is made up, to make it more comfortable. Exposures of twenty-four hours are given every six weeks, the apparatus being fixed to the skin by adhesive strapping and bandages. The heavy treatments at long intervals are preferred. Caution is urged. The skin must be watched closely and should any reddening occur, treatment should be postponed

The writers look upon exophthalmic goiter as an example of vicious circle in disease. Ray treatment to one cycle, the thyroid, removes one link from the circle, without disturbing the nervous factor, for good or ill. They concede that widespread irradiation including the anterior aspect of the neck and upper chest often seem to give better results than the more local application, but they believe that this is due more to the greater dose received by the thyroid than to any action on the thymus or cervical ganglion.

In their experience, the immediate effect of radiation seems to be an inhibition of the secretory function of the gland. The lowered pulse-rate will rise again after an interval if no further treatment is given. Prolonged treatment sets up a more permanent fibrotic process. Removal of the thyroid factor in bad cases may leave behind ameliorated, but still severe, nervous symptoms, such as palpitation, exophthalmus, indigestion and rarely diarrhea. The symptoms usually abate a great deal, however, as time goes on. It is in connection with these cases that the interval of complete stoppage of both *x*-ray and radium treatment is so useful. Too vigorous a rest and dietetic treatment should be avoided because of the depressing effect on the patient. Rather, they should return as nearly as possible, during that interval, to normal life.

The first sign of improvement is a feeling of well-being, and it is usually observed by the end of the third week. The pulse-rate, as a rule, after a quick drop, is followed by a slight rise and gradually gets slower, as low as sixty per minute. The writers state that they have never seen a case of artificially produced myxedema after even the most prolonged and severe treatment. To their minds, should it occur, it would be but a proof of the efficacy of the rays in the treatment of hyperthyroidism. Some slight quickness in the pulse rate may remain. The increase in the weight of the patient is, to them, the best indication of good progress toward recovery.

During recovery no particular symptom or sign goes first, but all gradually diminish except that the exophthalmus is the last to go, and may remain in a patient virtually cured. If the thyroid enlargement is not of long standing it steadily grows smaller under treatment and after. Intercurrent disease and foci of infection delay the favorable progress of the case. They must be removed. The blood picture is of no help in determining the progress of the case.

Prognosis is difficult. Very severe cases are often spectacular in progress, but the end results are not so good as in the mild ones. The most difficult to treat are those in which the exophthalmic type has developed in a case of old simple goiter. In these the treatment is prolonged, the progress slow. The acute toxic cases are considered hopeless by the writers, and they believe that such cases should not be treated by radiation. Only one death is reported (under the heading "not improved" in the radium column).

The results are given in table form, "perfect" meaning no symptoms or signs remaining; "good functional," that the patient can follow an ordinary, not too arduous life; "improved," that the patient is undoubtedly better than when treatment was begun; "abandoned treatment" includes those cases in the service and those who moved away. The tables are for a series of 100 consecutive cases treated with *x*-rays, and the first 100 cases treated by the authors with radium.

	X-Rays	*Radium*
Perfect	27	20
Good functional	49	20
Improved	20	40
Abandoned treatment, not improved	4	20

In summarizing, the writers discuss the advantages and disadvantages of the medical and surgical treatment of exophthalmic goiter and conclude by saying that they do not think there is evidence that any treatment of exophthalmic goiter gives such safe, uniform and promising results as irradiation of the thyroid gland.

Karl F. Kesmodel.

Halphen and Cottenot (Paris). Clinical Cure of a Spinocellular Cancer of the Larynx by Roentgenotherapy. (*Rev. de. laringol.*, etc., Nov. 1, 1921.)

Despite the short interval since treatment the result in this case is so clean-cut that the authors feel obliged to publish it. The diagnosis made by biopsy is beyond doubt.

Patient, a man of fifty-eight, seen Nov. 30, 1920; had complained of his larynx for two months. The symptoms were local, the general condition being good and unimpaired. The mirror showed a papillary, mulberry-like growth on the lingual face of the epiglottis, which somewhat obstructed the view of the cords. There was a second lesion of the same nature midway in the right cord. A piece was taken from the epiglottic lesion for biopsy and the pathologist reported spinocellular epithelioma. The regional lymph-nodes showed no enlargement.

Preliminary tracheotomy was performed Dec. 30th. Total laryngectomy and radium had been deferred until the *x*-rays could be given a test, which was begun ten days after tracheotomy. From Jan. 11th to the 17th six daily applications were made of very penetrating rays equal to 20 cm. spark, filtration 8 mm. aluminum. Rays were applied on both lateral aspects at the level of the thyroid plates. The total dose for the six sessions was 44H. There was a slight external reaction, but nothing within the larynx. The improvement was so striking that in ten days it was hardly possible to recognize the epiglottic growth. The lesion on the cord, however, was still visible, so that 6 more daily sessions were given, from Feb. 9th to the 15th. The administration and dosage were the same, and eight days after the last session the entire larynx was quite clean. There was no sign of any recurrence on March 18th, but two extra sessions were given prior to extracting the tracheotomy tube. The total given was 15H. The tube was extracted April 5th.

Since this period the patient, although not apparently affected in weight by his disease, has put on 12 pounds and continues free from local trouble.

The result is the more remarkable because spinocellular cancers are naturally malignant and radioresistant. He was last seen July 10, 1920, and nothing has been heard from him since. His home is in Constantinople.

An important question is "Was the preliminary tracheotomy necessary?" The author replies "Yes," and for two reasons. First, the larynx is put at functional rest; second, the use of penetrating rays is likely to cause some edema of the larynx. This did not develop in the present case; nevertheless the author would do the same thing again under the circumstances.

Steiger (Berne). Pregnancy and Labor after Radiation of a Myomatous Uterus. (*Schweiz. med. Wchnschr.* Nov., 24, 1921.)

The patient was thirty-nine, had borne four children before 1907, and then had no conceptions until 1914, when she had an abortion in the tenth week. She entered the clinic June 1917 with a fibroid uterus. She also had exophthalmic goiter (a condition believed to favor sterility). She was rayed 3 times—June 7th, June 21st and July 5th. The tumor was now seen to be smaller. She was given a second series of two sessions between July 19th and Aug. 2nd. Tumor now notably smaller. Menstruation July 19th and July 28th each lasting three days.

Seen again the following November (1917). Amenorrhea since September 22nd. Goiter worse, and the thyroid was treated with the rays until May, 1918. This condition was notably improved. She had received some *x*-ray treatment of her neck before consulting for fibroid.

Next seen October 8, 1919; believed herself pregnant. Seen January 14, 1920. Fetal heart sounds heard. Confined April 20th. Infant born at term. Unable to nurse it. Child strong, well formed. Menstruation resumed. Fibroid size of fist. Goitre became aggravated during pregnancy. This case shows that despite radiation of the ovaries (of a woman not likely, from her clinical history to conceive) conception took place and gestation went to full term, the child being free from malformation. The author theorizes at great length.

Pincherle. Radiography of Tumors of the Left Hypochondrium. (*La Radiol. Med.* July, 1921.)

In all cases in which ordinary resources are insufficient for diagnosis in suspected tumors in this region, the *x*-rays may be invoked. Neoplasms may of course originate in the spleen, stomach, intestine, left kidney, pancreas, retroperitoneal glands, mesentery, etc. A condition confounded with tumors is subphernic abscess, and in the female, tumors in the left hypochondrium may originate in the genital apparatus.

The indirect radiological examination, based on the relation of the neoplasm to the viscera of this region, is often of great service. The spleen is but little accessible to a direct examination, although when enlarged it is the more readily visible, giving then an ovoid shadow, homogeneous and smoky, not well outlined against the surrounding structures. It often happens in the indirect examination that the gas bubble of the stomach is shifted toward the middle line, while not affected in respect to its relation with the vault of the diaphragm. Much advantage accrues from artificial pneumoperitoneum.

Pincherle's technique in the examination of the digestive apparatus in suspected tumor of the left hypochondrium is as follows: On the evening preceding the examination a saline purge is given, and on the morning following, an enema. The patient fasts up to the time of examination, when he is placed supine on the trochoscope and is given an enema of 300 gm. of gelatinized barium in 800 gm. of water. He is then examined in the erect position from the side.

In regard to pancreas tumors, several Italian radiologists have recently published reports. In these cases, diagnosis is based on the behavior of the stomach, which is, however, equivocal, because in addition to its own variability there should be reckoned the alterations due to the presence of the tumor. The most important datum is the displacement of the stomach, which may, according to the case, be to the right or left.

There are numerous records which show that tumors of the spleen and left kidney may produce a depression of the left flexure of the colon from its habitual subdiaphragmatic position.

This depressed flexure then stands behind the lower pole of a splenic tumor, while if the neoplasm is of renal origin it stands above and is often displaced mesially. In renal tumor with marked ptosis the neoplasm may be seen in a space bounded above by the transverse colon and externally by the descending colon.

Subphrenic abscesses are usually displaced below the splenic flexure, while indirect radioscopy shows that the gas bubble in the stomach is depressed, compressed and at times displaced mesially. Tumors of the pancreas do not usually modify the left flexure, but may compress and displace the stomach. The left half of the diaphragm is often elevated, while often tumors of the left hypochondrium and especially subphrenic abscesses interfere with the play of this structure.

WISSING, OVE (COPENHAGEN). Comparative Researches upon the Motility of the Stomach. (*Acta Radiol.*, 1922, i, Fasc. 3, 243–261.)

The majority of normal stomachs empty within two or three hours after the opaque meal is digested, and in the majority of cases the barium gruel passes through the stomach somewhat more rapidly than the bismuth gruel.

There appear to be certain stomachs, normal in other respects, which possess an astonishingly irregular motility.

The motility of the stomach has been examined in 217 patients suffering from various complaints of the digestive canal; the examinations were made either six hours after Kemp's test-meal, or five hours after the ingestion of barium gruel (with 150 gm. of sulphate of barium). A retention of the barium after five hours ought probably to be considered as a manifestation of a motor incompetency, and for this reason the author recommends making the radiological examinations of the motility five hours (and not six) post coenam.

The radiological test cannot be entirely substituted for the clinical method, but the two tests can complement each other, for, by employing both, an increase in the duration of the evacuation is found more often than when one of these methods is used.

A retention of the barium for twenty-four hours (pseudo-retention) may exist without there being any ulcerous or cicatricial changes at the level of the pylorus; thus, for instance, in atony, and when ulcers are in the body of the stomach.

In gastric ptosis, neither the low position of the stomach nor an atonic condition of the organ, nor both these factors combined, appear to have a cardinal influence on the duration of evacuation.

EIKEN, TH. (COPENHAGEN). Clinical Examinations of a Four Hours' Roentgen Retention. (*Acta Radiol.* 1922, i, Fasc. 3, 262–265.)

On comparing the different groups, it may be said, as a general rule, that the further away the disease is removed from the stomach, the less is the influence on its emptying capacity.

As a result of the examinations the author ventures to say that, in a four hours' roentgen retention we have a delicate test of the emptying capacity of the stomach, a test which, however, must always be judged in association with the other clinical findings.

P. FLEMING, MÖLLER (COPENHAGEN). Roentgen Examination of Ileocecal Tuberculosis with Special Reference to the So-called Stierlin Sign. (*Acta Radio.* 1922, i, Fasc. 3, 266–273.)

The so-called "Stierlin Sign" in ileocecal tuberculosis has not the great diagnostic value which Stierlin has ascribed to it. It is certainly a relative rarity.

The roentgen-ray picture of ileocecal tuberculosis, and the other tumor-producing complaints in the ileocecal region, commonly corresponds to the well-known picture of other tumor formations in the digestive tract, and has as diagnostical signmarks:

1. A pathological diminution of the shadow of the caecum-ascendens;
2. An abnormal shape and contour in analogy with the shadow defects in cancer ventriculi;
3. An inexpansibility and stiffness of the intestine wall.

ÅKE, ÅKERLUND (Stockholm). The Niche Symptom in Carcinoma Ventriculi. (*Acta Radiol.*, 1922, i, Fasc. 3, 274–283.)

The internal treatment of niche-formed gastric ulcers, which is being ever more and more employed, brings increased responsibility in its train for the roentgenologist in the interpretation of verified gastric niches.

According to a report on the rather sparse roentgen-ray literature appertaining hereto, over 7 cases of niche-formed, carcinomatous gastric ulcers are recorded, which have come under observation during the period of a few years. In 3 of these cases the correct diagnosis was made at the first roentgenological examination; in a further 2 it was expressly stated that carcinoma could not be precluded.

It can happen that the determination of acidity in niche-formed, cancerous ulcers gives normal values. The presence of niches in older persons, hitherto healthy, is to be interpreted as a serious warning; atypical niche localization is also suspicious of carcinoma.

The tracing of a hard, stiff, wall- or plateau-like infiltration in the neighborhood of the niche—which infiltration can now and again appear more distinctly on the plates that have been taken from direct compression—strengthens one in this suspicion. In uncertain cases a speedy control-examination should not be neglected.

Kreuxfuchs, S. & Schumacher, O. (Wien). The Topographical Conditions of the Interlobular Fissures of the Lungs. (*Acta Radiol.*, 1922, i, Fasc. 3, 284 307.)

If we summarize the most important experiences from our investigation, we arrive at the following:

The median interlobar fissure is triangular in shape, with dorsal, short base and ventral apex. The anterior and lateral surface is steep and curved convexly.

The lateral border or the median interlobar incisure (fissure-inlet) is frequently adherent medially, descending forwards. It presents the form of a recumbent *S*, but is also curved in conformity with the thoracic curve.

The posterior border or section-line with the principal fissure represents the cut of the middle lobe wedge and lies transversely in the transverse section of the body. But this line is often not to be seen on the floor of the fissure, as parenchymatic or pleural bridges extend from the posterior lobe to the middle lobe.

The medial border forms the pleural sac from the superior lobe to the middle lobe. It always lies in a sagittal direction, and can reach to the medial anterior border of the lung.

The fissure is so located in respect to the hilus that its most posterior and medial point lies exactly opposite to the so-called depth of the fissure, hence the "hilus-near point." The level of the fissure is between the hilus-centre and the lower margin of the hilus.

The principal fissures show right and left differences in regard to the direction of their course, the curve of their surfaces, the height of their dorsal portions and the section-line of the base of the lung; both are approximately oblong and surround the hilus at the medially located pleural sac; their surfaces are therefore approximately kidney-shaped. The left one extends higher up, the highest dorsal point lies in a third of the apex-distance of the diaphragmatic dome, the medial anterior border-line lies farther medially than to the right, the base of the lung is cut farther forward than to the right.* Both are propeller-shaped; the right one more pronouncedly so than the left.

*The curving to the left is more steep than to the right.

Klason, T. (Stockholm). Radiological Methods for the Determination of the Conjugata Vera. (*Acta Radiol.*, 1922, i, Fasc. 3, 308–318.)

The procedure for the radiological measurement of the pelvis is given in the employment of the localization method of Mackenzie-Davidson. The method is based on the works of Manges, Runge & Gruenhagen, Guilbert, Léby-Solal, etc.

Two exposures are necessary. For the execution of the measurement the focus plate distance, the displacement and the orthoprojection of the focus on the plate must be known. These points are marked on the cassette holder by the help of a mirror arrangement with lead marks. For measurement, the plates are placed on each other in the same position as for their exposure, after which the images of the lead marks and the images of the end-point of the required diameter are drawn on tracing-paper. A stereoscope is then often necessary. These latter are to be connected with the focus-point appertaining hereto, and the distance of the point of intersection thus obtained gives the orthoprojection of the required diameter. The height of both end-points above the plate level must also be determined. By the base of the rectangular triangle that is formed from the focus, its orthoprojection and the image of the end-point, one knows the orthodiagraphic projection of the required point and has thereby all values that are necessary for the calculation of its height above the plate level. The lesser height is now deducted from the greater, and from the one end-point of the orthoprojection of the required diameter the figure obtained is recorded in cm. The distance between the point so obtained and the other end-point of the orthoprojection of the diameter gives the required diameter.

The conjugata vera of a symmetric pelvis can also be determined by a single exposure, if the orthoprojection of the middle line and the focus are noted on the plate (the focus laterally from the middle line). The determination takes place in a manner analogous to the previous one.

If during the exposure two metal rods are placed vertically on the plate level—one of them provided with a centimeter scale—the determination can be effected also through a construction, without knowing the focus plate distance and O-point (see further in the article).

By making lateral exposures of the pelvis, the author has, with the employment of sufficiently hard tube and careful development, obtained plates on which the symphysis as well as the promontory appear with satisfactory distinctness. It was thus possible to determine the true conjugate of a symmetric pelvis, if the plate had been placed parallel with the sagittal level of the body, and the focus plate distance as well as the distance of the focus middle line were known.

Panner, H. J. (Copenhagen). A Peculiar Characteristic Metatarsal Disease. (*Acta Radiol.*, 1922, i, Fasc. 3, 319–333.)

A metatarsal disease arising during the period of growth (at the age of ten to fourteen) is found which almost always is localized to the second metatarsal.

The disease falls into the category of diseases to which belong Calvé-Perthes's hip-disease, Koehler's disease in os naviculare pedis, Schlatter's disease in the tuberositas tibiae, and the spinal disease described by Scheuermann.

The primary starting point is the capitulum metatarsi, that is, as in the other cases, in an epiphysis; secondarily, arthritis deformans-like alterations may appear in the joint as well as thickenings of the diaphysis; often the last stage is, however, only a more or less marked deformation of the head of the joint itself.

The progress of the disease is mild, the symptoms not infrequently so slight as to be left quite unheeded, and a thorough treatment is but seldom necessary.

The changes are therefore frequently found only by an accidental roentgen-ray examination, and the latter gives (as is also the case in the above-mentioned disease) such characteristic pictures that the diagnosis will thereby be established.

Baastrup, Chr. I. (Copenhagen). Os vesalianum Tarsi and Fracture of Tuberositas Ossis Metatarsi V. (*Acta Radiol.*, 1922, i, Fasc. 3, 334–348.)

At the proximal extremity of the fifth metatarsal appear two forms with the likeness of epiphysis.

1. The "apophysis," a frequent, perhaps constant shell-formed epiphysis on the latero-plantar part of tuber. V. The ossification of it commences in the tendon of musc., peron. brevis.

2. The proximal part of tuber. V has now and then a certain independence showing a special centre for ossification. Occasionally a terminal form like an epiphysis may be seen, which at autopsy in the 3 cases hitherto examined has proved to be not an epiphysis but an independent bone: Os Vesalianum tarsi.

Tuberositas ossis metat. V corresponds morphologically, phylogenetically and ontologically to the vanished os tarsale V in the distal row, and os Vesal. must be understood as an atavically appearing os tarsale V.

The fact that os Vesal. is so seldom found, though more frequently than was formerly supposed, supports the supposition that os tarsale V disappears at an early stage in the development.

In further agreement with this theory is the fact that an os tarsale V is only found in toads, reptiles, and in the embryonic life of the lower class of mammals.

The theory is sustained by the mutual position of the bones in the early stages of the human embryonal life.

Now and then os Vesal. and the above-mentioned apophysis are mistaken for fracture of tuber. V. Several different circumstances in the anamnesis and in the roentgen-ray photos help to make the differential diagnosis.

The usually stated criterion for recognition of the genuine bones—that they are bilateral—cannot be maintained as a necessary claim.

Westman, Axel (Stockholm). Blood Changes by Roentgen and Radium Treatments. (*Acta Radiol.*, 1922, i, Fasc. 3, 349–357.)

The author has studied the blood changes in patients treated by roentgen-rays and radium. In both cases the changes are absolutely identical, only varying in degree according to the intensity of the irradiation. The changes of the red corpuscles are characterized by a slight increase in the number of erythrocytes as well as in the quantity of hemoglobin and the globular value, which are very differently expressed in the different patients, and which persist for a more or less lengthy period.

No certain conclusions can be drawn from these changes; they do not appear to be able to give any aid towards forming a prognosis. The changes of the white corpuscles are much more pronounced. After a few weak doses, corresponding approximately to a treatment for castration, an initial increase is obtained in the leucocyte count, caused by the neutrophile polynuclears, and on the fourth to the sixth day a decrease in the leucocytes occurs, followed by a slow retrogression towards the initial values. The leucocyte count remains constant. The changes in the blood, after the irradiation of tumors, belong to another type. By means of curves, it is shown how, after the irradiation by radium of uterine cancer, a transient increase of leucocytes is at first obtained and finally a decrease in the polynuclears and the leucocytes. At the end of but a few months, the blood-picture has returned to its normal value. In the case of irradiations of mammary cancer after the operation, where there is no secondary toxic effect from the resorbed tumors, the initial increase of the leucocytes does not take place. The changes in the eosinophile blood-picture are attributed to a secondary toxic action proceeding from the tumescent resorption. The cases favorably influenced by the radiological treatment show much less marked blood changes immediately after the irradiations and a much more rapid repair, especially of the lymphocytes, than for the refractory cases. Consequently, the examinations of the blood may serve as a guide in respect to the prognosis.

Heyerdahl, S. A. (Christiania). Treatment of Malignant Tumors with Radium Needles. (*Acta Radiol.*, 1922, i, Fasc. 3, 358–365.)

The previous favorable results of the treatment of malignant tumors with radium embedded in needles confirm what has also been experienced from other quarters. Embedded in the tissue of the tumor, the radium exercises throughout a much greater influence on the tumor than when applied on the outside, and it is also much more lenient towards the surrounding healthy tissue.

Tumors which had formerly been treated on the outside with radium, without any result, vanished after the embedment of radium in the tissue of the tumor.

As these observations have been made in rather a short time, they must, of course, be considered as quite preliminary.

Laederich and LeGoff. A Case of Painful Gynecomastia Cured by Radiotherapy. (*Bull. et mém. Soc. Méd. des Hôp. de Par.*, May 18, 1922, xxxviii, 764.)

A vigorous man, seventy-seven years of age, a year before examination began to complain of extreme sensitiveness of the breasts, which had begun to enlarge in a lively fashion. Examination of his other organs gave negative results, especially the testicles. It is stated that this condition frequently follows disease of the testicles. After four radiotherapeutic applications given at weekly intervals to the right breast, it was found to have diminished notably in size; the spontaneous pains had disappeared, but the hyperesthesia to pressure and movements, although lessened, still persisted. The left breast had not altered during this time. Treatment with the roentgen rays was then administered to the left breast in a similar manner. The final result was all that could be desired, all the pains and inconveniences having disappeared, and the breasts having diminished in size almost to the normal.

J. T. C.

Loeper, M. and Baumann, J. The Action of Pepsin on the Motility of the Large Intestine. (*Bull. et mém. Soc. Méd. des Hôp. de Par.*, May 11, 1922, xxxviii, 726.)

To a certain number of patients with simple constipation (the dyschesic type of Hurst), the authors administered pepsin in subcutaneous injections of 20 cm. in solution in one c.c. of physiologic salt solution, after a preliminary control of the position of the large intestine by fluoroscopic observation twelve or thirteen hours after a barium meal. The effect of pepsin on the large intestine does not appear until after thirty to forty minutes and lasts only ten to twenty minutes. Intestinal peristalsis and muscular tonus of the bowel are excited, the effect being most marked in the cecum, ascending and right half of the transverse colon. Visible peristaltic movements are not seen, but there are very definite modifications of form indicating a temporary exaggeration of muscular tonus, manifested in some cases by a considerably more rapid evacuation of the cecum, in others by deeper and more numerous incisures in the transverse colon. The injections of peptone made under similar circumstances gave no appreciable effects. Patients suffering from so-called spastic constipation showed marked aggravation of this condition; whereas cases of atonic constipation with muscular and motor insufficiency exhibited definite acceleration of the intestinal transit. Untoward symptoms were nausea, and a tendency to vertigo and syncope. The pepsin probably acts through the vagus nerve. Many physiologists have admitted that the right colon is under the influence of the vagus nerve, and the experiment of Lebon and Aubourg in 1911 caused contractions of the ascending colon by excitation of the pneumogastric nerve.

J. T. C.

Terry, Wallace L. Radium Emanations in Exophthalmic Goiter. (*J. Am. M. Assn.*, July 1, 1922, lxxix, 1.)

The author and his associates at the University of California Hospital have treated 33 cases of extreme hyperthyroidism due to hyperplasia of the thyroid with the idea of converting them into better risks for major surgical procedures. No elaborate skin preparation is made. The operation is done at the office or at the bedside. For local anesthetic the author prefers to chill the sites selected with a small cotton sponge saturated with ethyl chloride.

Then the minute capillary tube containing the emanation is introduced into the gland by means of a small-caliber, hollow needle, and is pushed into place by a plunger. Usually six emanation tubes, containing a total of from 6 to 10 mc. are inserted in the upper, middle and lower thirds of each lobe and through one skin puncture on each side, the tubes being buried at least half a cm. in the thyroid. When the cases came to operation the author found that no adhesions were present, or that they were minute points where the needles had entered the gland. The adhesions were less than are found after ligation of an artery.

Results were checked in 16 of the cases. Fourteen were operated upon (resection) after intervals varying from thirty-two to one hundred and fourteen days after radium. Four of the 14 died from various causes. Ten are definitely cured after resection. In 2 cases there has been an apparent cure after radium alone. In one the basal metabolic rate was reduced in four months from 122 per cent plus to 12.9 per cent plus. In the other, the basal metabolic rate was reduced in four months from 84.4 per cent plus to 5.7 per cent plus.

The author considers radium contraindicated in the adenomas for the same reason that the roentgen ray should not be used, viz., the danger of producing atrophy of the thyroid gland proper and consequent hypothyroidism.

J. T. C.

Heyerdahl, S. A. (Christiania). The Treatment of Myoma Uteri and Menorrhagia with Radium and Roentgen Rays. (*Acta Radiol.*, 1922, i, Fasc. 3, 366–371.)

Of 30 patients suffering from myoma uteri, 25 were exclusively treated with roentgen rays, and 5 were given combined roentgen-ray and radium treatment.

In 25 cases a good result was obtained: cessation of the menses together with complete or partial disappearance of myoma in most cases. Five patients were operated upon after the roentgen-ray treatment. Of 13 patients suffering from menorrhagia, 12 cases attained to a complete cessation of the menses. In one case there was a recurrence and later on an operation.

Hoffman, K. (Dresden). Appendicitis in Pregnancy. (*Arch. f. Gynaek.*, 1920, cxii, 230.)

The alleged displacement of the appendix by the gravid uterus is a subject which has caused much controversy, and Füth has claimed that in the latter months of gestation the cecum is forced well up in the abdominal cavity. This view has, in fact, been widely accepted, and the author after research is compelled to dissent from it. His roentgenograms show the cecum in normal position, making no unusual attempt to bring out the appendix. In one of his illustrations this organ appears naturally and is seen to hang down into the lesser pelvis. The 39 women whom he examined lay prone on the plate. He gave 100 gm. of barium sulphate mixed with 200 gm. of grits pulp. The earliest period at which the cecum became visible was six hours.

Diagrammatic sketches made from the plates show the positions of the cecum and fetal head and spine. The duration of gestation varied. The findings were as follows: In 86.5 per cent the cecum lay at a level below that of the iliac crest, while in 4 cases it was at the crest, and only once above. No relationship could be traced between the size of the uterus, tone of the abdominal wall and displacement of the cecum.

Reinhard, W. (Hamburg). Unique Case of Swallowed Foreign Body. (*Zentralbl. f. Chir.*, 1919, xlvi, 260.)

A man of twenty-two, in a suicidal attempt, swallowed a slender iron brace 22 cm. long by 2 cm. broad and 0.5 cm. thick. For two days he felt the weight of the object, which was 168 gm., but was not much incommoded, and ate as usual. At the end of this period the object evidently slipped into the small intestine, after which the patient complained much of colicky pain in the right hypochondrium with belching and nausea. The object could be plainly felt by the patient through the abdominal wall. There was at no time any intestinal obstruction, although pain persisted and diarrhea developed. Suddenly, the iron seemed to drop into the pelvis with the upper end to the left of the navel. The roentgenogram showed the object extending from the level of the left iliac crest obliquely to the right and into the pelvis. It was assumed that it was in the small intestine, wedged between the pelvis and the abdominal wall. It was removed by enterostomy, having been found in the lower part of the ileum near the cecum, evidently unable to pass the ileocecal valve. The author could find no case in literature of so long a body having travelled so far along the intestine. According to the older authorities, such objects have a strong tendency to remain in the stomach, but a recent analysis of 22 cases showed that the duodenum is the chief point of arrest because of its convoluted shape and its relative fixation. In order to make sure that there was no anomaly of the duodenum in his patient, the author studied it on both screen and plate, finding nothing amiss.

Brindeau and Boussin (Paris). Roentgenography of the Placental Circulation. (*Gynécol. et obstétr.*, January, 1921, iii, 1.)

Roentgenography proved to be of great assistance in the demonstration of the finer vascularization of all the organs, and this is the case with the placental circulation. The injection solution must be very fluid and penetrating and must coagulate, which makes it necessary to inject it while warm. If hot melted double mercurial ointment is thrown into the vessels, coagulation at once follows, when the placenta is plunged into cold water. The specimen is then placed in formol for forty-eight hours. The freshly delivered placenta is taken before the blood can coagulate, and at once placed in warm water, when, by massage of the structure from the periphery toward the center (or rather the insertion of the cord) the blood is expelled from the latter. This act must be performed under water throughout; otherwise air-bubbles may enter. The blood-vessels are next flushed with warm water, using a syringe of 8 oz. capacity. The needle is blunt, and of the pattern of the trocar used for venous puncture. The cord is dissected to expose the mouth of one of the placental arteries, into which the needle-point is inserted and ligated. This operation is very delicate. The hot water is slowly injected and escapes from the other artery, forcing before it the residual blood. In certain cases, water also escapes by the placental vein. This phenomenon was never seen when the mercury was injected, and the latter could never be made to enter the venous circulation; nor if first injected into the vein could it be made to enter the arterial system. The water was injected until it came away quite clear.

The mercurial ointment was heated on a water-bath until quite fluid. The three parts of the syringe—metal barrel, rubber joining and nozzle—were all warmed, and the placenta itself with the cord was also warmed by immersion in warm water, the best temperature being about 60 C. The melted ointment was slowly thrown into one artery until it escaped by the other. This second or exit artery was then tied, and pressure applied by the piston to force the mercury into the finest ramifications of the capillaries. The venous system must necessarily be separately injected. The needle is inserted into the placental vein and the liquid forced in until resistance is encountered. It is less difficult to inject the venous system. When the process is completed, the vessels on the fetal surface of the placenta are seen to be turgescent. The cord is now tied tightly, the placenta washed on both sides and then plunged into a crystallizing dish filled with cold water; after thorough chilling it is placed in a 4 per cent formol solution. In injecting a number of placentas, some should have only the arterial system filled, others, only the venous and others, both systems. In the double injection specimens the effect is somewhat confusing. The authors have therefore tried to use barium or bismuth for one system and mercury for the other; without, however, much improvement. The older methods in which different colored wax was used may have had the greater merit in this respect. But in most of the specimens, the trained eye could distinguish between the two systems. Both sides of the placenta should be roentgenized. Sections made at various levels may also be plated, for the finer circulation is then visualized in a superior manner.

Bingel, A. Encephalography. A Method for the Roentgenographic Demonstration for the Brain. (*Fortschr a. d. Geb. d. Rontgenstrahlen*, xxviii, 205.)

The author attempted to roentgenize the brain, without having any knowledge of the work of Dandy, who already in 1919 made intraspinal air injections in cases of brain disease. The author uses a lumbar puncture only with a stop-cock and a 10 c.c. record syringe. These instruments are connected by tight-fitting rubber tubes and by a T-shaped glass tube. The latter branches off to a rubber tube 60 cm. long to which a glass funnel is connected. The author injects, with the patient in the sitting position, 5 to 10 c.c. of air. The spinal fluid escapes by lowering of the funnel. The level of the spinal fluid is brought to its original pressure level. This method is represented until 40 to 60 c.c. of air have gotten into the spinal canal. It is of the highest importance that the pressure remains constant. The exposures are made with the patient in the horizontal position. Bingel saw in a case of gun-shot wound of the frontal portion of the brain, distention of the fissures; in a case of epilepsy, a very much distended left ventricle, which he attributed to scar formation in the cortex (later proved by operation); in a case of tuberculous meningitis, distention of the ventricles; finally, in a case of otogenous pachymeningitis, distention of the longitudinal fissure, disfigurement of the left ventricle and distention of the right anterior horn and of the left inferior cornu. The distention of the third ventricle and an encephalographic expression of a choked disc, he considers respectively as optic neuritis. Out of 40 cases he has employed the American method in two, in which the injection of air through the lumbar puncture was unsuccessful. In several cases, especially in a case of meningitis of doubtful etiology, this procedure has had a favorable therapeutic result. In a case of meningitis, complete healing occurred.

Jaensch. The Roentgen Appearance of Pneumokoniosis, Especially Its Coarse Form. (*Fortschr. a. d. Geb. d. Roentgenstrahlen*, xxviii, 299.)

The author calls attention to an unusual form of pneumoconiosis. In addition to the cases which present the usual net-like markings, mottling, circumscribed spot-like shadows, he also found, in 7 cases, tumor-like shadows and strand-like markings. The differential diagnosis from tumor could be made, although clinically to some extent, tumor suggested itself. Close study of the roentgenogram, the history and the slow development of the process were the deciding factors.

Metatarsal Pain. (*Fortschr. a. d. Geb. d. Roentgenstrahlen*, xxviii, 311.)

It is the author's opinion that, as a rule, sufficient attention is not paid to discomforts in the metatarsal portion of the feet (metatarsalgia) in cases of flat-foot, and that consequently they are not properly treated. In 30 cases, the author demonstrated roentgenologically changes in the first metatarsal phalangeal articulation (largest number); less frequently in the 2nd, 3rd and 5th (2 cases). Clinically, there was flat-foot or trauma. Roentgenologically, the changes correspond mostly to those of arthritis deformis. The changes at the second metatarsal bone were similar to those demonstrated by Köhler. At the 5th metatarsal bone, he always observed atrophic changes. While it was frequently assumed clinically that gout, tuberculosis or lues were present, the condition was, for the most part, hereditary. The roentgenological changes in the metatarsal bones seem of the utmost importance to the author, because one has to assume also the presence of changes in the adjacent parts of the joints (synovial bursæ, sheaths of tendons, muscles, nerves) and because of this the indications for therapy are given. It must be borne in mind, however, that the difference between roentgen-ray findings and the symptoms is often very marked. In early cases the roentgen-ray finding is often negative. As a therapeutic measure, the author recommends relieving the underlying cause, for which purpose well-fitting shoes, sufficiently high and broad in front, are necessary. Relief of the painful area may be secured by the application of devices for flat-foot, such as felt pads, excavated soles, occasionally even by tight bandaging of the metatarso-phalangeal area, massage, mechano-therapy and, in the most difficult cases, by operative procedure.

Sgalitzer. The Roentgenologic Demonstration of Non-opaque Foreign Bodies in Empyema Cavities. (*Fortschr. a. d. Geb. d. Roentgenstrahlen*, xxviii, 332.)

An experimental test of 40 different small rubber drainage tubes demonstrated that a third were transparent to roentgen rays. Such drainage tubes, as well as gauze pads or sponges, which are frequently the cause of unexplained suppuration, may in empyema cavities be rendered visible by the *x*-rays, when these cavities are filled with opaque material. This opaque filling (bismuth vaseline, soluble tablets of circoniumoxide) may cling to the rubber tube or the sponge even after the contrast filling has been discharged from the empyema cavity. The foreign bodies then become visible, and may be removed with dressing forceps under *x*-ray control.

Broeman, C. J. Abstract of Paper on Radium. (*Kentucky M. J.*, June, 1922.)

Radium is the ideal treatment for all forms of basal-celled epithelioma and for prickle-celled epithelioma, if seen early enough, and no glandular involvement is present.

In carcinoma of the lip it is the treatment of choice when the case is seen early.

Radium is to be preferred in certain uncomplicated cases of uterine fibroid and bleeding.

Radium should be universally used in cancer of the cervix and inoperable cancer of the body of the uterus.

In all forms of inoperable cancer it relieves pain and hemorrhage and lessens discharge.

Radium is to be preferred to the *x*-ray in cases of goiter, because of its exact dosage, deeper penetration and ease of application.

It is the preferred treatment in tuberculous adenitis and vernal or spring catarrh, while in certain systemic diseases, such as splenomedullary leukemia, pernicious anemia, and Hodgkin's disease, radium therapy has proved beneficial.

In dermatology, radium improves and eradicates many heretofore stubborn and incurable conditions.

Freer, Otto T. Radium Emanation in the Upper Air Passages as Compared to Radium; a Method of Applying it with Especial Reference to Laryngeal Carcinoma. (*Illinois M. J.*, August, 1921.)

Since November, 1919, the writer has used radium emanation instead of radium, with an extraordinary gain in efficiency, especially in carcinoma of the larynx. The great advantage lies in the very small bulk of the applicator for radium emanation. As much as 400 mc. may be applied in a very small container, whereas even 30 mg. of radium salt requires so large a container as to be impractical in throat work. Needles are the next best method, but are liable to cause deep sloughs, leading to severe hemorrhage; the pain following their use is severe; and patients often refuse to be needled, considering the procedure to be an operation. The apparatus used is a headband on which is a strong clamp for holding the laryngeal or pharyngeal tubular applicator ending in the screen. For the nose, simple wire applicators are fixed in small clamps attached to a headband. Silver or brass screens are used. The dosage used for carcinoma is 400 mc. hours in divided doses, repeated in six weeks. For papillomas, 150 mc. hours is enough.

L. S. Goin.

Kohlman, Wm. Radium in Carcinoma of the Uterus. (*Surg., Gynec. & Obst.*, August, 1921.)

The unsatisfactory results achieved by surgery in cancer of the uterus, particularly in cancer of the uterine cervix, are only too well known. The high mortality in even the most competent hands, and the complicating sequelae have brought the method into disfavor. The possibility of a new treatment, therefore, is welcomed. The palliative and even curative results of radium have been surprising, and give rise to these questions:

1. Whether radium should be applied only in inoperable carcinoma, and after surgery has failed;

2. Whether it should be used in assistance to surgery, as preoperative and postoperative radiation; or

3. Whether it should be given the preference.

In inoperable carcinoma, radium treatment is the treatment of choice. Preoperative radiation should have a distinct value. He who believes that postoperative radiation is advisable, is primarily a believer in radiation and that it destroys or checks the growth of malignant cells. The writer has used radium as the sole treatment in a number of cases, with gratifying results. The effect of radiation is noted clinically within a very few days. The writer, believing that a reduced blood supply and increased development of scar tissue are important factors in securing results with radium, has practiced ligation of the internal iliac and ovarian arteries, prior to, or simultaneously with radiation. In 12 cases thus treated, 5 were not benefited and died, 6 show primary cure, and one is living and unimproved. The writer has treated 96 cases of carcinoma of the uterus, 56 of them with radium alone. Nearly all were benefited. Those showing no improvement after one or two treatments were not, as a rule, benefited after prolonged treatment. Recurrences after clinical cure with radium occurred mostly in from six to nine months: most of these were very advanced cases.

The following table summarizes the results obtained in 96 cases:

Group 1. Carcinomata which are early and easily operable; (*a*) Cases treated with radium only. (*b*) Cases with panhysterectomy and postoperative radiation.

Group 2. Carcinomata that are doubtful and inoperable; (*a*) Cases treated with radium. (*b*) Cases treated with ligation and radium.

Group 3. Recurrence of carcinoma after panhysterectomy.

Group 1:	*Living*	*Dead*	*No Report*	*Total*
a.	4	1	1	6
b.	5	4	0	9
Group 2:				
a.	22	22	12	56
b.	7	5	0	12
Group 3:	4	4	5	13
				96

L. S. Goin.

Taussig, Fred J. In What Cases do Uterine Fibroids Still Require Operative Removal? (*J. Am. M. Assn.*, lxxvii, No. 5.)

The writer's opinions are based on three years' experience with radium, and a review of numerous reports from clinics here and abroad. Of 123 cases of uterine fibroids he operated on 87, and treated 36 with radium. The operative results were good in 82 cases; 2 cases developed phlebitis, and 2 died. The radium results were good in 32 cases; complications (nature unstated) occurred in 2 cases, and there were two failures. The dosage ranged from 800 to 1750 mg. hours, usually 75 mg. of radium were applied in the uterus, using silver and brass filtration, for sixteen hours. In 10 cases the radium was applied in the vaginal fornix instead of in the uterine cavity. He considers as contraindications to radiotherapy the following:

1. Fibroid larger than 12 cm. in its average diameter.
2. Submucous fibroids protruding through the cervix, subserous fibroids with a pedicle, cervical fibroids and intraligamentous fibroids.
3. Rapidly growing tumors, calcified fibroids, necrotic fibroids, and those complicated with malignancy.
4. Those cases in which a desire for children or for the preservation of menstruation make myomectomy or sub-total hysterectomy preferable.
5. Pyosalpinx and ovarian cysts, except small retention cysts.

A review of the literature shows a total of 1,099 cases of fibroid treated by radiotherapy by nine different men. A percentage of 95.5 of cures was obtained. L. S. Goin.

Frank, O., and Amreich, I., (Vienna). The Histological Changes Incident to Radium and X-Ray Treatment of Uterine Carcinoma. (*Surg., Gynec. & Obst.*, August, 1921.)

The writers have attempted, by means of serial sections of excised tissue, to learn the time of greatest action of radium or x-rays and the point at which their effects begin to lessen. The radium treatments were given with 50 mg. of radium in a platinum or brass filter (thickness not stated) and 1 cm. of cotton and rubber, for twelve hours. This was repeated at intervals of one or two days for 5 treatments. The x-ray treatment consisted of a dose of 18 H., using 3 ma., 11 Benoist penetration., 22 cm. skin distance, 3 mm., of brass, 0.5 mm. zinc, and wood or chamois four times as thick, forty minutes to each field. Eight or nine fields were covered, three or four in front, four behind and one perineal. The series was repeated after six weeks.

The same histological changes were observed after radium and after x-ray treatment. These were first, edema, then enlargement of the cells, carcinoma nest penetration of lymphocytes, vacuolization and hyaline changes. The first changes were noted on the third and fourth days. The influence of the rays was greatest between the fifth and seventh days. The rays were no longer effective after the fortieth day when the genoceptors of the cells became active and caused proliferation. They conclude that carcinoma cells respond more quickly to x-rays than to radium and do not show the stages marked by swelling of the cell body. They advise the use of the x-ray in treating the parametrium and the glands, and the use of radium in treatment of the carcinomatous crater. L. S. Goin.

Peterson, Reuben. The X-Ray after the Inflation of the Pelvic Cavity with Carbon Dioxide Gas as an Aid to Obstetric and Gynecologic Diagnosis. (*Surg., Gynec. & Obst.*, August, 1921.)

Pelvic roentgenography has been the most helpful and interesting study the author has ever made. It has led to more careful diagnosis and to the study of diagnostic errors in order that similar mistakes might be avoided. Fewer exploratory operations are done than were performed before he began its use. He has inflated the pelvis 150 times with no bad effects. Both animal experiments and clinical experience have shown that there is no danger of injuring the intestines by the needle thrust, when the intestines are not adherent to the parietes.

There is some discomfort from the distension with gas, and patients may complain bitterly after the introduction of more than 1000 c.c. It is rarely necessary to use more. Chronic peritoneal adhesions increase the discomfort. The inflation should be conducted slowly. Carbon dioxide is used rather than oxygen because it is quickly absorbed. For transuterine inflation the gas is introduced at a pressure of not more than 200 mm. of mercury, as permeable tubes will permit the passage of the gas at this pressure. This method is contraindicated in patients with acute or subacute pelvic conditions, and in those past the menopause.

L. S. Goin.

Lacassagne, Antoine. Experimental Researches on the Action of the Beta and Gamma Rays of Radium in the Tissues Following Radium-puncture. (*Journal de Radiologie et d'Electrologie*, v, No. 4.)

The advantages of radium-puncture are:
1. Utilization of the entire sphere of radiation, whereas treatments from the surface permit the utilization of less than half.
2. Direct contact with tissue to be treated, thus reducing to a minimum the loss of energy due to dispersion according to the law of inverse squares.
3. Relative safety from radiodermatitis.

The disadvantages are: the complications which may result from the opening of the tumor and the difficulty of maintaining in place over a considerable period the relatively large tubes which may be introduced. The substitution of radium emanation for radium removes most of these objections.

The factors which form the bases for rational radiotherapy are: the relative radio-sensibility of the tissues, the intensity of the radiation, the duration of the application, and the total dose necessary and sufficient.

Dominici divides the rays of radium into two groups: The infrapenetrating, including all the alpha rays, most of the beta rays, and a few of the gamma rays; and the ultrapenetrating, including most of the gamma rays, and a few of the very hard beta rays. A lead screen 0.5 mm. thick is sufficient to arrest the infrapenetrating rays. One-half mm. of platinum will serve the same purpose, and Dominici advised this filtration even for intraneoplastic radiation. Recently, however, following the technique of Janeway, the tendency has been towards the utilization of all the beta and gamma rays.

The writer's experiments were carried out by the introduction of a glass tube 1 mm. long and 0.5 mm. in diameter, containing radium emanation, into the lumbar muscles of a rabbit at the level of the ovary. The distance from the radium emanation container to the ovary was known and constant. Under these conditions, muscular tissue being very slightly radiosensitive, the immediate effects will be those of caustic radiation, while the effects of the ovary will be due to selective cyto-causticity. The animals were killed, after varying periods of time, and the tissues were studied histologically.

The muscle tissue was found to have undergone a constant change in each case. On cross section the tube occupied the center of a circle, the limits of which were clearly defined, within which the muscle had become chalky white, homogeneous in aspect and firm in consistency. Its external limits were marked by hemorrhagic exudate. On longitudinal section the degenerated zone was seen to be a regular cylinder. Microscopically the general structure seemed to be preserved, but to have undergone a necrosis. The tissue stained weakly, all detail of its structure had disappeared, the cytoplasm had undergone a granular degeneration and the majority of the nuclei had disappeared. At the external limit of the zone the tissues stained normally. The transition from dead to living cells is very sudden without a transition stage. Beyond this point the capillaries are dilated and are full of blood and there is more or less interfascicular extravasation of blood. A little further from the zone the muscle is absolutely normal. The size of the area of necrosis depends somewhat on the amount of radiation. The necrotic cylinder is well formed after four and a half days. After twelve days the process is complete. After thirty days the necrotic cylinder is still characteristic and readily recognized. After two and a half months the cylinder is well recognizable but has undergone an appreciable diminution. After four and a half months the macroscopically visible lesion is very much reduced and has become a simple white area surrounded by scar tissue.

In one animal needles containing the same amount of emanation were introduced into the lumbar muscles, one on each side. One was extracted after twenty-four hours; the other was allowed to remain twelve days. The necrotic lesions produced had the same structure and were about equal in size. Several rabbits were killed fifteen days after radiation, lasting one, two, three, and seven days. The lesions produced did not differ markedly. The writer concludes from these experiments that the caustic action is most intense during the first few hours of radiation, and that it acts at a distance proportional directly to the strength of the tube, and, to a certain degree, independent of the total dose.

The following tables show the effect of filtration on the extent of the necrotic lesion:

a. Bare tubes.

Initial Value	Radius of the Lesion
0.70 mc.	1.5 mm.
1.25 mc.	1.8 mm.
2.30 mc.	3.5 mm.
6.00 mc.	5.0 mm.
8.00 mc.	6.0 mm.
16.00 mc.	7.0 mm.
26.00 mc.	8.0 mm.
35.00 mc.	8.5 mm.
48.00 mc.	8.5 mm.

b. Platinum needles 0.15 mm. thick.

Initial Value	Radius of the Lesion
1.5 mc.	0.0 mm.
3.0 mc.	1.5 mm.
5.0 mc.	2.0 mm.
7.0 mc.	3.5 mm.
9.0 mc.	4.0 mm.
12.0 mc.	5.0 mm.
20.0 mc.	6.0 mm.
35.0 mc.	7.0 mm.

c. Platinum needles 0.30 mm. thick.

Initial Value	Radius of the Lesion
7.0 mc.	0.0 mm.
9.0 mc.	1.8 mm.
12.0 mc.	3.0 mm.
20.0 mc.	4.5 mm.
28.0 mc.	5.5 mm.
38.0 mc.	7.0 mm.

d. Platinum needles 0.40 mm. thick.

Initial Value	Radius of the Lesion
8.0 mc.	0.0 mm.
8.5 mc.	0.7 mm.
12.0 mc.	2.5 mm.
18.0 mc.	4.0 mm.
26.0 mc.	5.5 mm.
42.0 mc.	6.8 mm.
48.0 mc.	7.0 mm.

e. Platinum containers 1 mm. thick.

Initial Value	Radius of the Lesion
10.0 mc.	1.0 mm.
16.0 mc.	1.5 mm.
20.0 mc.	2.2 mm.
34.0 mc.	5.0 mm.
45.0 mc.	7.0 mm.

It is noteworthy that the maximum radius of the lesion, with any amount of emanation and any degree of filtration, does not exceed 7 mm. except with the bare tube, the maximum with which is 8.5 mm.

The effects of radium on the ovaries have certain characteristics. They are selective, proportionate to the dose received, and independent of the amount of filtration.

The author concludes:

1. Radium-puncture by means of screened needles is preferable to that with bare tubes.
2. The initial value of a tube, filtered by a known thickness of platinum must not exceed that indicated in the tables as the maximum useful amount.
3. In order to attain the intensity necessary to destroy a tumor, the punctures must be multiplied, correctly placed with regard to each other.
4. For applications on the surface or in cavities by means of tubes of great intensity, the secondary filter must be at least as thick as the radius of the cylinder of necrosis resulting from a tube of such intensity.

L. S. Goin.

Pauchet, V. What the Radiologist should Communicate to the Surgeon and to the Physician in Regard to a Gastroenteritic Patient. (From Le due Costipazioni—the two types of constipation.) (*Policlin.*, 1922, xxix, 3.)

Ninety times out of a hundred, the radiologist's findings, even if he is very competent, are useless and insufficient. Such failure of the radiological examination does not depend on the radiologist *per se*, but upon the insufficiency of the demands put on him by the treating physician. The radiologist ought to furnish the following:

(*a*) How does the stomach function? Modifications of its form during evacuation.

(*b*) What is the diameter of the duodenum, and its mode of evacuation? The mode of evacuation is in accordance with the state of the duodenojejunal angle and with ileal stasis.

(*c*) How does the terminal ileum fill and empty? Is it dilated, angulated, thickened? Is it filled with a gross mass of barium and rapidly; or, on the contrary, by a normal quantity of bismuth? Does the mass of barium which remains in it stay 3, 5 or 18 hours?

(*d*) What are the conditions of the ceco-colon? Is the cecum distended, mobile, lowered, or deformed? When does it fill? Is it empty after 18, 24, 36 or 48 hours?

(*e*) State of the transverse colon. What is its shape? How much has it descended? What is its degree of kinking at an acute angle? Can the segments formed by this angle be isolated or not? Is there a double-barreled symphysis of the right and left halves of the transverse colon with the ascending or descending colons?

(*f*) What is the state of the sigmoid? Is it elongated, dilated, deformed? Are there diverticula? Is there megacolon? Dolico-colon?

(*g*) What is the aspect of the colon in its totality? Is it completely emptied in 48 hours? Are particular parts dilated, elongated or restricted?

The radiologist ought to administer an opaque meal and barium enema; both methods of examination are necessary.

In order that the examination should be complete, a radiography of the right flank will be necessary to see if there are any calculi in the kidneys or ureters, and if possible in the gall bladder; also the thorax should be examined to indicate the state of the mediastinal ganglia; the pressure or absence of ectasia, or aortic deformity, and the condition of the lungs.

The radiologist should instruct the patient not to take a purge or laxative nor mineral oil for the ten days preceding examination. The evacuatory clyster is indispensable.

Since these examinations are long and costly, it is not always possible for the radiologist to carry them out; however, it is indispensable that he should give these data to the surgeon:

(*a*) What is the state of the stomach?

(*b*) Does the terminal portion of the ileum fill in mass?

What time after the ingestion of the barium does it evacuate?

(*c*) In what time is the ceco-colon emptied?

(*d*) In what time is the large intestine completely evacuated?

Taeckel and Sippel. Concentration of the Roentgen Rays and Increase of the Dosis-Quotient by Means of Scattered Radiations. (*Müenchen. med. Wchnschr.*, 1920, No. 20.)

The authors attempted to obtain an intensification of the direct radiation by means of scattered rays which attack the part laterally from the angle of incidence of the direct rays. For that purpose they used a water phantom 7 cm. high, with a surface measurement of 40 × 40 cm., in which a space of the size of the original area of radiation, 14 × 14 cm. or 8 × 8 cm. has been left opened. The scattered radiation of the water increases the depth dose of the central cone of rays. The surface dose is not increased, because the inner walls of the water phantom are covered with lead. The central field, therefore, is subjected to only the usual skin erythema dose, with the usual filter of 1 mm. copper. This is an advantage as compared to the ray collector of Chaoul, which is similarly constructed. The secondary irradiator, i.e., the water, is irradiated through a weaker filter, consequently there is no increase in the superficial dose, and no injury to the skin, but an increase of the depth dose by means of the secondary rays emanating from the water.

Blumenthal. The Therapeutic Problem in Cases of Malignant Tumors. (*Deutsche med. Wchnschr.*, 1921, No. 39.)

The author emphasizes the point that the malignancy of individual carcinomata depends not only upon the different biology of the cells, but also upon the resistance of the organism to the growth of the carcinoma. The statistics of operative results are unfavorable. The postoperative irradiation (e.g., in carcinoma of the breast) offers no guarantee against recurrences or metastases, but the poor results of postoperative radiation of carcinoma of the breast mentioned by Perthes and Payr may be explained by errors in technique. Just as other radiotherapeutists attempt to destroy the carcinomatous cells by means of the rays, but without greater injury to the normal tissues, he emphatically rejects treatments lasting several hours at one session (distance irradiation over large fields) because they are superfluous, not devoid of danger, and a torture to the patient. In order to increase the effect of the rays, Blumenthal recommends the attempt to cause an indirect effect by stimulation of the reactive processes of the organism, reactions such as Bier has produced in the tumor by means of the protein treatment (injections of caseosan). The author in addition also employs chemotherapy, using "Alival," which contains 63 per cent of iodine, by administering it intravenously or intramuscularly in doses of one to two c.c., three to six times a week. Alternately with "Alival" he employs arsenic (atoxyl in conjunction with sodium arsenate), which has no collateral effect, and Solarson strong. He considers futile the argument as to whether one should operate or irradiate because both are strong weapons. Neither solves the therapeutic carcinoma problem, because neither has more than a local effect. While Blumenthal generally would operate every operable case, he nevertheless varies his method occasionally; thus he did not operate an operable carcinoma of the breast in the male, but treated it with irradiation, iodine and arsenic, and cured it.

Anschuetz and Hellmann. Results of Irradiation after Radical Operation for Carcinoma of the Breast. (*Müenchen. med. Wchnschr.*, 1921, No. 32.)

A number of authors (e.g., Perthes and Payr) abandoned the postoperative treatment of breast carcinoma, because of the bad results. Even at this year's surgical and roentgenological congresses, there was a strong feeling against this postoperative radiation. The authors, however, have had favorable results; their statistics, which were collected critically and carefully, comprise 240 cases of carcinoma of the breast observed for from three to twelve years. In cases that were treated by operation only, there were, after three years, 49 per cent cures; after five years, 36.4 per cent; while with postoperative irradiated cases, there were 60 per cent and 55.5 per cent cures respectively. He ascribes the difference in his results as compared with those of other authors to his careful technique. He rays three fields, giving $^{2}/_{3}$ of a skin erythema dose, through 3 to 4 mm. of aluminum, six to eight irradiations every four weeks, and then about three irradiations at eight-week intervals. (Haenisch of Hamburg has employed a similar technique with slightly increased doses, covering four or five fields. His results are approximately similar to those of Anschuetz. Haenisch will consequently continue to give postoperative radiations carefully in cases of carcinoma of the breast.)

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FOREIGN BODIES IN THE BRONCHUS AND ESOPHAGUS*

BY CHAS. F. BOWEN, M.D.

COLUMBUS, OHIO

FOREIGN bodies have, I might say, always been more or less a hobby with me. My first serious endeavor along this line was described in a paper before this society, read at the Niagara meeting, in 1906, on the subject, "The Localization of Foreign Bodies in the Eye." This paper described a modification of Dr. Sweet's method of eye localization. The method is extensively used today, the apparatus being manufactured by Kelly-Koett and others. At the New York meeting, in 1908, a second paper told of the necessity of keeping the eye in a fixed position during the examination and described an apparatus for accomplishing this purpose.

At the same New York meeting a paper was read upon the subject, "The Localization and Removal of Foreign Bodies from the Extremities." A special fluoroscope was shown and the method of operating under direct fluoroscopic guidance was explained. This work led to my first "big case," where I removed a tack from the bronchus with a pair of hemostatic forceps, guided by the fluoroscope through a tracheotomy opening. The patient was twelve years old and had a temperature of 105°F. at time of the operation. The tack was removed in fifteen seconds from the time the room was darkened. This operation was performed on February 6, 1909, before I had heard of Dr. Jackson, or even knew that there was such a thing as a bronchoscope. This case was examined for supposed tuberculosis, and the tack found accidentally. Previous to this time I had removed so many needles and other metallic particles from the hands and feet, under fluoroscopic examination, that when I examined the chest plate and saw the tack I felt as though I should be able to take a pair of forceps and lift it right out. But how? I thought of opening the trachea and passing down a pair of forceps, and told of my plans to our leading surgeon, who answered, "Fools sometimes tread where angels fear to go." However, after several days of study and rehearsing, the tack was successfully removed, and the patient promptly recovered.

As far as I am able to learn, this was the first time that a foreign body had been removed from the lungs by a pair of forceps under fluoroscopic guidance. To sum up, a foreign body was removed from the lung for the first time by a new method in less than fifteen seconds. Why this success? Was it luck or something else? It was something else. I studied this case from every angle and rehearsed the operation with my assistants, as a stock company would rehearse for a new show. Remember this was a "first nighter" and the show just had to be a success. While the trachea was being opened in the operating room, I was waiting in the roentgen-ray room, with my eyes blindfolded. The patient was placed upon a table with the tube underneath. When everything was ready, the bright lights

*Read at the Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

were turned off and I removed the covering from my eyes. The forceps were placed in the tracheotomy opening and the room darkened. The tack was at once seen, grasped and removed. This was done so quickly that no one else saw the tack removed, for their eyes were not in condition. We were successful because we were thoroughly prepared.

attention to the early symptoms of a possible foreign body. In this way I have undoubtedly aided in making an early diagnosis, and thus prevented a fatal termination in a great many cases.

The roentgen ray plays a very important part in the diagnosis and is becoming more and more the "whole show" in the removal of foreign bodies. For this reason, I believe

Fig. 1. Round smooth foreign bodies in the esophagus can be removed by means of a pair of forceps, guided by the fluoroscope. If the patient is unable to swallow liquids, indicating that the mucous membrane has become swollen over the object, then the foreign body should be removed by direct observation, through the esophagoscope, perhaps guided by the fluoroscope.

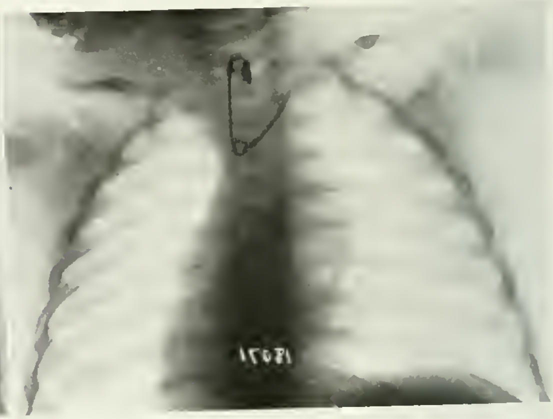

Fig. 2. Sharp foreign bodies, such as an open safety pin, should be removed only after a careful study by direct examination through the esophagoscope, to determine how much of the point is imbedded. The esophagus is easily torn, and great care must be used.

And now we have come to the first thought which I wish to present, i.e., "preparedness," or, I might say, preparation. I believe that any person of intelligence can master any subject if he will only concentrate and put his whole heart and soul into that subject.

Dr. Jackson is undoubtedly the leader in this work, and is certainly a genius. But what is a genius? Simply any ordinary human being of a little more than average intelligence, who has concentrated upon a single subject. Jackson cannot do all of this work, neither can the dozen or more men who are doing more or less of this work. These cases are much more common than generally supposed. My own records will show this. I have had a total of 386 cases, only 5 having come from outside of Ohio, the great majority of them coming from within a radius of fifty miles.

I have read papers and have called

that more roentgenologists should take up this work to relieve the shortage of skilled operators.

Following my first "big case," reported above, I had quite a series of foreign bodies in the esophagus, all successfully removed by means of forceps, under fluoroscopic examination. At the Detroit meeting, in 1910, I read a paper on the "Removal of Metallic Foreign Bodies from the Esophagus by Means of Forceps and Fluoroscope." In this paper, reports were made of 2 cases of open safety pins in the esophagus, with their points up, being successfully removed.

Following this meeting, I was invited by Dr. Jackson, who had heard of my work, to visit him at Pittsburgh. We discussed the advisability of combining the two methods, i.e., using the roentgen ray and the esophagoscope together. I worked this out, and at the Richmond meeting, in 1911,

FIG. 3. A bent safety pin, swallowed by an insane patient, was lying in the esophagus, with the point penetrating the posterior wall of the trachea. After a careful study of both views, the pin was removed in only a few seconds, without an anesthetic.

FIG. 4. A long bone in the esophagus. Foreign bodies in the upper part of the esophagus can best be shown by a lateral view, with the patient lying on the back without a pillow, with the chin high up and shoulders pulled down, making the neck as long as possible. The rays pass through the neck horizontally, while the plate is held at the side of the neck with sandbags. Usually the first eight vertebrae can be shown.

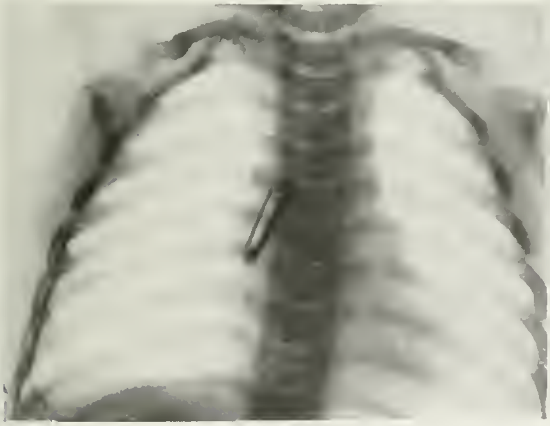

FIG. 5. Open beauty pin in the right main bronchus (no lung changes), removed without difficulty through the bronchoscope. The fluoroscope was at hand, but not used. Opaque objects in the bronchi can be differentiated from those in the esophagus by their position. They lie away from the middle line and usually at an angle, and point toward the trachea.

FIG 6. Metallic tip of lead pencil, with short piece of pencil completely plugging the left main bronchus with pent-up secretion. When the pencil was removed, the secretions flooded the lungs and prevented the author from seeing through the bronchoscope. The fluoroscope located the pencil in the opposite bronchus, from which place it was removed by means of a pair of forceps, passed through the bronchoscope, guided by the *x*-ray. Artificial respiration was used, with draining of the water-filled lung, and patient recovered. If both methods (*x*-ray and bronchoscope) had not been available, this patient would certainly have died.

I read a paper on the "Use of the Fluoroscope as an Aid to the Esophagoscope and Bronchoscope in the Removal of Foreign Bodies." Each method has its advantage in certain cases, but I do not believe that one is justified in attempting to remove a foreign body from the esophagus or bronchus by either method unless the other is

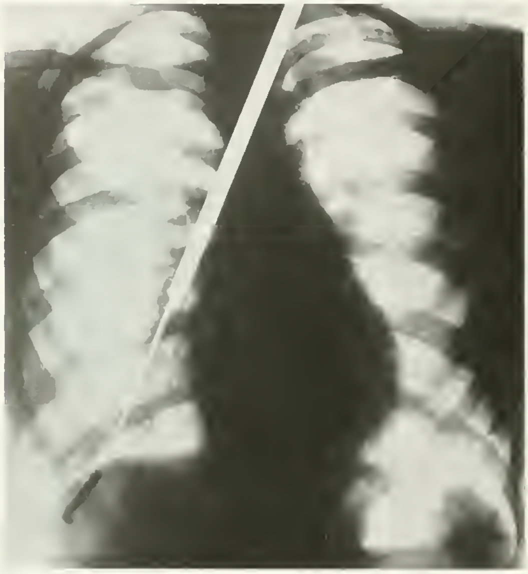

FIG. 7. Girl, aged nineteen, "swallowed" a beauty pin ten years before. Diagnosed tuberculosis, because of hemorrhages. Had been examined repeatedly with the fluoroscope, but nothing found. An *x*-ray plate showed the pin to be lying below the dome of the diaphragm, anteriorly. The bronchoscope was passed as far as possible, which was still six inches from the pin. A pair of forceps were then passed through the bronchoscope and guided toward the foreign body, by means of two fluoroscopes working at right angles. Pin removed in four minutes from time bronchoscope was passed. Hemorrhages ceased at once, and patient made prompt recovery.

immediately available. This has been proven so many times in my own experience that there is no need for discussion.

The whole subject of foreign bodies in the bronchus and esophagus is a very interesting one, and I know of no branch of roentgenology which is so exacting and requires such painstaking work. You cannot just simply make a plate. The case must be really examined and studied. A plate of the neck may not show the foreign body; one of the chest, abdomen or pelvis may be necessary. But find the foreign body, unless you can state positively that none is present. Be sure, however, that the intestines did not move the foreign body around so fast that it did not show. I will never forget a case in which I gave a negative report, and the baby passed a safety pin four hours after my examination. A careful examination of the negative, which was given only four seconds' exposure, showed at least ten separate, but very faint, shadows of the safety pin over an area of about 4 in. in diameter. Or again, the pin which had been "swallowed," may have gone up in the posterior nares, instead of down, as was reported in one case. So in this work we must be sure, for there is no middle ground. The child either has or has not a foreign body. You are either right or wrong. Just imagine that the little patient is your child, and make a thorough study. These patients cannot be run through the laboratory like fracture cases. Really examine your patient and then rely upon the sense of fairness of the operating surgeon to see that you are compensated for your work.

From the standpoint of the roentgenologist, foreign bodies can be divided into three classes:

1. Those which are plainly "visible," as a nickel in the esophagus or tack in the lung.
2. Those which are not opaque but are "visible" by indirect methods, as a grain of corn in the bronchus, by the lung changes, and a bone low in the esophagus by a barium meal.
3. Those which are not opaque and cannot be located by indirect methods.

The first class of cases, i.e., those which are opaque and show plainly, needs no particular comment, as far as diagnosis is concerned, except that it is always necessary to get a plate of sufficient clearness to show a foreign body if one should be present. Sufficient penetration must be used to go through the mediastinum and other thick structures. Only recently I saw a case in which a large beauty pin in the lung had been overlooked, once by roentgenographic and three times by fluoroscopic examination, by different men. The pin was lying below the dome of the diaphragm and sufficient penetration had not been used to pass through the liver.

It is sometimes difficult to tell whether the foreign body is in the esophagus or trachea, from a single plate. A lateral view will, as a rule, give at once the exact location. Again, it is at times extremely difficult to tell whether a foreign body is lying in the stomach or the intestines, especially in the transverse colon. If, however, the shadow is well below the diaphragm, its exact location is not at all necessary, unless the symptoms are urgent, for they are seldom removed. Heavy foods, as bread or potatoes, can be given, but no physic.

If the foreign body is in the esophagus it can be easily removed by means of forceps and fluoroscope, if it is smooth and not imbedded; otherwise, it had better be removed by means of the esophagoscope, guided by means of the fluoroscope. It is not always necessary actually to use the roentgen ray, but it should always be at hand. If the foreign body cannot be located at once, with the esophagoscope, the reason should be determined fluoroscopically. The foreign body may have passed on into the stomach or may have been overlooked and the esophagoscope slid past it. The roentgen ray will answer the question and should be at hand.

Foreign bodies in the trachea or bronchi must of necessity be removed through the bronchoscope, but the roentgen ray must be a part of the operating table and must be connected ready for instant use. I have seen its advantages so many times that I would make no exception. A small screw was located in the left main bronchus. The child struggled terribly while going under the anesthetic. The bronchoscope was passed to the location of the screw, but it had moved. I could have located it with the bronchoscope, but why take the time? The fluoroscope was used at once and the screw found to be lying about 2½ inches farther down in one of the smaller bronchi. A pair of forceps was passed through the bronchoscope and the screw grasped by the forceps with the aid of the roentgen rays, 2½ inches beyond the end of the bronchoscope. The entire operation did not require over four minutes.

Fig. 8. Non-opaque foreign body: peanut. Roentgenogram is typical of a foreign body blocking the bronchus. The diaphragm on the affected side is flattened; the entire mediastinum is pushed over to the opposite side and the lung contains an excess of air. No other lung change. One rather large piece of peanut was removed by the author, from the right bronchus, in this case.

Fig. 9. Forty-eight hours after inspiring peanut candy, upper right lobe consolidated; only slight obstruction to passage of air to rest of lung, as shown by slight emphysema and slight flattening of diaphragm on right side. Temperature 102, pulse 110, respiration 80. Eleven small pieces of peanut were removed from upper right lobe bronchus. Recovery.

I will now cite a case in which the child would certainly have died on the table had it not been for the roentgen rays. A boy, aged twelve years, had inspired a piece of lead pencil, with its brass tip. The pencil was so short, that of the pencil proper there was just a conical point projecting from the brass end. This had entered the left bronchus and acted as a plug, back of which the secretions had accumulated. The entire lung being water-logged, cast a uniformly dense shadow on the plate. The child was very ill. The bronchoscope was passed, the brass end located, and at once grasped with the forceps and traction made. The forceps slipped off and there was a gush of fluid which literally drowned the patient. I had loosened the pencil and allowed the pent-up secretions to escape. The child stopped breathing, for he was literally drowning. I could not see through the bronchoscope because of the secretion, which now was running out of the end of the bronchoscope. The fluoroscope was used and the pencil found in the right main bronchus. The situation was this: left lung water-logged and right lung completely blocked with a foreign body; the bronchoscope was so filled with secretions that I could not see through it. A pair of forceps was passed through the bronchoscope and the pencil grasped while watching it with the fluoroscope. Time of operation not over five minutes. Artificial respiration for a few minutes and the child was again breathing. Had it not been for the fact that the roentgen-ray apparatus was all connected up and tested, with the motor running, this child would certainly have died on the operating table.

The second clas consists of those which are not opaque but are "visible," by indirect methods. Non-opaque foreign bodies in the lung are very common and at times very hard to diagnose positively. If the foreign body has been present for some time, changes in the lung itself will be noted. An abscess or a pneumonic process will give a clew.

However, it is the early cases which are the most difficult. The history of the child choking should put you on your guard to be on the lookout for early lung changes. These children, as a rule, are hard to roentgenograph. Several plates of the chest should be made with as short an exposure as possible. A flattening of the diaphragm, a displacement of the mediastinal shadow or a darkening of the lung is usually positive proof that a foreign body is blocking the bronchus on that side.

In these non-opaque cases the services of the roentgenologist end with the making of the diagnosis, for the bodies all have to be removed by the direct method through the bronchoscope. These cases are all serious, and if there is the slightest doubt as to the diagnosis, I invariably pass the bronchoscope and make a thorough search.

Non-opaque foreign bodies in the esophagus can be located by watching the passage through the esophagus of a rather heavy barium meal, or a barium capsule. The esophagoscope, of course, must be used to remove the obstruction.

The third class, those which are not opaque and which are not visible, comprise a rather small group and need not concern you. Remember, however, that if you are unable to locate a foreign body, either by the direct or indirect method, there may still be one present, which is not opaque or has not as yet produced changes. Make your report read: "I see no shadows or conditions present which would lead me to suspect a foreign body, but I do not say positively that there is none present."

DISCUSSION

Dr. Manges. I would, of course, refrain from any technical discussion so far as bronchoscopy is concerned. First, as to the fluoroscopic control of removal of foreign bodies, Dr. Grier, some years ago, published a paper in which he described an apparatus where the control was by means of two fluoroscopes at right angles. If you are going to use fluoroscopic control for the direction of your forceps, then you should by all means use two fluoroscopes and two screens, one at right angles to the other. I have had considerable experience in this work. I have helped Dr. Jackson through some exceedingly difficult problems, and our experience has been that with one screen alone it is difficult to tell whether you are in front or in back of the foreign body. You want to do as little damage to the lung tissue as possible. Dr. Jackson is insistent on extremely careful localization before he attempts to remove any foreign body. I feel that we, as roentgenologists, ought to perfect our technique in this matter of localization and that we should perfect our knowledge, as nearly as possible, in the minute details of the anatomy of the lung, that is, to know where the main bronchi are, or even study the location of the vessels.

Those of you who have seen Dr. Jackson work know that it does not make a bit of difference what the foreign body is; he always prepares for anything that might happen. He has all his instruments out, no matter what he is going to do, and it is with the utmost care that he selects his instrument. He used to get a great many cases fairly early after aspiration.

He does not get as many now, and it shows there are many men doing this work. The fact that many more men are doing this work is positive proof of the reiterated assertion that there are many more of these foreign body cases than we ever suspected.

Foreign bodies are apt to move. It was thought that a jackstone would not move after it got stuck in the esophagus. We had one recently that did move. Almost immediately after Dr. Jackson attempted to remove it, we found the jackstone in the abdomen. So even a jackstone may pass. You must not assume anything. Go to the utmost length to prove it. Here is another lesson with regard to careless localization. This case came to our laboratory one day: A baby that had been in another hospital in Philadelphia, down on the table under a general anesthetic for over an hour while the bronchoscopist attempted to remove a safety pin from the bronchus. He failed to find it. They rushed the child down to Jefferson Hospital expecting Jackson to start right in and find the safety pin. He said in his quiet way, "Send it down to Manges and see what he has to say." The child was sent to me. I put the child on the fluoroscope table and the safety pin was in the abdomen. It had not been in the bronchus at all. That child almost lost its life from careless localization.

I think Dr. Bowen is deserving of the utmost congratulation and of the greatest encouragement in his work. But I doubt, honestly, whether there are very many of us, as roentgenologists, who are really fitted or capable temperamentally, mechanically, and in other ways to undertake a work like this. My own feeling is that, inasmuch as Dr. Jackson is so eager to spread his knowledge and teach others how to do it, we ought not to interfere. We ought to encourage it. I think, as roentgenologists, we ought to keep out of the field. On the other hand, Dr. Bowen ought to keep up his good work.

Dr. Hickey. I had the pleasure of watching Dr. Bowen work and congratulate him on the progress he has made. With regard to removal of foreign bodies under fluoroscopic control, I think a word of warning should be said; and that is, unless you are very expert with the method, the forceps should be passed into the esophagus or passed into the trachea under direct inspection of your bronchoscope, because unless you are experienced and know the anatomy of the throat so that you can visualize things which you cannot see, you should not attempt to push the forceps down without this precaution. It is very easy to slip a bronchoscope into position and see your opening into the esophagus and introduce your forceps. The same way with the trachea; once your forceps are in the trachea, then you can pass down and you are not able to do any particular damage. But unless the head is in proper position and unless the forceps are guided, you are apt to traumatize the lower pharynx.

Every case should be rayed, no matter how clear the history is. There was a child brought into the hospital and the father said it was choking from a burnt match. They said it was not necessary to ray it, as wood would not show. However, we did ray it and found it was a nail instead of a match. It is best not to take for granted that your foreign body will not show, but to ray all cases.

With regard to Manges' statement about misinterpretation of roentgenograms, this came forcibly to my mind not long ago: I was called to go to the hospital to see a child. A tracheotomy was done looking for a safety pin, but it could not be found. I asked to see the plates. I said the safety pin was not in the trachea but was in the esophagus, because you could tell the way it lay with the longest dimension laterally, expanding in the direction of least resistance in the esophagus.

A recent case, which is somewhat unique, illustrates the direct value of fluoroscopy. A boy, about eight years old, was taken with severe hemorrhage after a tonsillectomy. The nose and throat man attending the case started to sew up the pillars and broke his needle. The case was brought to the hospital, and the doctor who lost the needle was very anxious to have it recovered because it would be much easier to explain to the parents. One or two of the nose and throat men searched for the needle for some time. I suggested that they bring him to the fluoroscope room if they wanted to find the needle. After a little reluctance they brought him down. We used the oil immersed unit which we use for reducing fractures. The child was placed on his side; the forceps introduced into the mouth, watched until it came above the needle, then the forceps were closed and the needle removed. A roentgenogram did not help in that case, because there were no landmarks in the mouth. I wish to compliment Dr. Bowen on his work and on the fact that he gets down to rock-bottom facts without many preliminary remarks.

Dr. Gray. In this connection I want to enter a plea for fluoroscopic control of esophageal dilatation. It was recently impressed upon me most forcibly that we are entirely too prone to make a diagnosis of cardiospasm. The case is referred to a man who is going to do dilatation, whether he be a gastro-enterologist, bronchoscopist, or surgeon, and that is the end of it. He either succeeds or he fails.

Not only as a caution is it advisable to use the fluoroscope, but quite frequently, particularly in ill-proportionate individuals is it difficult to tell whether or not the tip of the dilator is through and whether or not you have the rubber bag in proper position to dilate the cardia.

In quite a number of cases I have been able to assist the surgeon in that way. It is very necessary, particularly in these cases of greatly dilated esophagus, especially when the dilatation extends to the right.

Dr. Dunham. I believe, in dealing with localization of these foreign bodies in the lung, much benefit can be had by knowing the anatomy of your bronchi. This does not mean that you can do away with any of the refinements which have been so definitely spoken of with reference to the plate or fluoroscope, but above all judgment should be used in the handling of any of these cases. I believe, if there was one thing Dr. Bowen brought most to your knowledge, it was judgment with complete preparation. Sometimes, especially in older people where they are able to hold still and the foreign body has been there for a long while, it is possible to get very good stereoscopic plates. By those plates you can localize the various bronchi. It has been a long discussion as to whether the line markings in the chest are the result of bronchi or veins. That is purely an academic question. Again, the fundamental thing to remember is that in every one of those trunks leading from the hila of the lung you have bronchi, and by following the bronchi you have your localization. You can, therefore, tell which bronchi are going to the middle, upper, or lower lobe on the right side. You can often tell whether you have abnormal lobation in the lung. It is often possible accurately to localize the lobe and tell whether the foreign body is anterior or posterior, by giving careful study to the localization of the bronchi near which the foreign body is located.

Dr. Bowen (closing). I wish to thank the members for their kind discussion of this paper. I did not have time to go into it very thoroughly and could not describe the apparatus. I always use two fluoroscopes and have them ready to use in either way. My two assistants can use the fluoroscope while I am doing bronchoscopic work.

It was Jackson who urged me to take up bronchoscopic work.

We must remember that every case of foreign body is a case by itself and must be studied thoroughly and a scheme worked out for that individual case.

THE ROENTGENOLOGICAL STUDY OF THE PATHOLOGICAL GALL-BLADDER*

BY B. R. KIRKLIN, M.D.

MUNCIE, INDIANA

It is with considerable timidity that I attempt to discuss the roentgenological study of the gall-bladder before this society, for I realize that during the past few years this subject has caused a great deal of criticism, and that there has been more or less of a controversy regarding its real value. So many roentgenologists throughout the country have not had the interest to do this work, or if they have, it seems that little effort has been made toward a progressive study of the gall-bladder, or developing a careful and correct technique.

It is our opinion that most of the men who are attempting to do gall-bladder *x*-ray work are merely searching for gall-stones instead of carefully searching for any direct or indirect evidence of gall-bladder pathology other than the mere presence of stones.

A great many men are still of the opinion that they are wasting time and material in searching for gall-bladder pathology, and when they do go after a gall-bladder they do it in a half-hearted way, doubting if they will find any pathology, even though it be there. It is our opinion that unless a man attempts this work carefully, believes in its merits and is confident that his investigation is thorough, he had better not try it at all.

FIG. 1*a*. Case 3311A. Visualized gall-bladder showing one gall-stone shadow.

FIG. 1*b*. Case 3311B. Roentgenogram of removed gall-bladder showing the one stone which casts a positive shadow, and seven stones which cast negative shadows.

GALL-STONES

The question of gall-stones is of very small moment, for we all know that there is a large number of stones which offer no density, not even as much as the bile in which they are contained, which, in fact, may cast negative shadows. Again, George has called our attention to the fact that, though the stones individually cast no positive shadow on the *x*-ray film, and offer very little anatomic weight, yet,

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en masse, they assume a certain amount of density, which together with the changes in the gall-bladder wall, produces a characteristic shadow easily recognized with reasonably good technique.

Fig. 2a. Case 3415A. Pathological gall-bladder filled with very dense stones Referred for roentgenological examination of left kidney. All symptoms on left side.

Fig. 2b. Case 3415B. Roentgenogram of gall-bladder after its removal.

Fig. 3a. Case 2111A. Enlarged, pathological gall-bladder with stones.

Fig. 3b. Case 2111B. Roentgenogram of gall-bladder after removal.

THE GALL-BLADDER SHADOW

The question is often asked, "How do you make a positive *x*-ray diagnosis of gall-bladder pathology?" In the first place, we look for a *gall-bladder* shadow. The normal gall-bladder under ordinary routine conditions, is not visualized. There may be a rare exception to this rule, but for all practical purposes, we may say we are unable to visualize the normal, healthy gall-bladder. The above opinion is held by George, who probably has done more successful gall-bladder work than any other roentgenologist. If we agree on a shadow that must represent definitely, by its size, shape and location, the gall-bladder, and which shows readily on the roentgen-ray film, this gall-bladder must be pathological. Either it is enlarged, its walls are thickened, the bile is darker in color (which means increased density) or there are stones in the gall-bladder or ducts, in varying size, density and amounts. Any of the above factors, singly or collectively, will offer a fairly dense and easily recognized shadow with carefully developed technique.

Any shadow which we can interpret as representing a gall-bladder leads us very definitely to the opinion that it must

Fig. 4*a*. Case 3380A. Pathological gall-bladder. No stone shadows seen.

Fig. 4*b*. Case 3380B. Roentgenogram of gall-bladder after its removal, showing two large gall-stones which did not show on roentgen examination. Part of one casts a negative shadow. This case illustrates the importance of examining plates and films for gall-bladder shadows rather than for gall-stone shadows.

Fig. 5*a*. Case 2203. Pathological, distended gall-bladder with stones.

Fig. 5*b*. Case 3738. Pathological, distended gall-bladder, filled with very small stones.

Fig. 5*c*. Case 2408. Pathological gall-bladder with a large gall-stone. This patient was referred in for roentgenological examination of left kidney. Symptoms all on left side.

represent pathology in some degree or form within or about the gall-bladder, with or without stones, *and is so reported.*

INDIRECT EVIDENCE

We should go further in our investigations, however, than merely looking for a positive gall-bladder or gall-stone shadow. Even if no gall-bladder or gall-stone shadows are discovered, there are a number of roentgen-ray findings following a barium meal which are of invaluable assistance in arriving at a roentgenological diagnosis of gall-bladder pathology. It has been found that a gall-bladder, besides being easily visualized, may show pressure of itself upon the duodenum or antrum of the stomach; or possibly produce displacement, if it is large enough, of the jejunum, and especially of the colon, in the right upper quadrant; or again, cause a deformity of the first portion of the duodenum due to adhesions and picking up of the second portion, pulling it over to the right and outlining the gall-bladder; or it may cause hepato-fixation of the stomach due to pericholecystitis with adhesions, or produce deformities of the

Fig. 6*a*. Case 2704. Pathological gall-bladder with two large calcareous gall-stones.

Fig. 6*b*. Case 1883. Pathological gall-bladder filled with stones and adhesions picking up hepatic flexure of colon.

Fig. 6*c*. Case 4518. Pathological gall-bladder with stones. Note the negative gall-stone shadow at A.

Fig. 7*a*. Case 3471. Pathological gall-bladder with stone and adhesions involving second portion of duodenum with resulting distention of duodenum proximal to adhesions.

Fig. 7*b*. Case 1416. Distended, pathological gall-bladder with stone. Note pressure of distended gall-bladder against stomach.

Fig. 7*c*. Case 4925. Pathological gall-bladder filled with sand. Note adhesions between gall-bladder and stomach.

hepatic flexure. The emptying time of the stomach following a barium meal is usually much shortened with gall-bladder pathology present.

SURGICAL REPORTS

We do not believe that the roentgenological evidence or any other evidence of gall-bladder pathology should be considered wrong until the accused gall-bladder has, at least, been opened, or better still, has been removed and submitted for pathological examination. We have known of a few cases where gall-bladders have been palpated at operation and pronounced normal in spite of the fact that the roentgen-ray examination showed evidence of shadows which were interpreted as gall-stones. The surgeon was persuaded, however, in these cases, to open the gall-bladder, and gall-stones were found.

FIG. 8*a*. Case 1194. Upper shadow is stone in cystic duct; nine shadows represent nine gall-stones found in fundus of gall-bladder; below is seen the shadow of a pathological adherent appendix.

FIG. 8*b*. Case 3540. Showing pressure of distended gall-bladder against stomach.

FIG. 8*c*. Case 2808. Pathological gall-bladder with dense adhesions between gall-bladder and stomach.

FIG 9*a*. Case 3419A. Visualized, distended gall-bladder.

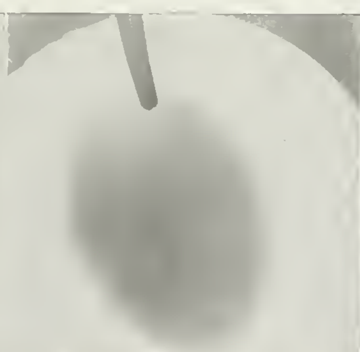

FIG. 9*b*. Case 3419B. Roentgenogram of gall-bladder after its removal.

FIG. 9*c*. Case 2047. Roentgenogram of removed gall-bladder of patient on whom we made a negative roentgenological report. Note the many small negative gall-stone shadows throughout the gall-bladder.

TECHNIQUE

The patient is instructed to take two drams of compound licorice powders each night for two or three nights previous to the examination, and to eat no evening meal the day previous and no breakfast on the morning of the examination. We first make from two to four exposures of the gall-bladder region (including all the area between the crest of the ilium and tenth

adhesions or pressure involving the stomach and duodenum, or any other findings that might have been missed on our first series of films. The hepatic flexure of the colon is studied at eighteen to twenty-four hours.

Fig. 10*a*. Case 4755. Visualized, pathological gall-bladder.

Fig. 10*b*. Case 5019. Visualized, pathological gall-bladder.

Fig. 10*c*. Case 4052. Visualized, pathological gall-bladder. Note low position of gall-bladder.

Fig. 11*a*. Case 4445. Visualized, pathological gall-bladder.

Fig. 11*b*. Case 3469. Visualized, pathological gall-bladder. Note low position of gall-bladder.

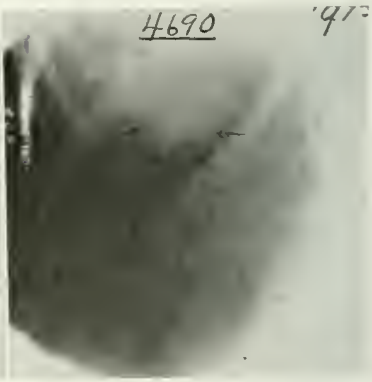

Fig. 11*c*. Case 4690. Visualized, pathological gall-bladder.

rib), varying the penetration, time, etc. but being careful that the dark-room assistant develops all the films for the same length of time, thereby insuring films of varying densities. The above preparation and examination is made on every patient examined for any abdominal condition. We then give a barium meal in the fluoroscopic room and search carefully for any indirect signs, which have already been enumerated. We then make more gall-bladder exposures in order to pick up any

A good gall-bladder plate or film should show a wealth of detail of soft structures, and one of the most important factors is the *absolute* stillness of the patient during the exposures. The Potter-Bucky diaphragm and double screens have been very valuable assets in this work and have made possible the obtaining of films of still finer quality than before.

We attempt to impress on the referring physician that we also need his clinical help, and I think that we, as roentgenologists, should consider ourselves as medical consultants and require a complete clinical history in every case. If such a history does not accompany our patients, we take a history in the course of our examination, so that this may be consulted, as well as our roentgen-ray findings, in arriving at our final conclusions.

Fig. 12*a*. Case 2118. Visualized, pathological gall-bladder.

Fig 12*b*. Case 3468. Visualized, pathological gall-bladder.

Fig. 12*c*. Case 3436. Visualized, pathological gall-bladder.

Fig. 13*a*. Case 3435. Visualized, pathological gall-bladder.

Fig. 13*b*. Case 3523. Visualized, distended gall-bladder.

STATISTICS

During the past twenty-eight months we have made a complete roentgenological gall-bladder study of 712 patients. We reported "Roentgen-ray evidence of gall-bladder pathology, with or without stones" in 251 cases, which is approximately 35 per cent of the total number of cases studied. We have been able to obtain the operative findings reported in 214 of these cases. The surgeons reported that the gall-bladder was normal to palpation in 7 of the cases in which we had reported positive roentgenological findings, and in 6 of the cases in which we had reported negative roentgenological findings, the surgeons reported gall-bladder pathology of some form. In other words, our roentgen-ray conclusions were confirmed in all but 14 cases, or approximately 93½ per cent.

Of course, the above represents a very small series of cases, but it also represents the reason why we have such firm convictions concerning this subject.

CONCLUSIONS

A careful roentgenological investigation should be made of the gall-bladder region of *every* case that is referred for abdominal study. We feel confident that if every competent roentgenologist will develop a careful technique and make a thorough routine search for gall-bladder pathology in every one of his gastrointestinal and other abdominal studies, the statistics reported so far will soon be more generally accepted, and no doubt improved upon.

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DISCUSSION

Dr. Cole. I want to congratulate the doctor on his presentation and especially his efforts in making up such a percentage that it seems as though it might be overstated. I think, however, that we should give this a little more time and I think if we do that many of you will come to the same conclusion that we have. Our success has been so good that in every gastrointestinal case we take at least two gall-bladder plates with very rare exception and we are often astonished at what we find.

I think two things must be kept in mind; one is that you must use good technique. Get good plates; if you do not, in the majority of cases, they are worthless. Second, study the plates, and learn how to interpret them. I think the interpretation of gall-bladder plates is difficult. It is astonishing how you can go back after operation when you know that stones were found, examine your plates, and see the stones. We had a case in which we reported to the surgeon that we were not certain about the presence of gall-stones, but it looked suspicious. He operated and found gall-stones and we were then able to see the stones perfectly. That showed that we had not studied our plates carefully enough. It is necessary to get the plates at the right angle and spend a good deal of time to interpret gall-stone plates properly.

As to the Bucky diaphragm, we have not been very successful with it in finding stones. It seems to me there is so great a wealth of shadows that it is confusing. I know of no other way to describe it except to say there are too many shadows on the plates. At present I prefer the double screen, and moderately fast exposure. I think we find more stones with a back-up of 3½ inches than we do with 5 inches.

Dr. Upson. I think this paper is very interesting and timely. While there are a number of things that occupy the center of the stage just now, this is something we have to do every day.

In speaking of these indirect evidences, I wonder how long it will be before we can consider them positive evidences. I suppose you all have the same trouble that we do, namely, that it is a little hard to convince the internist and sometimes the surgeon that these evidences are of sufficient importance for them to take seriously. In a series of cases we watched two or three years ago our percentage of indirect evidence was about 83 that proved to be positive at operation, a little less than those that have been reported today; but I believe that the time is coming when indirect evidences will be important enough for the internist or the surgeon to consider seriously. I think that in our reporting we should be a little more positive than we have been and insist on our reports being taken a little more seriously.

Another point: In the doctor's paper he spoke of two shadows being looked for in discovering the shadow of the gall-bladder. I believe you should look for three,—the shadow of the liver, the shadow of the right kidney, and over that a third shadow, which soulhd be regarded as the gall-bladder. We attempt in our cases, if we are depending on the shadow of the gall-bladder, to detect these three shadows. I believe that in detecting gall-bladder disease, the evidences shown on the pylorus and duodenum are of equal importance with the shadow of the gall-bladder. I believe these should be watched for in the fluoroscopic room as well as on the plates.

Dr. Evans. Some five or six years ago in Detroit, Dr. Reu gave a very fine paper on gall-bladder pathology. He showed that reverse peristalsis was an important finding in gall-bladder work.

Dr. Beeler. I would like to ask Dr. Kirklin if there is any way of differentiating between the kidney shadow and the gall-bladder shadow. Often you get a kidney shadow that resembles the gall-bladder. I have had a few cases with such shadows where operation showed a normal right upper quadrant. Has he any way of differentiating between the two?

Dr. Dachtler. I would like to ask Dr. Kirklin about reverse peristalsis, lagging of the duodenum and the differentiation of gall-bladder conditions from pathology at the duodeno-jejunal junction. I think perhaps those cases are a little more common than we were led to think in the past.

Dr. Crane. I want to put myself on record as not being able to find over 10 per cent of gall-stones on any of my plates. I have been very much interested in this subject; we have taken plates with double screen and without screen, we have examined our plates with the reducing lens and through opera glasses the wrong way and the right way, and we have found the shadow of the gall-stone in only about 10 per cent of the plates. I think in certain cases we have had very good plates. We have made a practice of taking serial plates. We have arrangements whereby we can take four views on a 10×12 plate in the region of the gall-bladder. You can take a number of these plates and get two or three views of the gall-bladder. Two or three views are all that is necessary in fleshy women over 40, where if you get gall-stones every time, you are right in at least 60 per cent of the cases. I think you can often tell in fleshy people, when you see the shadow of the right kidney, if there is a definite dark line, a rather narrow line, that it is the perinephritic fat, the fatty capsule of the kidney, which has about $^7/_{10}$ the density of the kidney. It leaves a dark margin which gives you a fair outline of the lower pole of the kidney. To my mind, there is nothing that has thrown so much discredit on the roentgenologic diagnosis among surgeons and internists as the attempted diagnosis of gall-stones and gall-bladder disease. I heard Dr. George say he could find 90 per cent gall-stones. I went home feeling very humble indeed. I am sure that 10 per cent is a liberal allowance for all stones we can see on plates that we are sure are gall-stones. We can have opinions sometimes that are best not expressed except to our intimate friends.

Dr. Potter. The question of using the grid for gall-bladder outline is like this: The grid gives an increase in contrast but because of the increased distance of the patient to film you lose some line detail, especially because of the way the grids are built. What we want in locating the outline is to find the dark line that marks the edge of the gall-bladder. All other technique is aimed at getting that clue. It helps in recognizing the gall-bladder with a grid that is built with a great space between film and patient. However, with gall-stones, what you are aiming at is to recognize a change in density, and you can get that better with a grid.

Dr. Hickey. I would like to ask the doctor to summarize his technique.

Dr. Arens. I would like to add a few remarks to what Dr. Kirklin has said, and I want to congratulate him on correctly diagnosing such a high percentage of pathological gall-bladders, both with and without stones. In our series we found 85 per cent, combining both roentgenography and fluoroscopy. We found one fluoroscopic sign that seemed to be almost pathognomonic of a pathological gall-bladder, and that was the presence of a duodenal stasis with regurgitation. Several other conditions may cause this phenomenon, namely, an appendix, colitis, ulcer, arterio-mesenteric occlusion, duodenal obstruction, etc. Ruling out these conditions leaves practically nothing else to account for this so-called duodenal stasis and dilatation except a pathological gall-bladder. I have checked this up in a large number of cases, and the percentage is high, making the check-up against the plate shadows and the operating table. I wonder how much stress Dr. Kirklin lays upon it. A year ago he called attention to duodenal lagging in gall-bladder disease, but he had reference to the bulbus duodeni, whereas my findings are beyond this point. I wonder whether he is still paying attention to this point and whether he still considers it as distinct evidence of gall-bladder disease.

One other item about studying plates. To me, studying gall-bladder plates consists of not only an accurate knowledge of the pathology present, but also using the proper method of illuminating those plates. I have a number of plates in which I can wipe out the shadow of the gall-bladder by intense light. By reducing the brilliance of the light by means of a rheostat it is possible to bring out the gall-bladder shadow clearly. I think proper lighting has a great deal to do with the correct interpretation of the plates.

Another point in conjunction with the Bucky diaphragm and double screen plates: I have personally not used the Bucky diaphragm extensively for gall-bladder work, and I do not want to go on record by saying that the Bucky diaphragm is not a good thing to use, but the fact remains that some of our poorest plates, in almost every case, will show the gall-bladder, while the best plates, technically speaking, do not show it. It seems to me to be entirely a matter of the proper penetration, i.e., quality of the x-rays used.

Dr. Kirklin (closing discussion). I want to thank these gentlemen for their very liberal discussion. It is very gratifying.

Emphasizing what Dr. Cole has said regarding looking over old plates, we have had the same experience. Another thing that I think should be emphasized is a very conservative report.

In speaking of the kidney shadows which Dr. Upson and Dr. Beeler mentioned, we always make sure that we can outline our kidney before we look for the gall-bladder, and so there is no danger of mistaking that kidney shadow for the gall-bladder shadow. We always want to be sure that we can definitely outline the kidney shadow first. Usually the gall-bladder shows superimposed upon the kidney shadow. Another thing to be remembered is that we are making the exposure posteroanteriorly, and the kidney is spread out over a large area, which makes it better for interpreting the gall-bladder shadow through it.

Regarding technique, our technique of course consists in the first place in the proper preparation of the patient. We instruct the physician to give the patient compound licorice powder for two or three nights previous to examination. We are able to eliminate gas with compound licorice powder better than with other cathartics. We have the patient eat a light supper and no breakfast the morning of the examination. We make two to four gall-bladder exposures, using various techniques, depending on the size of the patient. It varies from 3 to 4½ in. spark gap with a distance of 22 in. We started out that way and have never changed. It may be that a greater distance will give better results, but that is the distance we use at present for gall-bladder work. We do not give any two plates the same exposure. We vary the exposure from 2 to 5 seconds. The dark room assistant is instructed to place all the films in the developing solution at the same time and take them out at the same time. That insures a varying density.

We have always found that the best way to examine these films is to hold them on the slant. I can see, or I think I can see, more gall-bladder shadows by holding the film on the slant than by looking squarely at it. If we see suspicious shadows and are not satisfied, we ought to see those shadows on more than one plate or film.

There is one thing I noticed in the discussion. Dr. Crane says he is able to detect only 10 per cent gall-stones. I do not think that is anything surprising, because in gall-bladders in which we can see only one stone on our plate or film, there may be found eight or ten stones at operation as I have shown on slides. The question of gall-stones is of very small moment. It is the gall-bladder that we are interested in. Gall-stones are usually of secondary importance to gall-bladder pathology.

Another thing that will influence our statistics is that they are made up from cases operated upon. I do not say that every gall-bladder we can demonstrate is pathologic. It may not be pathologic enough to warrant surgical interference. So there are a number of cases on which we have no check. If we could prove them up definitely, our statistics might be materially reduced.

Regarding the subject of the duodenal stasis, I think Case called attention to this in 1913. He said that in gall-bladder pathology he had observed a dilatation of the first portion of the duodenum, also a tender point immediately to the right of the duodenal cap. He thought then it was due to the rapid emptying of the stomach, thereby dilating the first portion of the duodenum. I have tried to follow this work out, and have not been able to satisfy myself that it is constant enough to place much emphasis on, though, as I said, our series of cases is quite small.

Regarding Dr. Crane's discussion, I think we should not report gall-stones primarily, but *gall-bladder pathology*. I want to emphasize that one point. I think all we are interested in is whether or not the gall-bladder is pathologic. Of course, if we see definite gall-stone shadows, we report them. If you report a case as a pathologic gall-bladder with no stones, and the surgeon operates and finds definite gall-bladder pathology and cholesterin stones, he is apt to discount your work more than he is entitled to, merely because you didn't report the stones; so we always report "pathologic gall-bladder with or without stones." It is my opinion from many conversations with Dr. George that he has been misunderstood when he has been quoted as saying that he could diagnose 90 per cent of gall-stones. I think what he meant was that he could diagnoes 90 per cent of pathologic gall-bladders.

THE ROENTGEN RAY IN THE DIAGNOSIS OF SCOLIOSIS*

BY FRANK W. LAMB, M.D.

PORTLAND, MAINE

BEFORE entering upon a discussion of the value of the *x*-ray examination as a diagnostic agent in scoliosis, it is necessary to consider at some length its pathology, and to emphasize the fact that the so-called functional or habitual scoliosis, which is not a deformity but simply a normal physiological posture, is to be in no way confounded with the term scoliosis used in this paper.

True scoliosis is a fixed deformity of the spine, characterized by a lateral bending of the column, with structural changes in the parts entering into it, together with a rotation of the bodies of the vertebrae on their vertical axes. The rotation of the bodies is always toward the convexity of the curve with the greatest amount of rotation at its apex.

The lateral bending of the spine may be either to the right or to the left, and there may be a single curve, or more than one. In the latter case, the curves are in opposite directions.

FIG. 1. *X*-ray of model standing, showing spine straight.

FIG. 2. *X*-ray of model lying on table, showing an apparent scoliosis.

* Thesis presented with application for membership to THE AMERICAN ROENTGEN RAY SOCIETY in 1920.

FIG. 3. Model in frame showing normal right scoliotic position.

FIG. 4. Model in frame showing normal left scoliotic position.

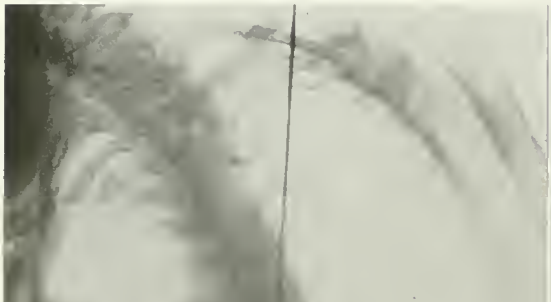


FIG. 5. X-ray of same model as shown in Figure 2, showing spine in right scoliotic position.

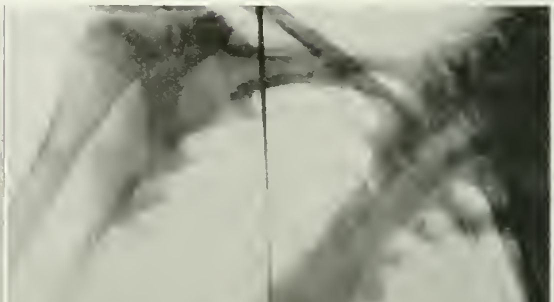


FIG. 6. X-ray of same model as in Figure 5, showing spine in left scoliotic position. This with Figure 5 shows the bending in both directions to be symmetrical.

The structural changes which take place cause a certain amount of the deformity, the ligaments and muscles shorten on one side of the spinal column and lengthen on the other, and finally the vertebrae change from their normal contour.

assume this position either to the right or to the left. These two positions, right and left, may be termed normal physiological scoliotic positions. This physiological scoliotic position is entirely distinct from a lateral bending of the spine and must not

Fig. 7. *X*-ray of a model bending to left with a right scoliosis.

Fig. 8. *X*-ray of same model as in Figure 7, bending to right. Spine cannot assume the curves diametrically opposed to those shown in Figure 7 because of the fixed right scoliosis.

In studying the normal physiological postures of the spine, it is found that one of them is identical with the posture of scoliosis, the parts deviate to one side of the median line and the vertebrae rotate in the same manner as found in scoliosis. It is also found that the normal spine can be confounded with it, as there is no relation between the two.

In the normal spine, the physiological scoliotic posture, either right or left may be readily assumed, but in scoliosis, while the correct anatomical position—the straight position—may be assumed with more or less ease, the structural changes which the parts have undergone prevent motion to the normal physiological scoliotic position opposed to the deformity.

Scoliosis is simply a fixation, not without motion, of the spine in either right or left normal physiological scoliotic posture. In other words, the spine, which is in one of its scoliotic postures, has its motion so restricted that it cannot assume the opposed scoliotic posture to the limits of normal motion, but the straight position can in early cases readily be taken, and the fact that the correct anatomical position can be assumed does not exclude scoliosis.

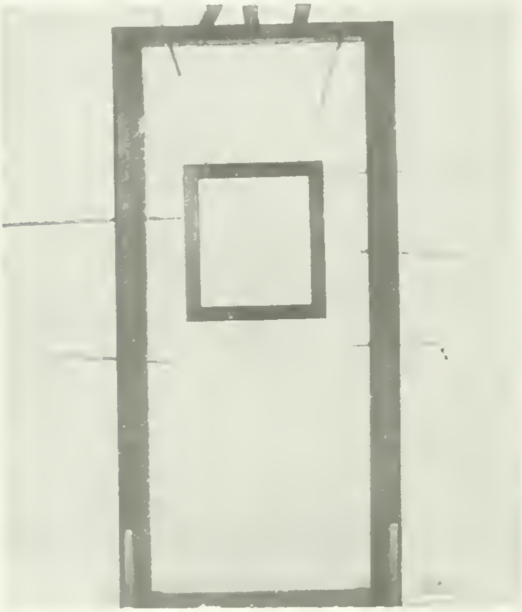


FIG. 9. Photograph of frame.

The methods heretofore in use for examining the spine have been so faulty and misleading that it was impossible to establish the presence of the deformity until it had reached an advanced stage of development, and treatment was thereby rendered difficult, or even impossible.

The diagnosis of scoliosis in its early stages is important, because when deformity of the bones is well established, and changes in the length of the muscles and ligaments are extensive, great force is necessary to establish normal motion, and the very limited motion often present in some cases, where diagnosis is delayed, complicates or prohibits the process of reduction.

In order to establish a diagnosis of scoliosis in its early stages, it is absolutely necessary to know the normal physiological scoliotic postures of the spine, for unless they are known, one of them may be easily taken for the deformity.

If scoliosis were simply a lateral bending of the spine to left or right, the old method of marking the skin over the spinous processes might well have been an important factor in making a diagnosis. It has, however, proved most misleading, and in beginning scoliosis is absolutely useless. The spine is so flexible that in beginning scoliosis the spinous processes may appear straight or curved, and the fact that a patient can easily stand so that no deformity is shown is no indication of its absence; i.e., although the patient may easily hold himself so that the marked spinous processes show a straight line, there is frequently a well-defined deformity of scoliosis.

It is necessary then, if a diagnosis of the deformity is to be made before it has become so extreme that it is difficult to reduce, that some other method should be employed.

A correct diagnosis, however, even in the earliest stages, may be made by the use of *x*-rays, but only if the operator recognizes the fact that the old positions produce misleading roentgenograms.

A patient with beginning scoliosis may easily stand with the spine straight while a plate is being made (Fig. 1) and the plate may then show a normal spine. If the patient is supine on the table, the normal spine may, on account of its flexibility, show lateral bending (Fig. 2), while the scoliotic spine will frequently show straight, since most early cases can bring the spine to the straight position.

For these reasons, all exposures made in either of the above positions are valueless. It is only by bending the spine laterally and twisting the vertebrae at the same time into the opposed positions, that the deformity of scoliosis can be determined.

In making an *x*-ray diagnosis of scoliosis, the extreme right and left scoliotic position must be used (Figs. 3 and 4). If the roentgenograms taken in these two positions show the lateral bending and the rotation equal and symmetrical (Figs. 5 and 6) there is no deformity.

On the other hand, if the patient is placed in the two positions above mentioned (Figs. 3 and 4) and the roentgenograms are asymmetrical (Figs. 7 and 8), there is a fixed deformity.

In order to hold the patient in position, some such frame as is shown in Figure 9 is advisable. This frame is constructed with a base and two uprights connected at the top by a bar; at regular intervals holes are bored, through which half-inch dowels may be inserted. These dowels are marked every half-inch and are used, not so much for support, as to aid in placing the patient in the same relative position to right and left. On each side, two dowels are inserted at such a height that the inner end of one touches the patient just below the ilia, and of the other, the outer side of the right shoulder. The cross-piece at the top is also bored, and a dowel rests on the top of each shoulder. From the middle of the top piece to the base extends a wire plumb for the purpose of showing a line on the plate to be used in making measurements.

The small square frame shown in the photograph is to hold the plate or film.

REPORT OF AN UNUSUAL FOREIGN BODY IN THE ARM

BY CHARLES FREDERICK BAKER, M.D.

NEWARK, NEW JERSEY

IN February of this year a woman fell on the ice. There was entire loss of function at the elbow with the presence of a small wound on the posterior surface of the forearm, just below the joint. appeared to be further substantiated by the projection of a small piece of "bone" from the wound. She was suffering both locally and from shock, hence no extensive examination was attempted.

FIG. 1. Lateral view showing lead pencil buried in soft structures of the forearm.

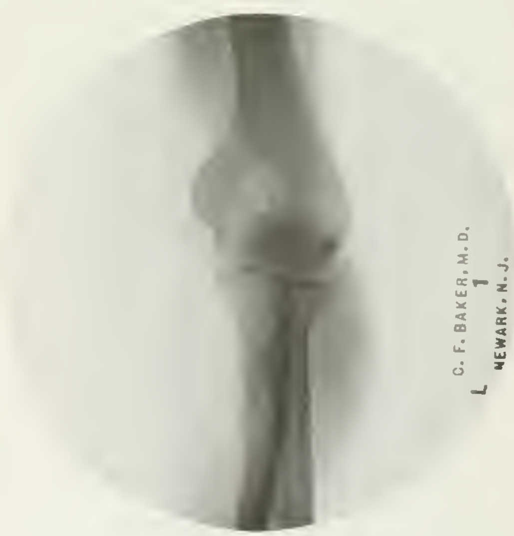


FIG. 2. Anteroposterior view showing same.

She was taken to a suburban hospital, where a diagnosis of traumatic elbow was made with a possibility either of a compound fracture or a dislocation. This

The films made that day with a portable apparatus were not up to the standard owing to the presence of a right angle perforated aluminum splint and to a defect in the apparatus. The films were considerably underexposed; furthermore, they seemed to contain artefacts and straight parallel lines, the significance of which at that time was not recognized.

The report rendered was negative as to fracture or dislocation, all the bones appearing quite normal.

Upon receiving the report, the surgeon in charge stated that he was positive as to the presence of a bone lesion, as he had pressed one of the fragments back under the skin at the time first aid was rendered, and that there was almost complete lack of flexion or extension at the elbow-joint.

Another examination was suggested, and the following day the patient was brought to the office. The new films clearly demonstrated that the lines, previously considered as artefacts, were due to the presence of a piece of lead pencil, $3\frac{1}{2}$ inches long, which lay in front of and slightly to the outer side of the elbow-joint, the point having penetrated the muscles of the forearm just below the neck of the radius and lodging under the skin of the flexor surface. The bones at this examination were found to be normal. Flexion and extension were limited by the foreign body and neither by fracture or dislocation, and the "fragment," which the surgeon pressed back under the skin, was the blunt end of the pencil, which being hard and well covered with blood was easily mistaken for bone.

Upon questioning the patient, she remembered that there was a lead pencil in the silk bag she carried on her arm at the time of the fall, but could not remember having seen it since the injury. By a singular coincidence, therefore, the pencil must have been in such a position that, when the patient fell, it penetrated the silk bag and skin with sufficient force to drive it entirely through the transverse diameter of the forearm, almost burying it from sight, so that the blunt end was not recognized.

The pencil was removed by slightly enlarging the wound, and antitetanic antitoxin administered. Recovery was uneventful with complete restoration of function.

REPORT OF THREE UNUSUAL CASES

BY T. A. GROOVER, M.D., A. C. CHRISTIE, M.D., AND E. A. MERRITT, M.D.

WASHINGTON, D. C.

In examining 35 cases by the pneumoperitoneum method we have noted an anomaly of the left lobe of the liver in two patients.

Both were examined for obscure intra-abdominal conditions and an error in the interpretation of the liver shadow led to an incorrect roentgen-ray report as demonstrated by subsequent laparotomy. It is exceedingly important to remember that the left lobe of the liver may occupy a position in the left abdomen, which in the average person is designated as the splenic area, inasmuch as it may be in contact with the left diaphragm and left lateral abdominal wall.

FIG. 1. Case I. Shows the right lobe of the liver (A) and left lobe (B) which is larger than the normal spleen, but which occupies the splenic area, and the spleen, which is markedly enlarged (C), is displaced downward; (D) normal eflt kidney.

In our cases, the tight lacing habit in girlhood in all probability contributed to or may have caused this condition, and that

FIG. 2. Case I. Shows the left kidney in normal position above spleen and below left lobe of liver with pelvis and calyces normal in size and outline. Laparotomy revealed position of organs as above stated with a spleen increased in size incident to chronic malaria.

FIG. 3. CASE II. A liver similar to Case I, excepting for smaller left lobe (B).

it had been practiced is abundantly demonstrated by what we have designated as the "German helmet" liver, in which the contour of that structure is strikingly similar to a silhouette of this, now not unfamiliar head-gear.

Reproductions of the plates in these and our other cases are submitted for study.

Fig. 4. Case II. Patient in same position, but plate made after a short interval. The spleen (C) has moved outward and upward. (D) normal kidneys. Laparotomy demonstrated structures as above stated with no surgical lesion.

Fig. 5. Case III. An unusual finding in a patient with perinephritic abscess, without the use of gas. Under fluoroscopic control the pelvis and calyces were outlined, showing some enlargement and deformity, while a thin stream of thorium apparently followed a course beyond the parenchyma of the kidney. This was due to a communication between the abscess and the pelvis of the kidney. The arrows in the illustration indicate the thorium shadow external to the pelvis.

TWO TABLES PERTAINING TO THE INCIDENCE OF BODILY HABITUS AND THE TIME OF COMPLETE GASTRIC MOTILITY IN DIFFERENT TYPES OF HABITUS

BY R. WALTER MILLS, M.D.

ST. LOUIS, MISSOURI

CERTAIN tables and statistics which have been in my possession as a part of a special investigation seem to me so necessary of general appreciation that I am presenting them in this informal form.

The first of these tables pertains to the incidence of different physical types which in a previous communication I have classified as the hypersthenic, sthenic, hyposthenic, and asthenic.* It seems not generally appreciated and certainly was not by me before tabulating this and other tables, that the numerical incidence of different types of individuals varies greatly. It will be noted in Table 1, which deals with this subject, that the larger proportion of persons fall in the intermediate, sthenic and hyposthenic groups, that the asthenic is a comparatively rare type and the hypersthenic quite so. We are doubtless misled in our subjective appreciation of the incidence of these types by the fact that a larger percentage of asthenics, being more subject to functional digestive disturbances and probably organic lesions, is seen by us in practice, and we consequently do not appreciate that this is not a reflection of their actual incidence which, as mentioned, is comparatively infrequent. In a different manner the hypersthenic type is perhaps impressed upon us by vastness of bulk, weight, and so on, in individuals of such habitus, so that we do not appreciate the fact that they are quite rare as compared to the general run of persons.

It is desirable for the reader to understand, however, that in the present tabulation of the incidence of different types, those rated as hypersthenic and asthenic are so classified on a strict standard. For instance, many persons who might superficially be considered as asthenic, on closer examination, are found not so, but to be essentially of the next higher type, the hyposthenic only tending to the asthenic. The same is true of sthenic individuals who tend to the hypersthenic. But in this connection individuals who are surely either hypersthenic or asthenic, but somewhat tend in turn to the sthenic or hyposthenic have been classified as primarily of the type to which they essentially belong. All this means that individuals shoud be closely studied before classification, as has been done in this instance, in which photos and numerous orthodiagraphic tracings, general scale reductions and graphic figure drawings have been made of all subjects before final classification. Incidentally, it is curious that one cannot sum up all physical proportions without a photograph. We are so impressed by other features, such as texture of skin, moulding of form and other minor features that we do not readily summarize great general proportions.

As mentioned, the greatly predominating sthenic and hyposthenic types represent a mean, or, as one might say, the average type, and perhaps might so be considered as "normal" by those who long for and can be mentally satisfied only with a monotype standard, with variations from such considered as abnormalities.

The practical import and value of an appreciation of variation in the incidence of types above mentioned leads in several directions. First and most important, as to the incidence of disease as occurring in different types of bodily habitus. Since we have learned that to a degree certain diseases or predilection to diseases and certain undesirable conditions are characteristic of certain types of persons, it follows that no true estimate of such predilection will be accurate without an appreciation of the numerical incidence of

* Mills, R. Walter. The relation of bodily habitus to visceral form, position, tonus and motility. AM. J. ROENTGENOL., April. 1917, iv, 155–169.

different types. For instance, it is well established that tuberculosis, or rather lack of resistance to it, is more marked in the asthenic. Judging by the comparative rarity of this type, this predilection is far more marked than is at first apparent, since the asthenic is comparatively rare.

Another aspect of the incidence of clinical disease with reference to physical type may be illustrated by duodenal ulcer. Many have doubtless been impressed as was I with the apparent preponderance of duodenal ulcer in heavy well-nourished persons of the more sthenic types. As a matter of fact, the reverse is true; duodenal ulcer is almost twice as frequent in the asthenic as in the sthenic. It only seems that a larger number of sthenic persons are subject to duodenal ulcer because of the larger number of sthenics and the comparative rarity of asthenics, and because duodenal ulcer happens to be a disease that more nearly affects all types alike. The same interesting disease incidence with reference to habitus may be followed through various diseases, such as colonic diverticulosis, gastric ulcer, arterial hypertension, apoplexy and multitudinous malstatic states, to great diagnostic and therapeutic, and especially prophylactic, advantage.

A second advantage to be derived from a consideration of the incidence of different physical types is in the establishment of approximate "normal" figures as to various physiological manifestations. For instance, the time of complete gastric motility, as is apparent in the second table. Since gastric motility is more rapid in the hypersthenic individual and definitely slower in the asthenic, it follows that what for practical purposes we might consider as the "normal" time of gastric motility, if one must have such, is best taken essentially from the intermediate average sthenic and hyposthenic types, because in large measure they are in very considerable numerical preponderance. It would seem that this would be better judgment than to take the average time of all types, no matter what their numerical incidence. The same process of reasoning would lead to the determination of other physiological norms along similar lines. Personally, I have been impressed with the idea that the degree of gastric secretion as determined by the

Table I. A table showing the incidence of bodily types, the relation of such to sex and the degree to which a single visceral structure, the stomach, corresponds to habitus as to its form, topography and tonus. It will be noted that there is a marked variation in the percentage of incidence of different types, that most physiques are of intermediate sort, sthenic and hyposthenic, and that the asthenic is rare and the hypersthenic even more so. These facts should be taken into consideration in statistics as in the incidence of disease as affecting different types, and in other similar considerations. It may be noted that there are more sthenics among males than females, and conversely that there are more asthenics females than males; and that consequently figures pertaining to sex incidence with reference to bodily type form a reversing gradient when arranged on a sex basis.

The final figure shows that, using the stomach as a test, visceral peculiarities fairly closely correspond to bodily type, that is, in approximately 80 per cent of all persons. Figures are those taken from studies of 1,000 subjects without known organic or marked functional disturbances.

Table I

CONSTANCY OF RELATIONSHIP OF STOMACH FORM AND POSITION TO BODILY HABITUS IN 1,000 SUBJECTS WITHOUT KNOWN ORGANIC OR MARKED FUNCTIONAL DISTURBANCES

Incidence of Habitus		Incidence of Sex		Relation of Stomach to Habitus		
Habitus	Number and Percentage of Subjects Arranged According to Habitus	Number of Male Subjects and Percentage of Each Type	Number of Female subjects and Percentage of Each Type	Number and Percentage of Cases in Which Stomach Corresponds to Habitus	Number and Percentage of Male Subjects in Which Stomach Corresponds to Habitus	Number and Percentage of Female Subjects in Which Stomach Corresponds to Habitus
Hypersthenic. . . .	47– 4.7	42–89.4 ↑	5–10.6	44–93.6	39–92.8	5–100.0
Sthenic.	481– 48.1	288–59.9	193–40.1	395–82.1	257–89.2	138– 71.5
Hyposthenic. . . .	354– 35.4	143–40.4	211–59.6	262–74.0	117–81.8	145– 68.7
Asthenic	118– 11.8	24–20.3	94–79.7 ↓	98–83.1	19–79.2	79– 84.0
Total.	1,000–100.0	497–49.7	503–50.3	799–79.9	432–86.9	367– 73.0

usual Ewald-Boas meal corresponds to physical type, being higher in the sthenic and lower in the hyposthenic and asthenic types. It may be that the faster gastric motility of the sthenic makes this apparent only, since the recovery of this test meal at forty-five minutes or one hour cuts through the various curves of gastric secretion in the various types at different levels, judging by their known different rates of motility and presumably corresponding rates of secretion. We may then come to consider that on the same time test the at that time present acidities of the stomach vary in a general way according to type just as does gastric motility. For practical purposes, however, since it might complicate matters to an impractical degree to attempt a judgment of gastric secretion on the basis of the individual type, it would seem better judgment to determine secretions in all types at a given time, and judge the result in the light of the type under examination. The same for gastric motility. It would thus seem better to judge *x*-ray gastric motility essentially on a six-hour observation, considering also intestinal distribution, and to interpret the result in the light of the type of individual and the rate of gastric motility characteristic of such, than to attempt a different time standard of motility for each type. My own method, however, is, while not carrying gastric motility observations beyond the six-hour period, to determine as closely as possible the actual time of stomach emptying, and then judge this in the light of the type of habitus of that particular case. Another example of physiological function that also probably follows a general relationship to physical type is alimentary motility in general, reflected in the frequency of defecation. As I have elsewhere stated, in markedly sthenic types defecation is frequent, twice or more times daily; while in the asthenic I might subscribe to the rank heresy that the lack of a daily bowel movement is not necessarily abnormal. Blood-pressure also seems to correspond to bodily type, being higher in the sthenic and lower in the asthenic. There seems also a relationship to physical type in functional attributes, general muscular tonus reflex reaction, mental peculiarities, endurance, and many other things that we subconsciously so appreciate, but through familiarity do not pause to crystallize in our minds until in some manner the facts are shunted to our attention. The same line of observation and reasoning is far-reaching in directions other than strictly medical, as in occupational therapy, in insurance statistics (which, by the way, if arranged on these lines will be definitely hard on the asthenic), in purely commercial activities as pertaining to the examination and employment of persons and selection of individuals for various activities such as factory work and military service, and above all, in the future application of these facts in practical eugenics.

In the table submitted, it will be noted that there are figures as to the extent of correspondence of the stomach to bodily habitus, the stomach serving as a single test example of the relationship of a viscus to bodily habitus. Figures are arranged so as to test the proposition that I have elsewhere advanced that all visceral peculiarities, structural and physiological, correlate bodily type. It will be noted in these tables that the stomach corresponds to bodily type in approximately 80 per cent (79.9 per cent) of all cases. It will also be noted that this correspondence varies with the degree to which a physical type deviates from the mean. For instance, that in extremes of bodily habitus, the hypersthenic and asthenic, the figures indicate, as might be anticipated, a more definite relationship than in average types in which all structural peculiarities approximate the average, and consequently in which individual variation plays a greater part making for disharmony.

There are interesting figures in the tables pertaining to the incidence of habitus as it relates to sex. It will be noted that hypersthenics are far more commonly men than women, that asthenics are correspondingly more frequent among women than men, and that with the percentage of intermediate types a reversing gradient is formed when figures are arranged on a sex basis (Columns 2 and 3). Consequently the classification of all individuals on bodily peculiarities as based on the classification previously proposed is perhaps in a measure a classification of sex peculiarities.

In addition to the table discussed (Table 1) a second similar table was compiled, consisting of 2,500 additional cases, but of subjects not completely free from pathological states; this primarily for testing the incidence of gastro-intestinal disease with reference to habitus. It is of interest, however, in conjunction with the foregoing, that in this table also, which is not presented at this time, the figures are almost identical with those of the first table of persons free from organic or marked functional disturbances as to the incidence of physical types; the figures of incidence being: Hypersthenics, 91 or 3.6 per cent, sthenics, 1,117 or 44.7 per cent, hyposthenics, 945 or 37.8 per cent, and asthenics, 347 or 13.9 per cent.

Table II. A table showing the relationship of the time of gastric emptying in bodily types. It will be noted that gastric motility is progressively slower from the hypersthenic to the asthenic. This fact should be taken into consideration in fine diagnostic work.

TABLE II

AVERAGE GASTRIC EMPTYING TIME OF DIFFERENT HABITUS FIGURED ON BASIS OF 1,000 SUBJECTS WITHOUT ORGANIC OR MARKED FUNCTIONAL GASTRO-INTESTINAL DISTURBANCES

Habitus	Average Total Motility Time	Difference between Times of Gastric Motility in Different Habitus
Hypersthenic	4 hrs. 22 min.	
		24 min.
Sthenic	4 hrs. 40 min.	
		40 min.
Hyposthenic	5 hrs. 26 min.	
		17 min.
Asthenic	5 hrs. 43 min.	

Average emptying time in all types of habitus: 5 hrs. 4 min.

The second table deals with a more simple problem, the rate of gastric motility in different types of individuals. Results were published in a previous communication.* It may serve to illustrate a single proposition of those suggestions in the foregoing. This table was compiled after an ordinary contrast artificial buttermilk meal with a preliminary water mixture, and on the determination of the exact time of gastric motility in 1,000 individuals to within fifteen minutes. The subjects under test were the same as those used in compiling the first table. It may be recalled that they were without known organic or marked functional disturbances, and may be considered approximately normal. It will be noted that the different times of gastric motility vary definitely and progressively in the several types so as to form a quite uniform gradient. Extremes in round numbers are from four hours and fifteen minutes on the average in hypersthenics to five hours and forty-five minutes on the average in asthenics. The most rapid gastric motility observed was one hour and fifteen minutes in an hypersthenic individual, and a six-hour residue was so frequent in marked asthenics that it can hardly be considered as actually abnormal. The practical inference of this information is great in judging gastric motility. We cannot say that because an hypersthenic person has no six-hour residue, his gastric motility is within normal limits. If his stomach total motility were completed only at five and three-quarters hours it would be as abnormal for him as a six and one-half-hour period for an asthenic. Contrary-wise, a six-hour residue in an asthenic has no such diagnostic significance as has a five and three-quarter-hour residue in an hypersthenic. To summarize: For fine diagnostic work the type of the individual must be taken into consideration in judging the period of complete gastric motility, irrespective of the type of meal used. As suggested previously, I feel, however, that it would be best to hold to the six-hour period as a standard time test, and judge individual motilities in light of bodily type and its associated rate of total motility.

* Mills, R. Walter. The x-ray test of gastric motility. *Tr. Am. Gastro-Enterol. Assn.*, 1918.

THE ROENTGEN-RAY LABORATORY OF THE UNIVERSITY HOSPITAL, PHILADELPHIA

BY EUGENE P. PENDERGRASS, M.D.

Assistant Roentgenologist, University Hospital; Instructor in Roentgenology, University of Pennsylvania; Assistant Radiologist, Philadelphia General Hospital

AND

WILLIAM R. JAMIESON

Technical Assistant, University Hospital

PHILADELPHIA, PENNSYLVANIA

THE value of the roentgen-ray laboratory depends greatly upon its organization and its equipment, and as we are frequently asked for general information regarding the establishment of a laboratory, a description of our department may be of interest to one planning a new laboratory.

The space devoted to a roentgen-ray department should be ample. Our laboratory occupies approximately 10,000 square feet. It is located on the ground floor of the hospital. There is abundant sunlight and ample ventilation facilities. In addition to the numerous windows there is a modern ventilating outfit, thus reducing the products of disintegration by high tension current to a minimum. The floor is divided into rooms, as seen in Figure 1.

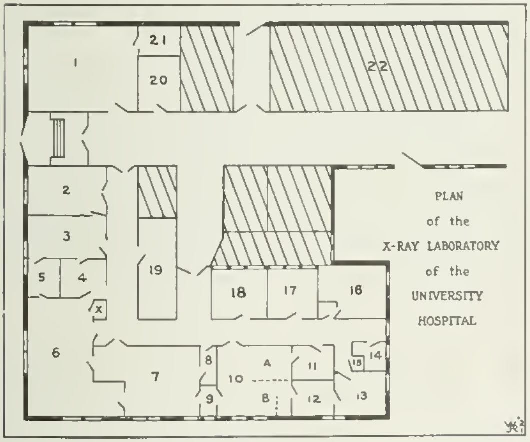


FIG. 1. (1) Demonstration and lecture room; records kept here also. (2) Private waiting-room. (3) Private office. (4) Examining and dressing room. (5) Lavatory. (6) General roentgenographic room. (7) Fluoroscopic room. (8) Dressing room. (9) Treatment control room. (10) Roentgen therapy room. (11) Dressing-room. (12) Room used for making lantern slides or making reductions. (13) Chemical room. (14) Lavatory (15) Service room. (16) Dark room. (17) Photographic and radium treatment room. (18) Small roentgenographic room. (19) Demonstration and film filing room. (20) Film filing room. (21) Supplies. (22) Room reserved for deep therapy.

In addition to adequate ventilation facilities, another important consideration is the protection of the staff from constant exposure to the roentgen rays. This is met by having the walls of the general radiographic, fluoroscopic and treatment rooms lined by sheet lead of adequate thickness. The protection of the operator will be taken up more in detail later.

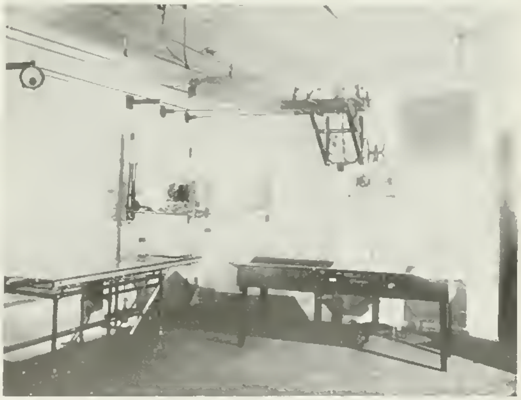


FIG. 2. A portion of the general roentgenographic room.

The maintenance of a roentgen-ray laboratory is an expensive undertaking, especially as at this time numerous new devices and equipment are being put on the market. Naturally, some of the new appliances are not necessary, but one should have the essentials for accurate radiography.

Room 6, Figure 1, is the general roentgenographic room. In this room all the roentgenographic work is performed with the exception of the gastrointestinal, and pyelogram examinations. The equipment in this room changes from time to time in order that it may be kept up-to-date. A list of the necessary apparatus includes: five adjustable roentgen-ray tube stands; vertical and horizontal plate changers; a horizontal table used for making serial

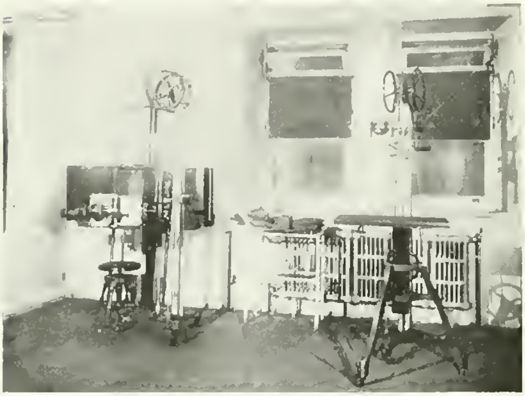


Fig 3. Another view of the general roentg.nographic room.

roentgenograms (Fig. 2); a wooden table used in preparation for examination, and a Bucky diaphragm and table. Rooms 4 and 5 connect with the general roentgenographic rooms and are used as dressing rooms by the patients. Room X is a closet in which all the roentgen-ray tubes are kept.

The transformer supplying the current to the general roentgenographic room is placed in the cellar in a special room, which is dry and adequately ventilated. The placing of the transformer in the cellar does away with the noise of the motor, and at the same time saves floor space in the rooms. The control stand is placed in Room 7, and from here the operator makes his exposures, thus making it almost impossible for the operator to get very much, if any, exposure. The patient, at the same time, is in full view of the operator, who watches the patient through an opening covered with $\frac{1}{2}$ inch of lead glass. The overhead system is constructed of $\frac{1}{2}$ inch brass piping instead of wires, thus eliminating as much of the electrical discharge as possible.

Room 7, the fluoroscopic room, is connected with Room 6 by two doors. Its walls are painted black and the windows are covered by heavy black shutters to exclude all daylight. This room is furnished with a vertical and a horizontal fluoroscope with foot switches and rheostat controls with each fluoroscope. The table for making

Fig. 4. Serial table used for gastrointestinal room and operated from adjacent room.

serial roentgenograms is operated from this room, although the table itself is placed in Room 6 (Fig. 4). We use the same transformer for fluoroscopic and roentgenographic rooms at the present time, but this is to be changed, and a separate transformer is to serve in each room. Room 8 is a dressing room used by patients preparing for fluoroscopic examinations.

Room 18 is a small room in which all simple examinations can be made. It is equipped with two adjustable tube stands, a Bucky diaphragm and table and an adjustable tripod table for examination of the upper extremities. The source of the high voltage current for this room is a bedside unit; that is, the transformer control stand and meters are all in one portable cabinet, which is connected to an overhead system similar to the one in the general examining room. This unit can be moved to any part of the hospital for the examination of patients who cannot be sent to the roentgen-ray department.

Room 16 is the dark room. It is provided with two large stone tanks, so as to give ample developing space. Numerous racks, around which the air is circulated by an electric and an exhaust fan, assure rapid and uniform drying of the films. The shelf and closet space is generous and sufficient for the stock of unexposed films.

Room 12 is a small room used for making reductions or lantern slides of films. The equipment consists of four Cooper-Hewitt lights used for illumination and the apparatus and camera. A small dark room is included so that the slides can be developed without interrupting the work of the other dark room.

Room 10, the treatment room, is divided by a partition, so that two patients may be treated at the same time. The room is equipped with two adjustable tube stands. The tube bowls have had an additional safety device added to them; that is, the space occupied by the terminals of the tube have been surrounded by fiber and rubber steam packing, thus making it almost impossible for the tube to come in contact with the patient. There are two wooden tables, on each of which are placed 4 inch mattresses. The air is constantly changed by two fans, one in the room and an exhaust fan, which has a displacement capacity of 2,600 cu. ft. per minute.

Room 9 is the control room, in which are placed the two control stands. The nurse operating the machines stands in this room and watches the meters, patients and tubes through a window covered with ½ inch lead glass. The transformers are placed in a separate room in the cellar which is dry and well ventilated.

Room 10 is connected with two dressing rooms, Room 11 and a small dressing room cut off from section B (Fig. 1).

Room 17 is an examining room; that is, it has the lights and accessories for making an efficient examination of the mouth and larynx. This room is also used for radium cases which only require a short seance. It is also used as a photographic room to take pictures of the lesions of the cases under treatment.

In addition to the above-mentioned rooms, there is a large basement under the laboratory in which there is a transformer

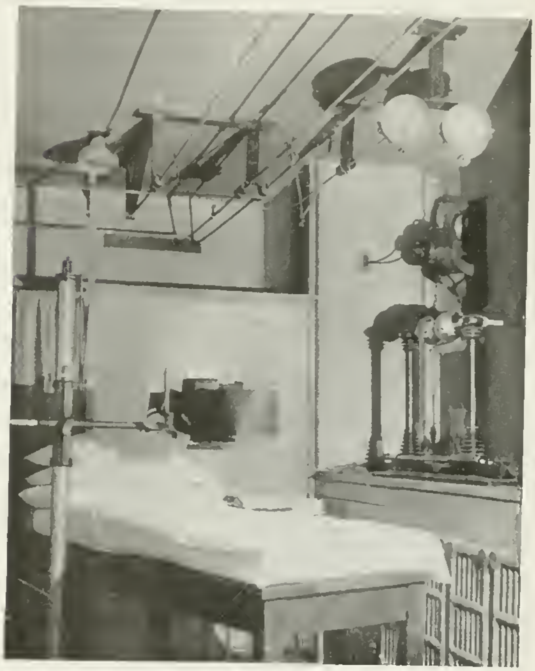


Fig. 5. A portion of the therapy room showing overhead system, tube stands and bowl with protection for terminals of tube and sphere gap.

room and also a large work shop where new apparatus and minor repairs are made. Room 22 is rather remote from the laboratory and has been reserved for deep roentgen therapy. When such a plant is established, Room 10 will be used as a roentgenographic room and Room 18 as a radium treatment room.

The personnel of this laboratory consists of a director, two medical assistants, a resident intern, a technical assistant, two graduate nurses, a pupil nurse, an office manager, a stenographer and a filing clerk, all of whom, with the exception of one medical assistant, work at the laboratory all day.

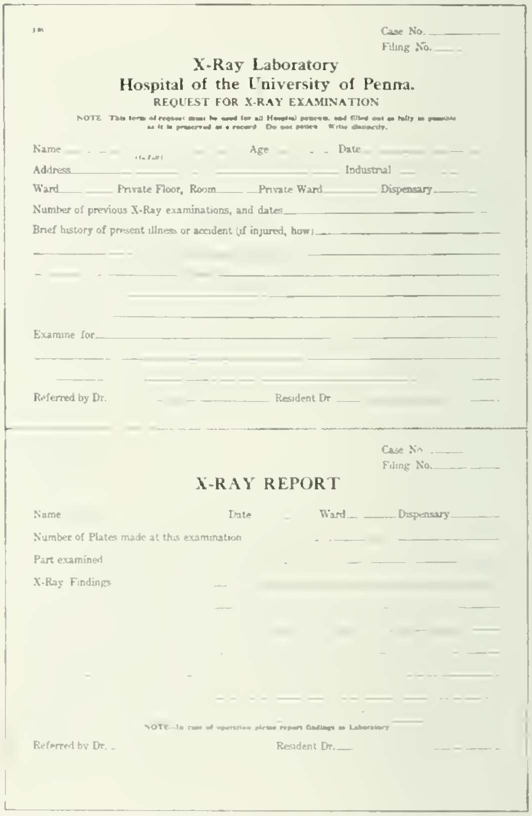
The office manager has charge of all appointments and sees all private patients and arranges for their instructions. To facilitate the handling of patients, and getting in touch with the members of the staff, an intercommunicating telephone system is installed from room to room. In addition to this there is a call bell system, each room having push buttons located on the walls. There are three outside phones.

In a department of this size, it is necessary that one have an efficient organization, otherwise delay will occur. This, of course, will have to be worked out in each laboratory, but generally we have divided the day, so that at a given time ward patients are examined, at another time private patients; in the afternoon gastro-intestinal examinations are made. The first hour in the morning is utilized for plate reading.

A complete record and filing system is very essential to every laboratory so that the records of any case previously examined may be looked up and obtained in a minimal amount of time. To give a concrete idea of our record and filing system, I will follow a case record through all branches of the laboratory.

The request blank (Fig. 6) is handed into our office and an appointment is given the patient. When the patient arrives in the laboratory, the nurse assisting in the roentgenographic room confirms or adds as much to the history as she can obtain from the patient. One question which should be asked of every patient is the number of previous roentgen-ray examinations and dates. Frequently we refuse to examine patients because they have had the maximum exposure elsewhere.

The nurse then fills out a blank similar to the one seen in Figure 7. This is placed with the plate or film after exposure, and sent to the dark room. After all films are developed, the filing clerk pastes the blanks (Fig. 7) on their several filing envelopes. The next morning the histories, envelopes and films are ready for diagnosis. After the diagnosis is written on blank (Fig. 7) it is given to the stenographer, who copies it on the roentgen-ray report blank of Figure 6. This blank is serrated; thus the report blank is returned to the history chart of the patient, and the request blank filed with the film. All these films are turned over to the filing clerk, who records in a book the name of


Case No.
Filing No.

X-Ray Laboratory
Hospital of the University of Penna.
REQUEST FOR X-RAY EXAMINATION

NOTE. This form of request must be used for all Hospital patients, and filled out as fully as possible as it is preserved as a record. Do not pencil. Write distinctly.

Name (in full) Age Date
Address Industral
Ward Private Floor, Room Private Ward Dispensary
Number of previous X-Ray examinations, and dates
Brief history of present illness or accident (if injured, how)

Examine for

Referred by Dr. Resident Dr

Case No.
Filing No.

X-RAY REPORT

Name Date Ward Dispensary
Number of Plates made at this examination
Part examined
X-Ray Findings

NOTE—In case of operation please report findings to Laboratory
Referred by Dr. Resident Dr.

Fig. 6.

the patient, age and diagnosis, doctor referring case and films made. At the same time she gives the patient a case number and an index number and in addition makes out a card for the patient, which is filed according to the vowel system (Fig. 8).

The different parts of the body are given numbers; i.e., chests are given number 2, heads number 1 and spines 17, etc. By this method an index number is given each patient, so that in event of subsequent examinations of the same part of the body, the last films made may be filed with those made at the first examination. In addition, each patient receives a case number, which is given to the patient as a numerical number, and not one of a particular part of the body.

If the examination shows pathological changes, a cross-index card is made out

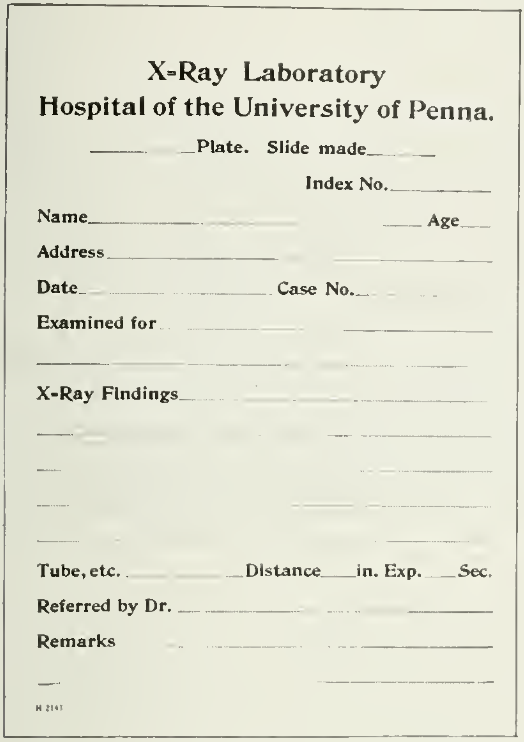

X-Ray Laboratory
Hospital of the University of Penna.

Plate. Slide made

Index No.

Name Age

Address

Date Case No.

Examined for

X-Ray Findings

Tube, etc. Distance in. Exp. Sec.

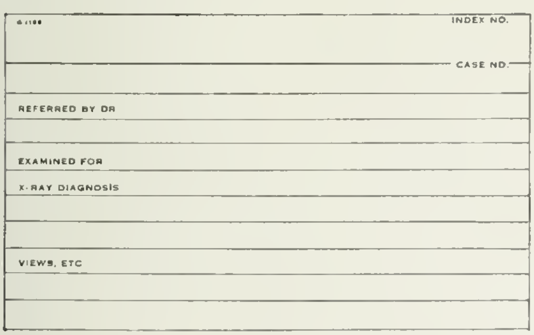
Referred by Dr.

Remarks

H 2141

Fig. 7.

and filed according to diseases (Fig. 9). Thus we have a three-fold check on the patient in the laboratory.


INDEX NO.

CASE NO.

REFERRED BY DR

EXAMINED FOR

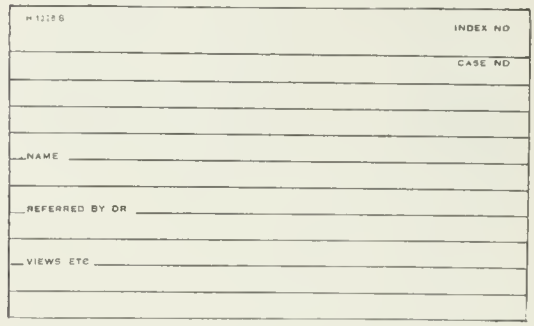
X-RAY DIAGNOSIS

VIEWS, ETC

Fig. 8.

All special examinations requiring fluoroscopy have a typewritten report sent to the doctor, a copy pasted on the filing envelope and a copy filed and bound into a book.

The films are filed in steel cabinets in Rooms 19 and 20. In addition, there is a large room containing several thousand square feet of shelving space, in the cellar. Most of the negative films are thrown away after a year. Those showing pathological changes are kept for five years and then thrown away, after slides have been made. The slides are then filed according to the index number and disease.


INDEX NO

CASE NO

NAME

REFERRED BY DR

VIEWS ETC

Fig. 9.

In this laboratory, we have ample opportunity to discuss the clinical side of the patient with the clinician and surgeon. Twice a week the medical men meet with us and the clinical and roentgen-ray findings are discussed, thus affording the best possible methods of arriving at the proper diagnosis.

Conclusion

It is well understood that the description of the above laboratory may be too elaborate for some hospitals and inadequate for others, but our hope is, that someone may get some benefit from our experience. Any laboratory planned in the future cannot be safely constructed and equipped without taking into consideration the rules which will be outlined by the Safety Committee of the American Roentgen-Ray Society.

ROENTGEN THERAPY IN DENTISTRY

BY JOHN L. GARRETSON, D.D.S.

BUFFALO, NEW YORK

WITH many physicians, the use of the *x*-rays in the treatment of various diseases is a comparatively old story.

The dentist, on the other hand, has confined his use of it to radiograms of the teeth and the jaws, to locate areas of bone and tooth disease, and to observe the results of treatment. The equipment which he has at his disposal has been for the purpose of radiography only, making it impossible for him to advance farther and observe the effects produced by *x*-ray therapy as applied to the gums and other oral tissues.

The dental profession have spared nothing in their efforts to find the causes and the best treatments for the disease commonly known as pyorrhea; every institution of research and the most noted clinics of medical investigation have been conducting exhaustive inquiries and studying this disease, hoping to find the cause and the cure. Much knowledge has been collected and many treatments instituted which have been found to be of value. The researches of Howe by injection of the bacteria of the pyorrhea pocket into normal healthy gum tissue, showed that he could not cause the disease, and that the etiological factors were to be found in some other way.

The researches of Dewey* and Noyes have proved that the infiltration of the lymphatic tissue, found in the peridental membrane and the gums, is the greatest factor in the cause of the recurrent infections of this disease.

The condition of the gums found in pyorrhea happens, in many cases, at a time when the metabolic conditions are at a low ebb, and the tissues are unable to throw off disease, and remain in a state of such lowered vitality that it is impossible for them to recover. The inflammation of the peridental membrane and the gums continues as the infection penetrates the lymphatics. Following the treatment of these lymphatic areas by the *x*-rays, absorption takes place which lessens the pressure of the swollen parts, and results in the restoration of the tissues.

In suggesting this method of treatment, I am applying the *x*-rays in doses which it has been common for the medical roentgenotherapist to use in other pathological cases.

It is to be hoped that the principle of the method here presented will be the part to be considered, and not the fitness of the dentist to undertake this work without thorough preparation. In all my papers before the dental societies I have warned the members against experimenting without a full knowledge of all the effects of the use and misuse of the *x*-rays, the protecting of the patient, and the use of a correct known dosage. One should guard against the use of any supplemental treatment by the employment of tissue stimulants such as iodine, scarlet red or any similar agents, as these have a reputation for causing violent sloughing when used during *x*-ray treatment.

The treatment of pyorrhea requires all the skill at our command in cleaning up the tartar and the products of the inflammation to prevent its further irritating influence, so that the greatest benefit can accrue from the *x*-ray treatment with the smallest number of doses.

Experimentally it is a simple matter to observe the influence of our treatment on the tissues without doing anything in the way of scaling and polishing the teeth. Here it is hoped that this method can be applied to the very sick and to those who are neglected and have very foul mouths. Again, it may be applied to those cases where it is suspected that the metabolic conditions will be apt to cause pyorrhea, and in this way keep the mouths of our patients in a state of health during sickness and convalescence.

My experiments have shown many fortunate effects, by-products of the treatment,

* Dewey, Karthe, and Noyes, Frederick B., A study of lymphatic vessels in the dental pulp. *Dental Cosmos*, April, 1917.

as it were; swellings from jaw infections have subsided, pain and soreness have left the parts, and cases of neuritis have, after long years' standing, remained quiet as the result of a few doses of the x-rays, and have apparently been greatly influenced by this form of treatment.

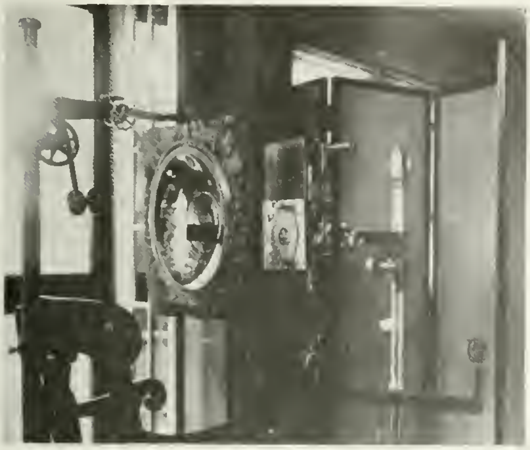


Fig. 1. An early method of protection used by the author.

It is hard to mention such findings without what might seem to be extravagant statements. But in order that the greatest good may come to our patients and these phenomenon be observed by all investigators in this field of research, I ask leave to mention them; for if they prove constant in the future, they will be of great value to our profession in the treatment of many obstinate and painful diseases.

In the near future I expect to be able to present to you the findings in a large number of cases where roentgen therapy was employed; also the histological and pathological findings which are now being secured.

Mention of the anodyne effects of the x-rays to operators in different fields of research has often brought forth the remark that they have observed similar effects, even from the use of very small doses such as they would use in the making of a few x-ray examinations of the teeth.

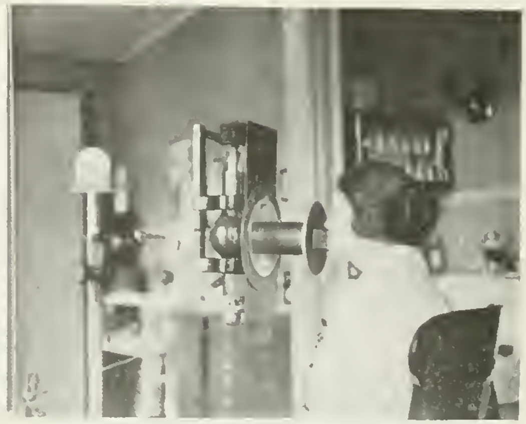


Fig. 2. Improved diaphragm allowing the x-ray to be applied to a definite area. Recording the area by marking automatically a square area which received the ray.

The technique that I employ* is based upon the mathematical formulae as outlined by W. D. Witherbee, M.D. of New York, and others.

SUMMARY

X-ray therapy may be employed in the treatment of the conditions of the teeth and the gums where the effect is to reduce the pain and other symptoms of inflammation, affording relief in a great variety of dental diseases. This is due to the effect of the x-rays on the lymphatic tissue.

The new factors in determining the dosage make it an easy matter to apply the method in treatment with a feeling of assurance that one is using factors which are under his direct control. It is hardly to be expected that dentists will attempt x-ray treatment with improper apparatus.

* Garretson, John L. Employment of x-ray dosage in the treatment of pyorrhea. *Dental Cosmos*, November, 1921.

THE VAN ZWALUWENBURG TYPE OF STEREOSCOPE

BY S. W. DONALDSON, M.D., AND E. F. MERRILL, M.D.

From the Department of Roentgenology, University of Michigan

ANN ARBOR, MICHIGAN

THE advantages of using the stereoscope method have long been recognized by the majority of roentgenologists. Consequently, several types of stereoscope have been devised, employing the prism, single mirror (French type), and the 90° mirrors.

The construction is based on the principle of all double-mirror stereoscopes, with the exception that the mirrors are mounted horizontally instead of vertically, and that the mirror stand is the only adjustable part.

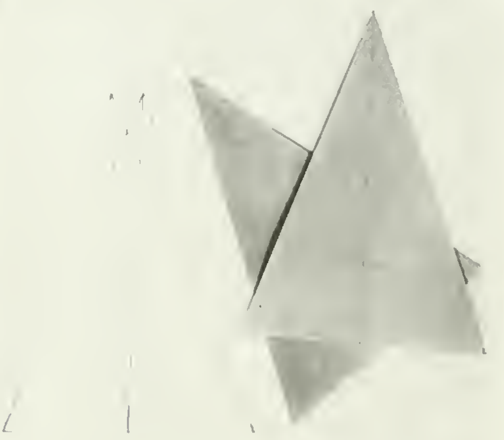


Fig. 1. Triangles erected on a common base, and two triangles of the same dimensions cut from colored paper.

Fig. 2. Paper triangle superimposed on triangle of same dimensions and then folded, the line along the fold forming the plane of one mirror.

In addition to its value as a means of studying plates, the stereoscope is appreciated by the visiting physicians and hospital staff members, who like to have pointed out to them the important pathological findings. In order to do this with ease, it is practically necessary that both demonstrator and the person to whom the plates are being demonstrated view simultaneously the stereoscopic radiograms. This is possible with the modified Wheatstone instrument, by placing a reversed pair of mirrors above the usual pair; but by this method one person sees the image in "false" stereo.

It is the purpose of this paper to describe a new type of stereoscope and to set forth its particular advantages over the types now in use.

If the usual type of illuminating box is used, in which the fronts of opal glass are perpendicular to the support table, the horizontal mirrors can be placed midway between the boxes. The distance from the mirrors to each box should be 2 or 3 in. more than the usual plate-target distance employed.

If it be desired to incline the fronts of the illuminating boxes so that plates can be leaned upon them, it will be necessary to employ exact measurement of angles and distances; and the following procedure is recommended:

Using any suitable scale, erect a perpendicular at the mid-point of a basal line 18 in. in length. Now construct two acute-angled scalene triangles upon this line as a common base so that their apices are 24 in. from the point at which the perpendicular bisects the base, and $1\frac{1}{8}$ in. from the perpendicular line, or, in other words, the apices should be $2\frac{1}{4}$ in. from each other (the approximate average of the distance between the pupils of the eyes). Now cut two such triangles from paper and superimpose them over the triangles of the drawing, fixing the apices securely. To obtain the angles for the mirrors and light boxes, fold the paper triangles back along such a line

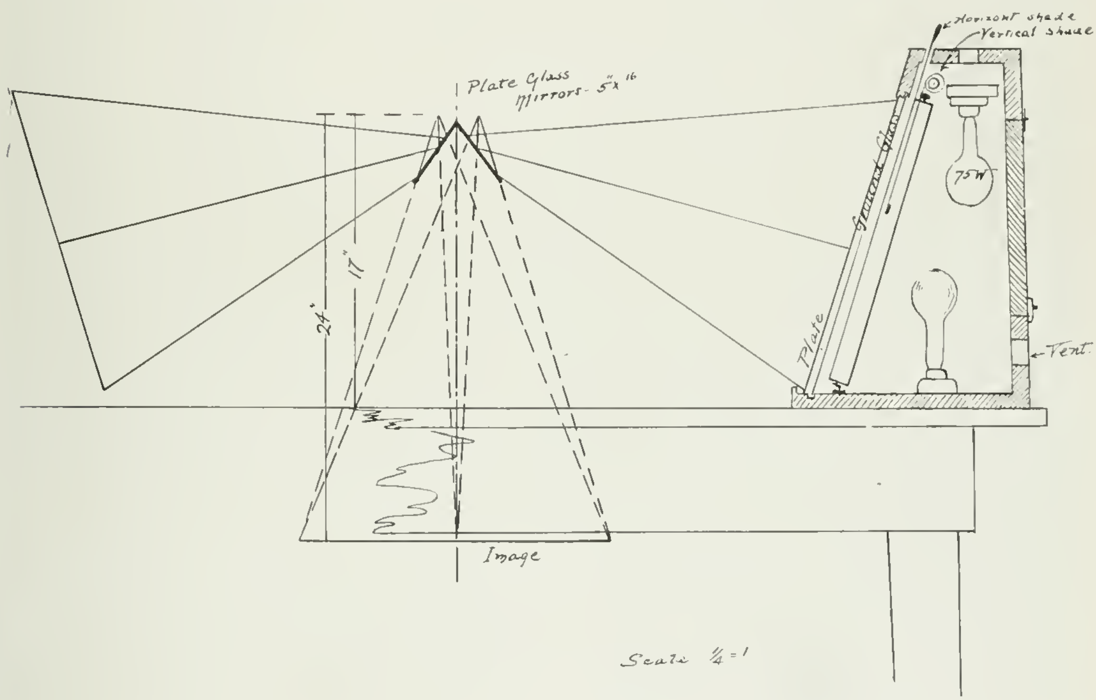


Fig. 3. Diagram of each step in construction and plan of completed stereoscope.

as to bring the base of the folded triangle parallel to the shorter side of the opposite triangle of the drawing. The bases now form the position and angle of the illuminated side of the light boxes, and the lines of the folded portions of the paper triangles when projected to cross the perpendicular erected at the point of bisection of the base, form the angle at which the viewing mirrors should be set.

Light boxes may be constructed and so arranged that their ground glass illuminated surfaces coincide with the line of the bases of the triangles. Two plate glass mirrors, preferably 5 by 16 in., are fastened on a holder so that they form the angle laid out above for them.

It has been found desirable to have the light boxes placed upon a table of such a height as to permit the study of plates while seated. This simplifies the construction of the mirror support and its adjustments, as it is necessary to have a single tubular support to allow for rotation, as well as for elevation of the mirrors. This can be done by having a support work in a friction holder placed either on or under the table at a point equidistant from the bases of the light boxes.

An advantage in the construction of the light boxes is placing the curtains inside the box and employing a rheostat control for the illumination.

Two persons may now view the plates in "stereo" by occupying seats on opposite sides of the table, and when adjustment has been made for one it will be found agreeable for the other.

We wish to bring out the following points in connection with this type of stereoscope:

1. Economical and simple construction.
2. Comfortable position while viewing plates, with the advantage of a table for notes or dictaphone.

3. An aid to persons using bifocal lenses, as the position of the head need not be changed to look through the lower lenses.

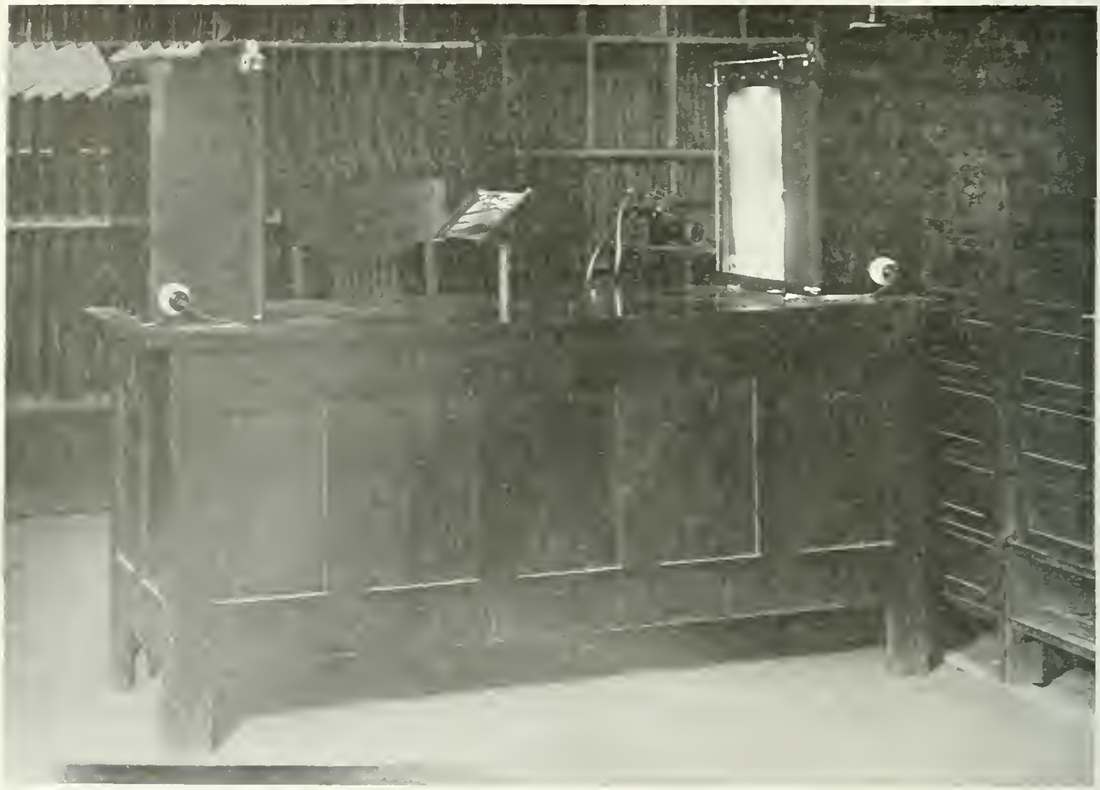


FIG. 4. Temporary stereoscope now in use. This one has vertical light boxes, but proves satisfactory in every way, and brings out all the principles set forth in this article.

4. The mirrors need only to be adjusted to make the images coincide.

5. Two persons may simultaneously observe a "true" stereoscopic image.

6. The inclined position of the ground glass of the light boxes provides such a support that films or plates do not fall forward.

In conclusion, we should like to state that this new type of stereoscope was designed and used by Dr. James G. Van Zwaluwenburg, but that his untimely death prevented him from bringing it before the profession.

A NEW SAFETY DEVICE*

BY H. W. VAN ALLEN, M.D.

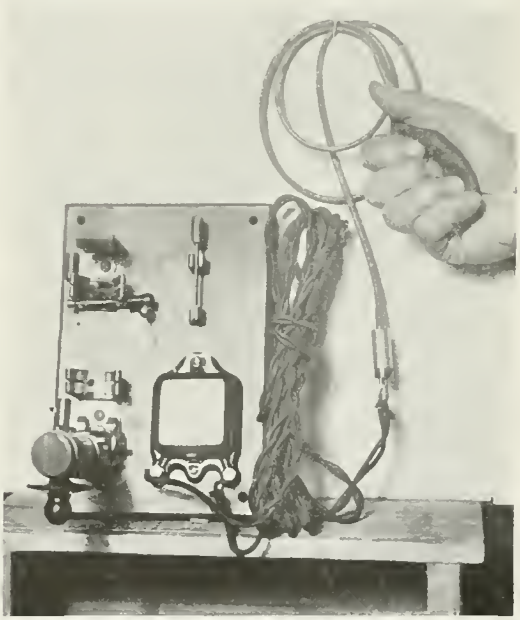
SPRINGFIELD, MASSACHUSETTS

APPLICATION of *x*-ray, in the practice of medicine, changes so rapidly that many customs and usages that were perfectly safe only a short time ago have, due to the increased efficiency of our present day apparatus, become dangerous to a degree not always recognized. It is well known that a number of deaths have occurred from the application of the high tension current to the body. Every effort should be made to eliminate such dangers.

It is only a few years since many of us were treating cases with static machines, our belief being that, ordinarily, the current could not do material harm. We shortly transferred our treatment cases to the coil of the Rhumkoff type with the rheostat control, and still later to the transformer containing the rheostat control. Up to this point, due to the tendency of the rheostat not to allow large currents to pass suddenly through it, we were still within safety. This was all changed when we began to use the auto transformer control. Provided the patient had a good ground connection and the secondary current passed through a vital part of the body, death would be very apt to occur.

At the recent Washington meeting many safeguards were urged upon the roentgenologists.

Position of circuit breaker when treatment is progressing—current passing.



Position of circuit breaker after patient has pressed bulb—no current passing.

I wish to present to you, to-night, an additional device, which, while it is simple, is effective in stopping at once the continuance of the current, and places the control of the high tension, in an emergency, in the hands of the patient as well as the operator. At times the patient has an intimation of trouble before it actually occurs, and the loss of time calling the attention of the operator might be fatal.

I have, for a number of years, given patients a push-button connection with a call-bell, instead of trusting to hearing them speak, so that, if they are uncomfortable, they can give the alarm in this

* Read before THE NEW ENGLAND ROENTGEN RAY SOCIETY, Nov. 12, 1921

way. Of course the wire connected with this push-button made an excellent ground which was undesirable. Since using the high tension currents this danger has become much greater.

Many of the machines are now made with circuit breakers, as all should be.

It is a combination of these two ideas which is involved in the little instrument presented. An ordinary one-pole circuit-breaker, which may be adjusted to act upon comparatively small currents, is seen at the left of the small switch-board. As some operators wish to use the same machine for roentgenographic work as well as roentgenotherapy and would not wish to reset the circuit breaker, a small switch is added above, which, when thrown in, cuts out the circuit breaker and makes large currents possible. At the lower right side is an ordinary electric bell to which has been added a special device which trips the circuit breaker. A pair of wires, in one of which is introduced two dry cells, extends from the bell to a position near the couch on which the patient is to be treated. At the end of these wires a specially constructed contact is seen, which is operated by air pressure. This latter arrangement prevents grounding of the patient through the wire and switch-board. To operate this air push-button the patient is given a rubber bulb to which is attached a few feet of rubber tubing which is connected with the air push-button. The slightest pressure on the bulb, by the patient, closes the air contact, throws the circuit-breaker and rings the bell continuously.

The advantage is manifest: the patient controls the high tension current, is able instantly to attract the attention of the operator, and is given a great sense of security. In actual practice, the device is not used unnecessarily by the patient.

TIME-SAVING DEVICES FOR THE ROENTGEN-RAY TREATMENT OF RINGWORM AND FAVUS OF THE SCALP

BY GEORGE M. MACKEE, M.D., AND GEORGE C. ANDREWS, M.D.

From the Department of Dermatology and Syphilology, College of Physicians and Surgeons, Columbia University
NEW YORK CITY

THE Kienboeck-Adamson method of dividing the scalp into five areas in preparation for roentgen-ray therapy is now well established, and it is employed by nearly all roentgenologists and dermatologists when treating ringworm or favus of the scalp.

The usual procedure is to place a steel tape-measure over the top of the scalp, in the middle line, from the forehead to the nucha. Marks are made upon the scalp 10 inches apart. These marks will be usually about an inch inside of the anterior and posterior hair lines. Their exact positions in respect to the hair lines will depend upon the size of the head. A third mark is made exactly halfway between the other two. Marks are then made about one inch above the pinna of each ear. With the aid of the tape measure these marks are placed or adjusted so that each mark is 5 inches from neighboring marks. Connecting lines are then drawn between the various marks. In this way the scalp is divided into 5 triangular areas of equal size. The marks or points are the targets for the direct rays while the lines help in establishing the correct angles of incidence. As is well known, it is essential to have each of the 5 exposures at right angles to the exposures made to neighboring areas.

Heads, because of age, sex, race, etc., differ somewhat in both size and shape. This makes no material difference in the results obtained with the Kienboeck-Adamson method of preparing the scalp for roentgen-ray treatment (see below). It does, however, make it difficult to construct an instrument or marker that will instantly and accurately indicate the Kienboeck-Adamson points and lines on any head.

The circumference of the head of the average tinea tonsurans patient is 20 inches, providing the circumference is obtained from points in the sagittal plane, $1\frac{1}{2}$ inches inside of the anterior and posterior hair lines and from points one inch above each pinna. Measured in this manner, the heads of some children show a circumference of 21 inches, while in others the circumference is only 19 inches. The circumference of adult heads, free of hair, is usually about 22 inches.

When preparing a head for roentgen-ray treatment one does not need to note the location of the circumferential line in relation to anatomical landmarks. It makes no difference whether the Kienboeck-Adamson points are on the anterior and posterior hair lines or a considerable distance inside of the hair lines. The lateral points may be an inch or more above the ear, or very close to the ear. The chief requisites are to have the points 5 inches apart (see below) and so placed that lines drawn between these points are at right angles. As a rule, it is possible to have the marks 5 inches apart, but this is not always so. In small heads the marks will be $4\frac{3}{4}$ inches apart, while in large heads the distance will be $5\frac{1}{4}$ inches or even $5\frac{1}{2}$ inches. This variation of distance between the Kienboeck-Adamson points does make a difference in the dose received at any spot between the points, but this difference can be corrected by changing the skin-target distance. This question will be discussed later. For the purpose of developing a marking device it is necessary to establish a circumferential line such as mentioned in the previous paragraph.

The instrument or marker herewith described has been used by us for some time, and it has given admirable service in ways that will be mentioned later. It can be made by the operator out of an ordinary flexible steel tape-measure. The marker is simply a duplication, in metal or other material, of the Kienboeck-Adamson points and lines. The base is a circular band to which are attached two cross-pieces. The ends of the cross-pieces are riveted or otherwise securely fastened to the circular band at the anterior, posterior and lateral Kienboeck-Adamson points. The intersection of the two cross-pieces is also riveted: this represents the central or vertex Kienboeck-Adamson point. A glance at the photograph of the marker will show that the cross-pieces are set at right angles to each other and at right angles to the circular band. When constructing a home-made marker, it is advisable to join the cross-pieces to the base in such manner that measurement begins at the lower border of the latter.

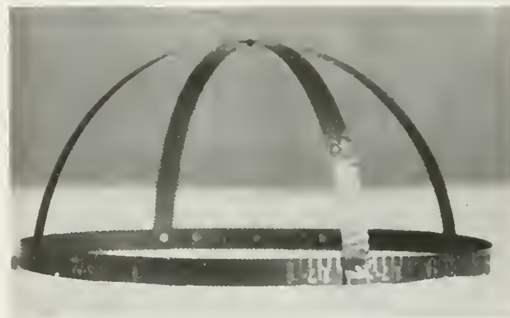


Fig. 1. Home-made tinea-marker. Made of steel tape-measure. Circumference, 20 inches.

For children, the marker is made in three sizes. The one that is used by far the most has a circumference of 20 inches and the Kienboeck-Adamson points are 5 inches apart. For smaller heads the circumference is 19 inches and the points are $4\frac{3}{4}$ inches apart. For the larger heads the marker has a circumference of 21 inches and the points are $5\frac{1}{4}$ inches apart.

When treating heads with a circumference of 19 inches it is advisable to use a skin-target distance of $6\frac{1}{2}$ inches in order to avoid too much overlapping. When the head is smaller than this, it is advisable to reduce the dose from the standard skin unit to $\frac{3}{4}$ of a skin unit. Heads with a circumference of 20 inches or over are treated with an 8 inch skin-target distance, and a full skin unit is administered. Adult heads with a circumference of 22 or more inches may rarely require $1\frac{1}{4}$ skin units or even a larger dose. We have never found it necessary to use a skin-target distance greater than 8 inches; nor have we ever found it necessary or advisable to use 7 instead of 5 areas as advised by the Germans. The spark-gap length is 6 inches, so that, even in very small heads, the distance between patient and tube terminals is greater than the length of the spark-gap.

It is possible to construct an instrument possessing adjustable joints so that one instrument can be adjusted to a head of any size. To do so, however, invites

FIG. 2. Tinea-marker (home-made variety) placed in proper position on scalp.

inaccuracy and the adjustments would require as much time as it would take to mark out the scalp by the old method. We greatly prefer a set of four markers—three for children and one for adults.

A very skilful physician or technician can work with surprising accuracy without the aid of the Kienboeck-Adamson points and lines, but to do so is to take an unnecessary and unjustifiable risk. One should never fail to use or do anything that adds to accuracy, certainty and safety in *x*-ray work.

After the scalp hair has been closely clipped, it requires from ten to thirty minutes to mark out a scalp by the old method. The time consumed will depend upon the skill of the operator, the shape and size of the head, and, above all, the behavior of the patient. It is exasperating to a busy physician to waste a half-hour with a refractory child preparing the head for treatment. Furthermore, this fussing makes an apprehensive child so nervous that the treatment can be given only with considerable difficulty.

FIG. 3. After the scalp has been mapped out with the tinea-marker and an indelible pencil, and the marker removed.

It requires not more than sixty or ninety seconds to map out the scalp with the tinea marker. The child, instead of being apprehensive, is rather amused and interested. The instrument is used as follows: The patient's family should be instructed to have the patient's hair cut very close to the scalp. Hair clippers should be used. The marker is then placed on the scalp with the anterior and posterior points in the middle line and at equal distances inside the anterior and posterior hair lines. A line is then drawn on the scalp along the inferior border of the circumferential band. Lines are also drawn along the cross-pieces. Dots are made at the intersecting points. The marking can be done with a skin pencil, with ink or with a dull-pointed indelible pencil that has been moistened with water. In the case of a very dark skin, white ink is advantageous. Iodine or other irritating chemicals should not be employed for this purpose.

Recently we have improved the "tinea-marker." The new instrument is made of celluloid. The circumferential band and the cross-pieces are of sufficient width to allow a slit in the center for nearly their full length. These slits represent the Kienboeck-Adamson lines, while holes, placed at the intersections of the cross-pieces and the circumferential band, represent the Kienboeck-Adamson points. In other words, the instrument is a stencil. It is placed on the head and painted with ink or chalk mixture; or the marking may

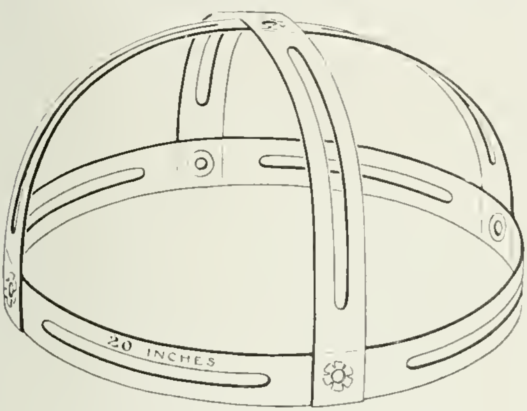


Fig. 4. Tinea stencil made of celluloid.

be done with a wet indelible pencil. When the stencil is removed, the head is ready for treatment. This instrument is manufactured in sets of four and it is now on the market. It can, of course, be made of metal. In either case it is easily sterilized.

Someone undoubtedly will suggest that the instrument be left on the scalp during treatment, thus obviating the necessity of making the marks and lines. This scheme has been tried and found wanting. No time is saved by so doing, because it is necessary to fasten the marker to the scalp with court-plaster; otherwise it is likely to slip out of position during the treatment.

Sparks from lead or other metallic substances, used for the purpose of protecting the non-hairy parts, may possibly ignite the very combustible celluloid.

Even thin celluloid may effect sufficient filtration to reduce the dose and prevent epilation; thus bands of diseased hair will remain to cause reinfection of the entire scalp. This undesirable result may be overcome by using filtered radiation. Coolidge has recently demonstrated, with very delicate and accurate ionization measurements, that there is considerable variation in the output from different standard Coolidge tubes operated under identical electrical conditions. The difference in intensity is due to variations in thickness of the glass walls of the tubes. Working with a 9 inch gap he found an extreme difference of 66.5 per cent with unfiltered radiation and 12.9 per cent with 3 mm. aluminum. This perturbing finding naturally encourages the use of filtered radiation. It is also possible that the difference between the amounts necessary to effect a temporary and a permanent defluvium is a little greater with filtered than with unfiltered radiation. It would seem, then, that filtered radiation should be the method of election. The results obtained in practice, however, do not yet support this contention, although further experience may do so.

Severe systemic reactions often follow the use of filtered radiation for this purpose. They hardly ever occur subsequent to unfiltered treatment. The brain, even of infants, has never been injured when unfiltered radiation has been used. Whether or not filtered radiation will injure the brain when employed for this purpose is not known. Buschke, Kleinschmidt and Gutmann report severe systemic reactions, and Buschke and Klemm report not only these, but also radiodermatitis, permanent alopecia and failure to depilate with filtered radiation in a large portion of their cases.

We have depilated over 1,000 patients with unfiltered radiation; always with certainty, never with untoward results. The work has been done with 8 or 10 different Coolidge tubes. This result shows a margin of safety sufficient for practical purposes. In fact, the margin of safety in practical work must be considerably greater than has been suspected. Hazen, Lane, and Fox and Anderson in this country and many English and French dermatologists and roentgenologists report similar results. Filtered radiation may prove to be superior to unfiltered radiation for this purpose, but our advice is to make the change from unfiltered to filtered radiation cautiously.

The scalp is often irradiated for diseases other than tinea—psoriasis, eczema, acne varioliformis, etc. In such instances one does not desire to effect depilation, so that the dose is never more than ½ skin unit in one month. When treating the

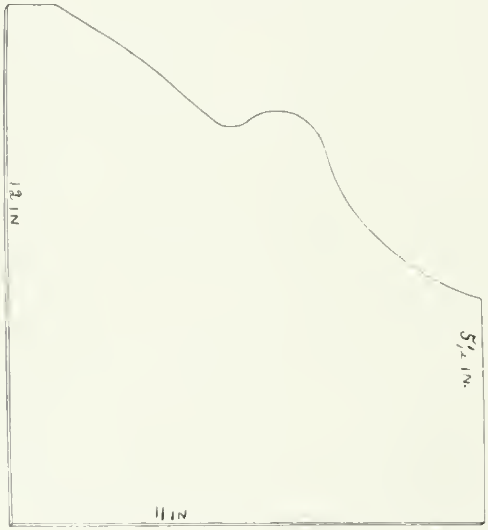


Fig. 5. Lead-rubber shield for side of face, ear, side of neck and shoulder.

entire scalp it is usual to employ the Kienboeck-Adamson angles, and because of the small dose it is permissible to estimate the Kienboeck-Adamson angles and points visually and without actual measurement. If, however, one desires to do so, the "tinea-marker" may be used for this purpose by placing it upon the head and leaving it there during the treatment. The filtration occasioned by the celluloid is not a serious matter in these diseases. A metallic marker is not suitable for this purpose. With celluloid one must be cautious about sparks. The circumference of adult heads, depending upon the amount of hair, varies from 22 to 26 inches. Special markers would have to be made for the large heads. We prefer to estimate the Kienboeck-Adamson angles and points with the eye or with a tape-measure when administering generalized irradiation in subepilating doses to the scalp for the treatment of such diseases as psoriasis.

The second time-saving device consists of a set of three "lead rubber" shields for the purpose of protecting the face, neck and ears during treatment. This scheme is not original with us. We first saw the shields used by Dr. A. Howard Pirie many years ago.

One square yard of "lead rubber," 3 mm. thick, is cut into three pieces. The exact

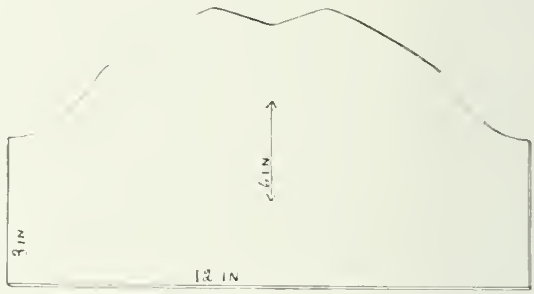


Fig. 6. Lead-rubber shield for forehead and face.

shape of each piece is depicted in the accompanying illustrations. One shield is for the face, one is for the side of the neck, shoulder and ear, and the third is for the back of the neck, the shoulders and the back.

The advantages of these shields are numerous. One of the greatest causes of

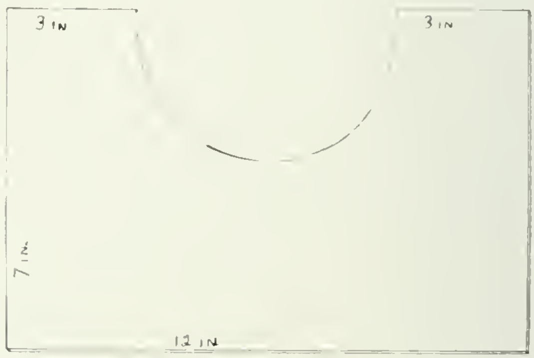


Fig. 7. Lead-rubber shield for back of neck, shoulders and back.

nervousness and restlessness during treatment is the sparking from lead foil. Much time is lost reassuring and quieting the patient; also time is lost in attempting to prevent sparking by obtaining good contact with the skin or by placing pads under the lead foil. The lead is likely to slip every time the head moves a little and the treatment must be interrupted while the lead foil is again adjusted. Shields made of lead foil do not last long and it is a nuisance to have to make new shields so often.

We have never noticed sparking from the "lead-rubber" shields. Patients never complain. The shields are easily sterilized and are always ready for use. They can be placed in position in a second. They seldom slip out of position during treatment, but if they do, readjustment can be made in a second without interrupting the exposure. They afford ample protection and they will last several years. We feel that the "lead-rubber" shields directly and indirectly save a great deal of time. The shields will be found useful when treating diseases of the scalp other than tinea. They are now on the market.

Ten or twelve years ago, working with a gas tube, induction coil and pastilles, it often required a half day to depilate one head. The advent of the Coolidge tube and the interrupterless transformer reduced the time to an hour or two. Routine treatments are now given in from fifteen to thirty minutes. Several patients can be treated in one afternoon without mental or physical fatigue to the operator.

In conclusion we thank Dr. John Remer, Dr. F. Steinke and Dr. V. A. H. Cornell for trying the "tinea-marker" and the shields on a large number of cases. All who have tried these time-saving devices dislike to work without them.

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A MARKER FOR IDENTIFYING RIGHT AND LEFT EYE IMAGES IN STEREOSCOPIC CHEST FILMS

BY PAUL C. HODGES, M.D.

From the Department of Roentgenology, Peking Union Medical College
PEKING, CHINA

Snook, writing in the American Journal of Roentgenology, January 1919, vi, No. 1, p. 39, discussed the principles of the formation of true and pseudo stereoscopic images, and described a simple method of marking films to show how they should be placed in the stereoscope to produce a true image. His method consisted in the use of a one inch wooden cube containing a metal brad. This cube was placed at one corner of the film-changing tunnel and left there during the exposure of both films. The variation in the appearance of the shadow of the brad, due to the shifting of the tube, determined which film was the right and which the left eye image. I have developed a slight modification of the method, for use with a vertical film-changing device, such as is used in making stereoscopic chest films.

In the particular film changer used in this laboratory, the window consists of a piece of transparent celluloid, $45\frac{1}{2}$ cm. high, $44\frac{1}{2}$ cm. broad and 3 mm. thick A point is selected $7\frac{1}{2}$ cm. above and $6\frac{1}{2}$ cm. to the left of the lower right hand corner of the window. Using this point as a center, a circle 2 cm. in diameter is inscribed on the celluloid. Two cork discs, each 8 mm. thick and 2 cm. in diameter are made, and fastened to the celluloid at the site of the inscribed circle, one disc being cemented to the front, the other to the back of the window. Either glue or acetone may be used as cement. After the cement has dried a few hours, a small hole is drilled through the center of the corks and the intervening celluloid, using a drill slightly smaller than the shank of a shingle nail. A shingle nail is now cut off at the point, leaving the head and 18 mm. of the shank. This is driven through the holes in the corks from behind until the head is flush with the rear cork. This gives essentially one of Snook's cubes, permanently fastened at the lower right hand corner of the celluloid window, at a point where its shadow will be visible on 14 × 17 films, in either the vertical or horizontal position.

In practice, we fasten the patient's lead *x*-ray number to the celluloid, just below the cork, using for this purpose a bit of adhesive plaster. This done, it is possible to forget the films until they have been developed, dried, and are ready for examination, when we proceed as follows:

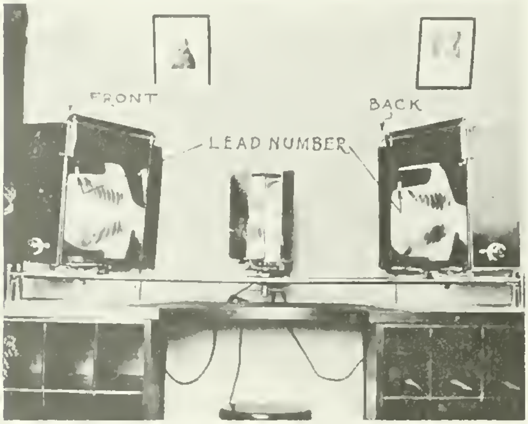

FIG. 1. This shows what is meant by the *back* and *front* of the stereoscope boxes. The shadows of the lead number and the marker are seen at the *front* in the left eye image and at the *back* in the right eye image.

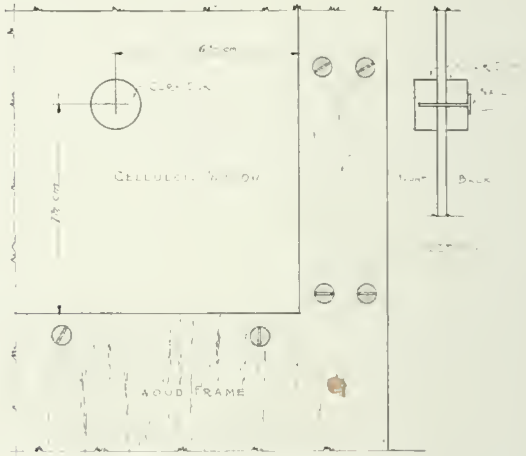

FIG. 2. A marker for identifying right and left images. Diagram showing section from lower right-hand corner of vertical film changer. The small diagram at the right shows a small section of the celluloid window, viewed from the edge.

The two films are arranged, one on top of the other, with the skeletal shadows in the erect position, and the numbers reading in order. It will be seen that the shadows of the numbers and the nail are in the lower right hand corner. The films are now turned over (because the stereoscope mirror reverses the image), so that the numbers read backward, and also turned sidewise, so that the skeletal shadows lie as though the patient were in the horizontal position (because the tube shift is vertical). We now have two films, each with the body in the horizontal position, with the numbers reading backward, and with number and marker in the upper left-hand corner. To determine which film is to go in the right-hand illuminating box and which in the left, one must examine the markers more closely. Doing this, it is seen that in one film the shadow of the nail is longer than in the other, and is angulated through a wider arc. This film is placed in the left-hand viewing box with the number at the front of the box; the other is placed in the right-hand box with the number at the back.

With the films so arranged, it is observed upon stereoscoping that we are looking through the chest from behind, forward; that the heart is on the left side; that the numbers read in order; and that the lead number strip appears farther from the observer than does the body of the patient.

There is one further step. Upon removing the films from the viewing box, a hole is punched in the upper posterior corner of each, so that on subsequent examination, it is merely necessary to turn the films over, so that the numbers read backward, turn them sidewise until the numbers are at the top, and then place them in the boxes with the punch marks at the back; that is, away from the observer.

A NEW METHOD OF SIMULTANEOUS STEREOSCOPIC OBSERVATION OF BOTH MASTOIDS

BY PAUL C. HODGES, M.D.

From the Department of Roentgenology, Peking Union Medical College

PEKING, CHINA

HILL and Thomas, writing in the *American Atlas of Stereoroentgenology*, February, 1911, ii, No. 8, described a technique for making stereoroentgenograms of both mastoids on a single pair of plates. Their method made it possible to stereoscope right and left mastoids simultaneously, and was consequently of great diagnostic value.

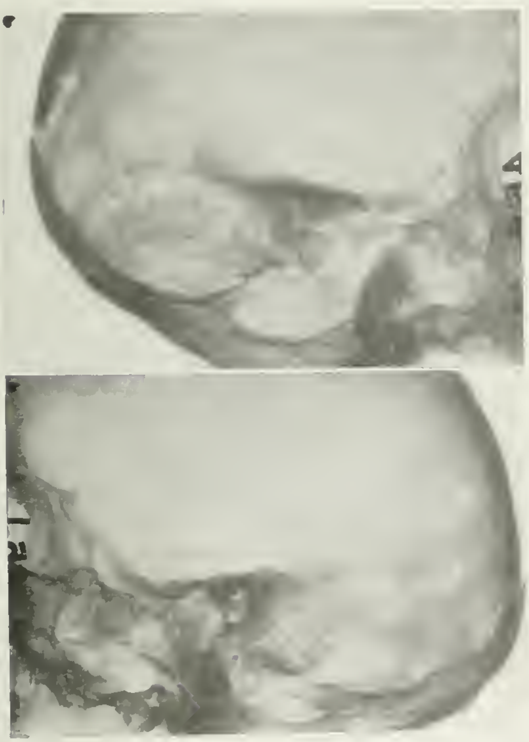

FIG. 1. Right Eye Image. Roentgenograms of dried skull. Right side above, left side below, punch marks of both films at the left, numbers and letters reversed.

FIG. 2. Left Eye Image. Roentgenograms of dried skull. Right side above, left side below, punch marks at the right. Figures 1 and 2 can be stereoscoped in the ordinary Wheatstone stereoscope.

The general use of films instead of plates makes possible another method of simultaneous examination of the two sides, which I have employed for about two years and which I find to be much simpler than the older method.

Stereoscopic pairs are made of both mastoids, using 5 × 7 films and marking right and left sides. The films of the right side are placed in the stereoscope so that they give a true stereoscopic image; then, using a conductor's punch, holes are punched to show the upper corner at the back of the box. The films of the left side are prepared in the same way.

Next, 10 × 7 pieces of celluloid are prepared, using discarded films with the emulsion washed off. The films of the right mastoid are turned over so that the numbers read backward (because the stereoscope mirror reverses the image) and fastened to the upper half of the celluloid mount, using paper clips. It will be found that the punch marks are located at opposite corners in the two films. The left mastoid films are now turned over so that the numbers read backward, and are fastened to the lower half of the celluloid mount, care being taken to see that the punch marks in the lower films correspond with those in the upper ones.

Two mounts are now ready for the stereoscope; in one the punch marks are at the left, in the other at the right. The mount with the punch marks at the *right* is the left eye image; in other words, the punch marks must be placed at the back of the box. The mounted films are now observed in the stereoscope to assure that the right mastoid is above, the left below, and that there is a true stereoscopic effect with the number farther from the observer than the shadow of the skull. If everything is in order, the films are permanently fastened to the celluloid with metal staples.

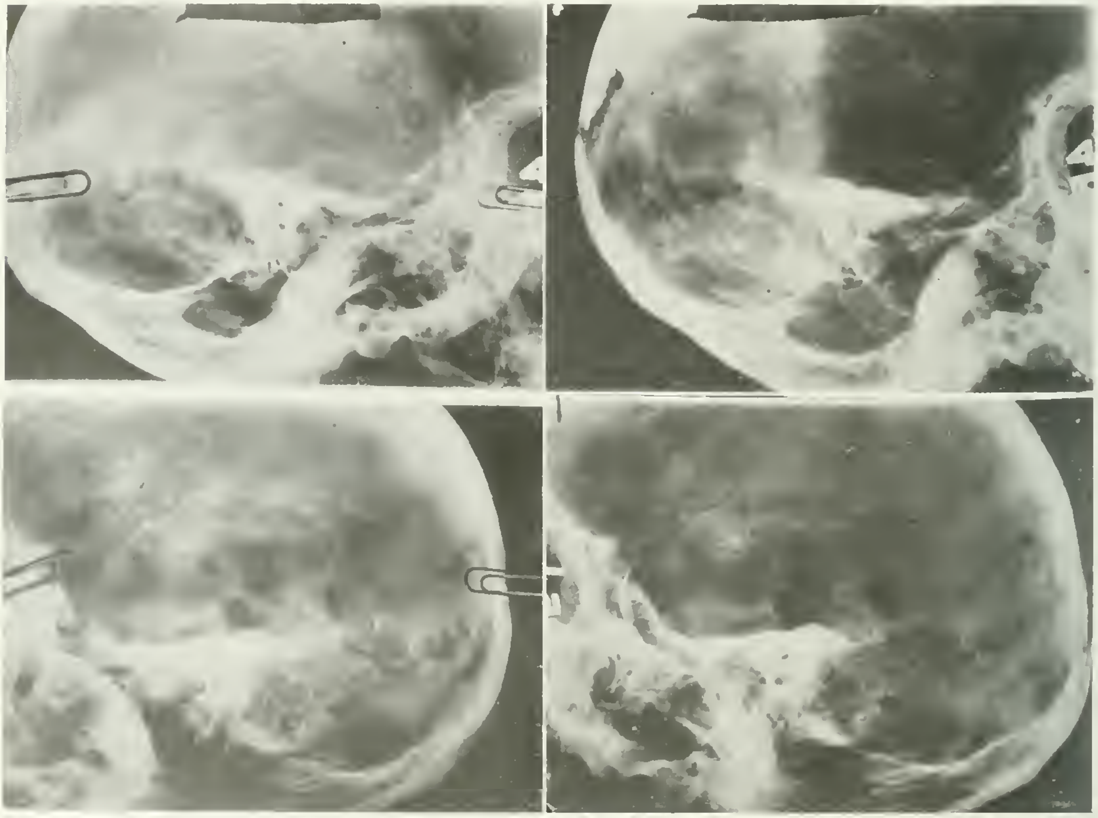

Fig. 3. Showing method of fastening films on celluloid mount. In the left eye image, the temporary paper clips are seen; in the right eye image, staples have been applied and the clips removed. It has been found unnecessary to use more than two staples; in fact, more than two are apt to cause buckling of the films. The curtains of the stereoscope boxes serve to hold the upper and lower borders of the films against the mount.

A. NEW RADIUM APPLICATOR FOR THE TREATMENT OF CATARACTS

BY BUNDY ALLEN, M.D.

IOWA CITY, IOWA

THE application of radium in the treatment of cataracts has been simplified by the applicator, as shown in the following cuts.

The concavity of the applicator is made to conform to the convexity of the eyeball, and is easily and comfortably inserted. The construction of the applicator is such that it is held in place by the eyelids. The applicator, as illustrated, obviates the necessary tanning of the skin from the eyelid when applying the radium externally.

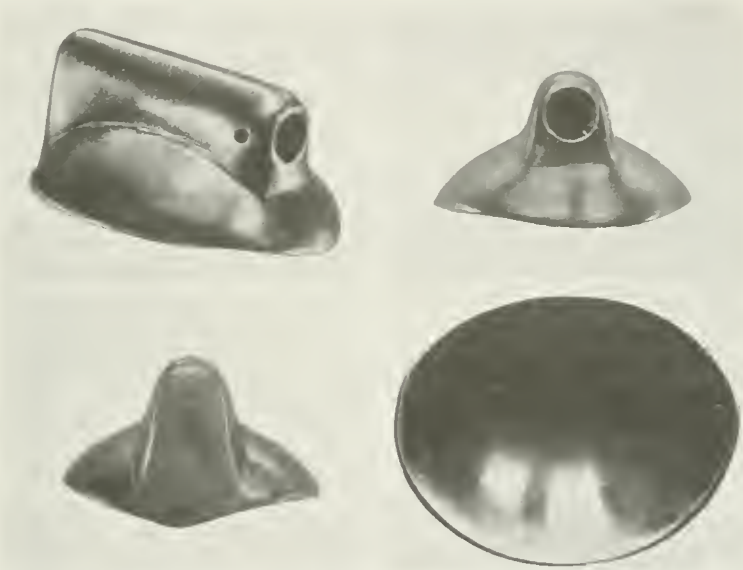

Fig. 1. Oblique view of applicator.
Fig. 3. Opposite end of applicator closed.

Fig. 2. End view.
Fig. 4. The under concave surface of the applicator.

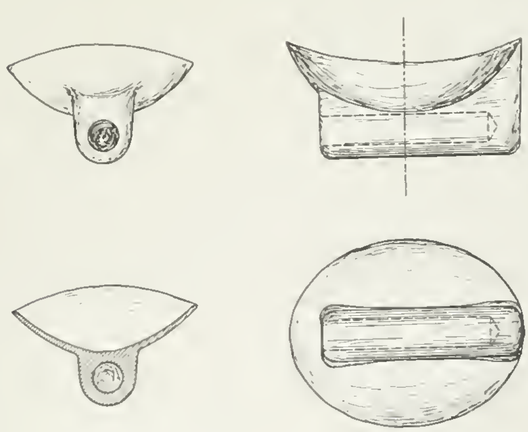

Fig. 5. Sketch of the applicator to show the position and method of filtering the rays.

A CASE OF TUBERCULOUS GINGIVITIS TREATED WITH APPARENT SUCCESS BY RADIUM*

BY GEORGE E. PFAHLER, M.D., AND B. P. WIDMANN, M.D.

PHILADELPHIA, PENNSYLVANIA

IN reviewing the literature, we find that tuberculosis of the oral cavity is comparatively a common condition. After a reasonable search, however, we have not been able to find any case recorded of radium therapy for tuberculous gingivitis. According to Levy, Thomae in 1838 made the first report of tuberculosis of the mouth. Since then much has been written and many cases recorded. Levy reviewed the literature of reports of 200 cases. We will not discuss here the pathology of this condition. Adami expresses the concensus of opinion that tuberculosis of the mouth is rarely a primary condition. Unlike many of the infections commonly found in the oral cavity, many of which are often attributable to bad teeth and uncleanliness, we find that this condition develops in patients who have observed oral hygiene most scrupulously.

Briefly, the notes on the case which we are reporting are as follows: Male, age 33, was referred to us by Dr. W. I. Galland, May 5, 1921. He had had pulmonary tuberculosis fifteen years before. He was in Colorado under treatment from 1915 to 1919. In the fall of 1916 an ulcer developed in the left side of the gum running along the outer side of the teeth, and in the spring of 1920 he noticed a spot developing over the right upper canine tooth. The diagnosis of tuberculous gingivitis was made by Levy of Denver, Col. The electric cautery and trichloracetic acid had been used without success. Gentian violet seemed to do some good. In 1918, under Levy, he received a course of tuberculin beginning at .000000001 gm. of O.T. and going up by graded doses to .7 gm. The lung condition improved, but there was a local reaction in the gum when there was a tuberculin reaction, and this kept the gum irritated. A section removed and examined by Dr. Galland showed the tubercle bacillus. This was confirmed by Dr. Eugene Case of the Department of Pathology of the Post Graduate School of Pennsylvania.

The lesions first appeared as small punctate areas scattered about the gum margins of the upper and lower canines and lateral incisors and the left lower molars on both labial and lingual surfaces. These soon blended, forming irregular, serpiginous lines extending well down over the surfaces of the gums and over a great area of the left cheek. The ulceration became progressively more definite and invading, remaining always fairly superficial with sharp, red, irregular borders, within which were interspersed soft granulations with pinhead spots of yellow and gray, and occasionally covered with cloudy films of dirty yellowish serum. There were much irritation and frequent pain.

The case having resisted all other forms of treatment, the application of radium was made as follows; a 10 mgm. plaque of radium covered with 1 millimeter of rubber was fixed to a wooden tongue depressor and was held firmly on as many areas as was necessary to cover all lesions. The time on each area was 20 minutes. Seven applications were made at intervals of three weeks. Special care was taken to guard against any local reaction or any destructive effect, and to keep at all times within the range of a stimulating dose. The actual dose given was between 1/3 and 1/2 of a skin erythema dose. After each seance the lesions grew paler, with less pain, until finally all signs of ulceration, irritation and pain had disappeared, September 22, 1921. To date, there has been no evidence or sign of recurrence.

All authors agree that these cases are most obstinate and resist all forms of treatment, such as excision, cautery, curettement, tuberculin and local medica-

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 26–28, 1922.

ments. Levy believes that tuberculous ulcers of the oral cavity rarely heal, though their progress is extremely slow.

We report this case, even though the duration of the results is short, because the results seem to be brilliant, and with the hope that others may at least try the obstinate cases.

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TECHNIQUE AND STATISTICS IN THE TREATMENT OF CARCINOMA OF THE BLADDER BY RADIUM*

BY B. S. BARRINGER, M.D.

NEW YORK CITY

DETERMINATION OF METHOD OF RADIUM TREATMENT

(I.) *Intravesical.* Growths confined to and around bladder neck. Small papillomata. Pedunculated papillary carcinoma if pedicle can be reached. Infiltrating sessile growths of no more than 2 cm. in diameter.

II. *Suprapubic.* Growths other than the above and without metastasis. Extensive infiltration of the bladder wall, large and multiple tumors are the indication for section, to which all doubtful cases are method in submitted.

TECHNIQUE

Intravesical Methods. By means of a flexible spring holder used through the sheath of the Brown-Buerger operative cystoscope 100 or more mc. of unscreened radium may be held up against the tumor for the period of half an hour while the tumor is being observed through the cystoscope. This may be repeated every two weeks, or less often if the tumor is disappearing satisfactorily. If the tumor looks solid or hard, or has a base which looks indurated, then we may treat it by thrusting into its base or the indurated part, a radium needle screened simply by the steel of the needle. This needle is also on a flexible spring and is used through the operating cystoscope. Needles from 50 to 200 may be used for a period of time up to forty minutes. We must remember that in this method the action is local and caustic. We have in a similar way implanted small bare tubes of radium into the base of a tumor and left them there. For this, bare tubes of 0.7 to 0.8 mc.[1] to a sq. cm. of tumor are used, and left in place. Of all the methods this has proved the most satisfactory. The action here is still more local and more caustic. We have used all of these methods and combinations of them in various tumors, and by all of them have destroyed small or recurrent carcinomata of the bladder. If a tumor is more extensive, if it is papillary in character, if the pathological examination shows pure papilloma, and especially if it be around the bladder neck, we often start the treatment by placing in the bladder two tubes of screened radium (.6 mm. silver, 2 mm. rubber). These tubes are inserted through the sheath of a straight cystoscope and tied with a string and left

[1] We have found that 0.7 to 0.8 mc. of radium produces no more irritation to the bladder than tubes of lesser strength, and produces more gamma radiation, and therefore is better.

* Read at the Seventh Annual Meeting of The American Radium Society, St. Louis, Mo., May 22–23, 1922.

in place for varying periods of hours and then pulled out of the urethra by the attached string. As a rule, we use two tubes of 50 mc. for five or six hours. The value of such radiation is first, to see how the tumor reacts to radium; second, temporarily to stop the bleeding to make cystoscopy possible; third, to destroy that portion of the tumor around the internal urethral orifice. If the tumor is carcinomatous and large, so that the incision may not go through tumor tissue. Between two clamps the bladder is opened and a 3 or 4 inch incision is made longitudinally. The cut surface of the bladder is grasped by clamps, the clamps being about 1 inch apart. The reason for this is that the bladder will otherwise collapse and fall down into the pelvis when retractors are put into it, thus making operation impossi-

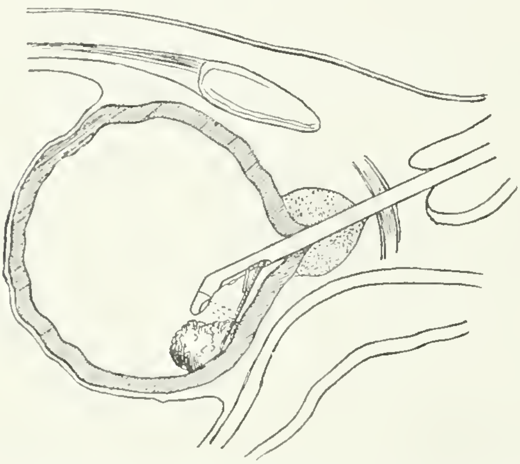

Fig. 1. Method of burying radium emanation tubes in growth by means of special introducer and the cystoscope.

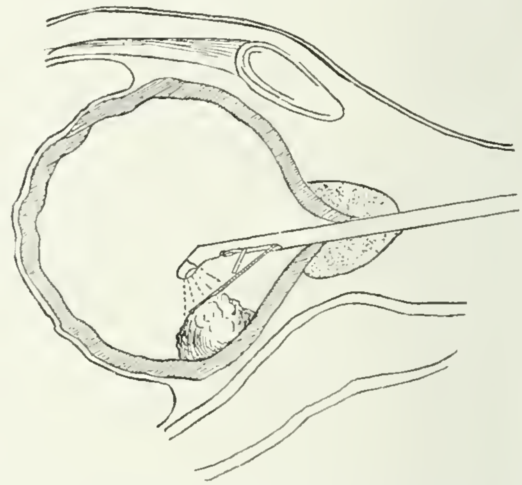

Fig. 2. Surface application of radium emanations to growth under vision by means of special applicator in cystoscope.

and we believe from our examination it is confined to the bladder, then we do the open operation described below.

Suprapubic Application of Radium in Extensive Carcinoma. Because we were unable to cope with extensive carcinomas of the bladder by the intraurethral method, in June, 1919, we began to open up the bladders in selected cases and implant radium directly into the carcinoma. The technique is as follows:

Gas and oxygen anesthesia is used. The bladder is prepared by washing and filling with a 1:4000 acriflavine solution. The patient is placed in Trendelenburg's position. The skin incision is a long one, extending from the symphysis to the umbilicus. The prevesical fascia is cut transversely at the symphysis and dissected back, the bladder being exposed well down its posterior wall. The urachus is cut, and the exposure extends beyond this. The sides of the wound are screened with gauze. The bladder is gently palpated

ble. A light is thrown into the bladder, and bladder retractors, three or four in number, are gently placed in the bladder. The retractors which we have used most have been made for us at the Memorial Hospital. They are made of 1/8 inch steel wire in the form of an open loop. The advantage of these is that the tumor may be seen through the open portion of the retractor, and treated. The tumor being exposed is sponged as little as possible to prevent bleeding and spreading of tumor cells. Any protruding portions of the tumor are snared off, using a simple wire snare. If the tumor is flat and not papillary in type, none of it is removed. The reason for snaring off the papillary part is better to expose and treat the base. Indurated parts of the tumor are implanted with radium bare tubes (0.7 mc.) by means of a needle, using one of these to the sq. cm. These bare tubes are put in to the extreme edge of the tumor.

The bladder is filled with 60 per cent alcohol after the method of Beer (three minutes) in order to kill any stray tumor cells and prevent implantation. The bladder is closed up with plain catgut, and usually drained with a small rubber tube.

STATISTICS

To determine the value of radium removal of bladder carcinoma we have attempted a comparison between radium and operative removal. This comparison is made in three ways:

1. Giving radium results in operable cases.
2. Giving radium results in inoperable cases.
3. Giving the results in cases in which operation is used as an adjunct to radium. That is, the tumor is exposed by cystotomy in order to implant radium in its base. This last to compare the mortality, results, etc., of this procedure with the mortality and results of operative removal of carcinoma.

Any classification of operable and inoperable cases is, of course, arbitrary, and varies with the successes any individual operator may have had in different kinds of carcinoma. We have put in the inoperable class, carcinomata in which successful removal by operation alone was highly improbable, namely:

1. Multiple carcinomata or large carcinomata of a base more than 4 cm. in diameter.
2. Carcinomata which have affected the trigone and posterior urethra.

Fig. 3. Use of special retractor in exposing clearly the carcinoma, especially its base. Snaring off pedunculated growth preparatory to burying radium emanation tubes in its bore.

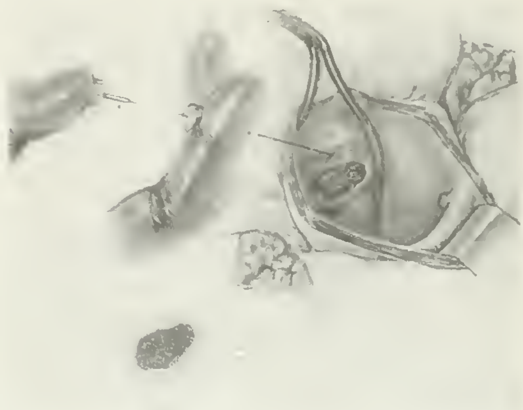

Fig. 4. Burying radium emanation tubes under direct vision after exposure of carcinoma by suprapubic cystotomy.

3. Carcinomata which have previously been operated upon and have recurred.
4. Carcinomata in patients whose age or condition contraindicated shock of operable removal.

Gross Pathology of Tumors. The characteristics of the 10 operable and 20 inoperable tumors below described are as follows:

Multiple	8
Indurated base	18
Involving ureter	5
Involving trigone	8
Involving bladder neck	12
Lateral wall	6
Vault	1
Grown through bladder	1

SMALL OPERABLE CARCINOMA[2]

Ten cases, (1 of these a borderland case).

Carcinoma removed,[3] 8 cases (proved by cystoscopy). Dead 2:

[2] Complete tables of these cases are appended at the end of this article.

[3] We have insisted upon the cystoscopic proof of removal. Simply to say that a patient looks and feels well for a year or two after an attempt at removal of bladder carcinoma, means little.

On 1 cystoscopy	1 case.
6 mo. to 1 yr.	4 cases.
1 yr. to 2 yrs.	2 cases.
4 yrs.	1 case.

Pathology:

Papillary carcinoma	2
Carcinoma	2
Epidermoid carcinoma	2
Squamous carcinoma	1
No pathology	1
Total	8

One died two years after radium from growth in seminal vesicle. Possibly it was primary there. One died three months post-cystotomy (before operation had 5 per cent sugar in his urine).

Removal:

Intravesically	7
Suprapubically	1

Complications:

In one patient, the kidney which corresponded to the side on which the tumor was situated, was non-functionating, and draining pus into the bladder. The patient has gone five years since the removal of his tumor. He has, in addition, an enlarged prostate, with residual urine, and a diverticulum.

Summary. In 8 of 10 operative cases (80 per cent), the carcinoma has been removed from the bladder. The two patients who died, lived two years and three months respectively after they were first seen. This is, perhaps, too small a number of cases upon which to base conclusions, so we now turn to the inoperable cases for confirmation.

INOPERABLE CARCINOMA OF THE BLADDER

In this class are recorded only the cases in which the carcinoma has been removed by radium.

Carcinoma removed, 20 cases (proved by cystoscopy):

1 mo	1 case.
6 mo	4 cases.
6 mo. to 1 yr.	2 cases.
1 yr. to 2 yrs.	9 cases.
2 yrs. to 3 yrs.	3 cases.
3 yrs. to 4 yrs.	no cases.
4 yrs. to 5 yrs.	1 case.

Another case, not reported above, is well eighteen months post-radium, but refuses cystoscopy. One of the above cases has an extra-vesical extension of carcinoma, to which he will succumb. One had a recurrence two years post-radium treatment. This was removed by radium, and she has been well one year. Two have had slight recurrences (one year after removal) at the interior urethral orifice (still treated). One died one year and two months after the first radium treatment from a sloughy, infected bladder, due to radium burn.

Pathology:

Carcinoma	2 cases.
Papillary carcinoma	2 cases.
Infiltrating carcinoma	6 cases.
Epidermoid carcinoma	1 case.
Papilloma	2 cases.
Squamous infiltrating carcinoma	1 case.
Carcinoma (?)	1 case.
No diagnosis	5 cases.

Removal:

Intravesically	10 cases.
Suprapubically	10 cases.
Previously operated upon	3 cases.

Summary. In 20 inoperable cases of bladder carcinoma, the tumor has been removed from the bladder. In 3 cases, the carcinoma has recurred after removal. In 1 of these 3, the recurrence is beyond the bladder; the other 2 are being treated. One is dead from radium slough of bladder.

Let us briefly take the third point of comparison. At the Memorial Hospital we have, in carcinoma which was too large to attempt to remove intravesically, and in which we believed the carcinoma to be confined to the bladder, exposed the tumor by a cystotomy, to see if it were suitable for removal by radium. If, on exposure, a tumor is found to be too large for removal, the bladder is simply closed, and the removal of the tumor by radium not attempted. We are always attempting to extend the field of radium, and remove larger and larger tumors. Thus we almost invariably implant radium into what we regard as hopeless tumors, to see if we cannot control them, even for a time. Thirty-five bladder carcinomas have been treated in this way. In but 2 of these cases might a tumor have been called operable. In 2 cases, the tumor was so large that the bladder was not opened, although radium was implanted in it.

In 12 of these 35 cases, the carcinoma had been removed from the bladder. Nineteen of these 35 are living. The deaths in this series were as follows:

1 mo	none
1 to 2 mo	1
2 to 3 mo	1
3 to 6 mo	6
6 to 12 mo	4
12 to 24 mo	4

I believe that the conclusion from this is, that in cases in which we could do no good, we probably did not appreciably hasten the demise of the patient. On the contrary, in some hopeless cases, we retarded the tumor's growth, lengthened the span of life and stopped bleeding.

Kidney Complications. Probably not a few of the postoperative deaths are due to kidney complications. We have found that 2 out of 3 cases of carcinoma of the bladder have a distinctly reduced kidney function. In the radium removal of bladder tumors we have made it our policy never to transplant a ureter, but simply to implant the radium into the base of the tumor, and deal with kidney complications which may arise subsequent to the operation. In but one case have we had a severe enough infection to demand opening the kidney. This was done under novocaine, and the patient subsequently died. Implanting the ureter likewise lengthens the operation.

The whole operation for the suprapubic implantation of radium into bladder carcinoma described elsewhere[4] takes considerably less time than operative removal of such tumors.

Let us now turn briefly to operative statistics. Scholl,[5] from the Mayo clinic, reports 94 cases of solid carcinoma of the bladder which were operated upon. Of these 94 cases, 67 (71.2 per cent) are dead after an average duration of life of seven and a half months and 27 (28.7 per cent) have lived an average of three years and three months. Twenty per cent of patients operated on for infiltrated carcinoma died during the first month after operation, as compared with no immediate postoperative deaths in radium removal.

Disadvantages of Radium. Much of our seven years' work with radium has, of necessity, been experimental. We have had radium burns; in 3 cases of extensive carcinoma in which the dose of radium has been too much, the patients died of sepsis, caused by radium slough. In cases in which a suprapubic operation has been done, the healing sometimes has been slow and protracted. All of these unfortunate results can and are being overcome by more accurate dosage and more accurate application of radium.

CONCLUSIONS

In 8 out of 10 operable cases of bladder carcinoma and in 20 inoperable cases the tumors have been removed by radium. Radium removal is superior to surgical, because it can cope with inoperable cases. If a suprapubic radium removal is necessary the time of operation is shorter and the kidneys are less disturbed by the operation. Postoperative or post-radium recurrences can be better dealt with. Many so-called operable tumors can be removed intra-urethrally without any operation.

[4] BARRINGER. Radium treatment of carcinoma of the bladder. *Ann. Surg.*, 1921.

[5] Histology and mortality in cases of tumor of the bladder. *Surg., Gynec. & Obst.*, Feb., 1922, xxxiv, 189.

INOPERABLE CARCINOMA OF BLADDER TUMOR REMOVED BY RADIUM

No.	Name	Age	Date Treatment	Description of Tumor	Pathology	Intra-vesical	Suprapubic	Result	Previous Operation
1	V.	36	June, 1910	Papillary tumor, large as orange, base 5 × 5 cm., of left bladder base.	Papillary infiltrating carcinoma (Ewing)	. .	×	Bladder clean (cystoscopy) 20 mo. post-op. (slight papilloma of urethra). Reports well 3 yrs. 2 mo.	One
2	K.	54	Jan., 1920	Papillary tumors, indurated base (largest 3 × 3 cm.) all around bladder neck.	....	. .	×	Bladder clean (cystoscopy) 24 mo. post-op.	0
3	W.	61	Mar., 1920	Solid tumor, ulcerated surface (6 × 6 × 6 cm.) on anterior wall of bladder growing through bladder, and adherent to pelvis.	....	. .	×	Bladder clean (cystoscopy) 24 mo. post-op.	0
4	H.	48	Sept., 1919	Number of hard nodules around bladder base. (Scar of radium in bladder neck from pre-op. treatment.)	Papillary carcinoma (Brooklyn Hospital)		×	18 mo. post-op. has slight urinary frequency (once at night). Looks and feels entirely well. Refuses cystoscopy.	One
5	G.	50	Apr., 1920	Solid flat tumor 3 × 4 cm., within 1 cm. of left ureter.	Infiltrating carcinoma (Ewing)		×	Recurrence after operation treated intravesically. Bladder clean (cystoscopy) Feb., 1921. Extra vesical carcinoma 23 mo. post-op.	0
6	D.	33	May, 1920	Solid tumor, left wall, 2 × 4 cm. Papillary tumors around bladder neck.	Infiltrating carcinoma (Ewing)	. .	×	Recurrence after operation. Treated intravesically (3 times). Mar. 3, 1921, no tumor. Radium slough. Well 23 mo. post-op.	0
7	S.	55	July, 1920	Papillary tumor, 4 × 5 cm., of left bladder base. Base indurated.	Infiltrating carcinoma (Ewing)		×	Bladder clean (cystoscopy) 17 mo. post-op.	0
8	W.	50	Aug., 1920	Indurated ulcerated tumor, 3 × 3 cm., around sphincter of bladder.	Epidermoid carcinoma (Ewing)	. .	×	Bladder clean (cystoscopy) 6 mo. post-op. Recurrence Jan., 1922. Still treated.	0
9	R.	70	Dec., 1920	Indurated, flat, irregular tumor, 3 × 3 cm., centering in left trigone and touching bladder neck.	Papilloma (Ewing)	. .	×	Bladder clean (suprapubic observation) 2 mo. post-op. sinus 1 yr. 6 mo.	0
10	M.	50	Dec., 1920	Indurated ulcerating tumor touching internal urethra 4 × 3 cm.	Squamous infiltrating carcinoma (Ewing)	. .	×	Well, no tumor, 15 mo. post-op. (Suprapubic sinus.)	0
11	T.	59	June, 1920	Flat irregular tumor around urethra (treated by radium before operation). Small tumor seen at operation.	Infiltrating carcinoma (Ewing)	. .	×	No tumor 6 mo. post-op. Radium slough (cystoscopy). Died 1 yr. 2 mo. post-op. infection.	0
12	C. A. C.	69	Dec., 1915	Cauliflower non-pedunculated, sloughly, base 3 cm., over left ureter.	Carcinoma (Ewing)	×	. .	Bladder clean 4 yrs. 4 mo. (cystoscopy). Well 6 yrs.	0

13	E. J. S.	54	July, 1916	Papillary tumor, sloughy, extensive, all around the bladder neck. Vaginal induration of 5 cm.	Papilloma (Ewing)	×	..	Bladder clean 1 yr. Well 4 yrs.	0
14	M.	70	Oct., 1916	Multiple, papillary, red tumor on bladder base, vaginal induration.	Carcinoma (Ewing)	×	.	Bladder clean 2 yrs., then recurrence. Removed by radium 1 yr.	0
15	R.	68	June, 1917	Sloughy papillary tumor, extensive, bladder neck.	Papilloma carcinoma (Ewing)	×	.	Bladder clean 3 mo. Recurrence. Bladder clean 1½ yrs. Well 2½ yrs.	0
16	P.	63	Nov., 1916	Two tumors, one sloughy, around bladder neck.	...	×	..	Bladder clean, 2 mo.	0
17	S.	53	....	Multiple sloughy tumors, bladder neck, largest ½ × 3 cm.	Carcinoma ?	..	×	Bladder clean, 5 mo. slough.	0
18	W.	58	Oct., 1921	Indurated tumor, bladder neck, 3 × 2 × 2 cm.	Infiltrating carcinoma	..	×	No tumor. Radium slough. 5 mo.	0
19	P.	45	Apr., 1921	Recurrent after operation. Small solid growth, 2½ × 1 cm. near left ureter.	Papillary carcinoma	×	..	Bladder clean, edema 8 mo.	One 0
20	D.	70	Sept., 1920	Left bladder base, sloughy indurated mass, 2 × 2 cm.	...	×	..	Bladder clean 1 yr. Recurrence 1 yr. 7 mo. Still treated.	0
21	W.	38	Nov., 1920	Multiple sloughy tumors, base indurated, left bladder neck and urethra.		×	..	Bladder clean 1 yr. 5 mo.	

SMALL OPERABLE BLADDER CARCINOMA, TREATED BY RADIUM

No.	Name	Age	Date	Description of tumor	Pathology	Intra-vesical	Suprapubic	Result	Previous Operation
1	W.	60	Apr., 1920	Pedunculated tumor (small tangerine) covered with incrustations, left bladder wall, indurated base.	Papillary carcinoma (Ewing)	.	×	Bladder clean (cystoscopy) 23 mo. post-op.	0
2	H.	62	July, 1916	Rapidly growing, flat, ulcerated, small operable near ureter.	Carcinoma (Ewing)	×	..	Bladder clean 4 yrs. (cystoscopy). (Kidney no function on side corresponding to tumor).	0
3	V. W.	59	May, 1917	Papillary tumor, some slough, left trigone, 2 × 2 cm.	Papillary carcinoma (Ewing)	×	..	Bladder clean once (cystoscopy) 1 yr. after treatment.	0
4			.	Small ulcerated tumor of left trigone.	Carcinoma	×	..	Died 2 yrs. later, extension beyond bladder. Possibly primary in semi-vesicles.	0
5	G.	64	....	Tumor, flat, ulcerating, right lateral wall, 2 × 3 cm.	Epidermoid carcinoma (Ewing)	×	..	No tumor 8 mo. later (cystoscopy). Radium burn. Well, Feb., 1922.	0
6	W.	50		Small, ulcerating, flat, back of left ureter, 3 × 3 cm.	Epidermoid carcinoma (Ewing)	×	..	No tumor 8 mo. later (cystoscopy).	0
7	H.	50		Red, smooth, rounded tumor, near right sphincter, 3 × 3 × 2 cm.	Questionable, if carcinoma	×	..	No tumor 1 yr. later (cystoscopy).	0
8	G.	.	July, 1921	Solid tumor back of left ureter 2 × 2 × 2 cm. Some slough.	Squamous carcinoma (Ewing)	×	..	Feb., 1922 (cystoscopy) slight slough at site of tumor. No tumor.	0
9	V.	45	Apr., 1921	Papillary red tumor, firm edge, 2 sloughy areas, left lateral wall, 3 × 2½ cm. indurated carcinoma.	O	×	..	March, 1922, no tumor. Slight slough at site of tumor.	0
10	E.	56	Aug., 1920	Sloughy flat carcinoma, right bladder wall, 3 × 3 cm.	Carcinoma (Ewing)	..	×	5 % sugar in urine at time of operation. Died 3 mo. post-op. of perirectal abscess.	0

RESULTS OF TREATMENT OF CARCINOMA OF THE CERVIX WITH STATISTICS AND TECHNIQUE*

BY CURTIS F. BURNAM, M.D.

BALTIMORE, MARYLAND

THE further development of means and methods for combating cancer of the cervix uteri is perhaps the most pressing gynecological obligation of the profession today. The established relationship between chronic irritations and cancer gives basis to the hope that surgical prophylaxis in the treatment of tears and ulcers will reduce the incidence of cervical cancer. Watery and bloody vaginal discharges are associated with the idea of malignancy, not only in the minds of most doctors, but of most women. In spite of this, and of the complementary knowledge that the hopeful time to treat cancer is in its incipiency, it is nevertheless true that a large proportion of these patients come first for help in advanced stages of the disease. It seems quite certain, no matter what education may effect, that these advanced cases will continue frequent, and it is equally clear that improved radiation methods offer greater possibilities of helping than anything else in view just now.

It is recognized that there are wide individual differences in resistance to cervical cancer, but neither the nature of the normal body defenses nor knowledge as to how to amplify them is at hand.

For the present, the simple conception that radiation is a means of killing cancer cells and that normal cells are more viable under radiation than cancer cells is a good working formula. It is not possible, however, to spray large portions of the body with radiation of an intensity sufficient to kill cancer cells without irreparable injury of essential normal tissues. The prediction is safe that by radiation alone it will never be possible to destroy a generally metastasizing cervical cancer. The problem is to apply a lethal dose to the tissues known to be involved and to those which general knowledge of the disease suggests are likely to be involved, and at the same time to spare all other tissues and regions to the greatest extent possible.

Our advantage over workers of the past in greater knowledge of the physics of radiation, as well as its biological effects, and in fuller clinical and pathological knowledge of cervical cancer, should result in much more rapid and accurate estimation of newer endeavors.

An indispensable preliminary to a critical consideration of the effectiveness of any form of treatment is a grouping of the cases according to the extent of the disease. This does not mean actual extent, but extent as determined by careful questioning and examination of the patient. The real extent is rarely less, but very frequently more, than the clinical findings indicate. Under each group a subgrouping according to histological type is a further step in clarification. The next step is to separate clearly into groups the methods of treatment, and to state in each case the method used and the reasons for doing so. Finally, the cases studied can be classified according to age, complications, or any other grouping that may seem profitable.

No adequate statistics are available today to enable us to answer the query frequently put by a patient or one of her family, "What is the chance of getting well?" The surgeon is under the same obligations as the radiologist. He should be able to show in each case the actual extent and character of the cancer, his technical procedure, his average primary mortality, his percentage of primary cures and five-year cures in each group. Until this is actually done, we can make no real progress in determining the best method to apply to the individual case. A five-year period of freedom from cancer after surgical removal has been taken as indicating permanent cure. This is of course arbitrary. Recurrences after operation do

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

take place in the sixth year and may occur at any time as long as the patient lives. I know personally of a thirteenth-year recurrence of a cervical cancer. We must not belittle the importance of four-year, three-year, or two-year cures. If, for example, two methods give in a single class the same percentage of five-year cures, and one a far greater percentage of amelioration and shorter cures in the ultimate failures, it is clearly a more successful procedure. There is, unfortunately, set by nature a very short limit to human existence, and in the longest life four years is a very material portion.

Our personal position is as follows: Surgical removal in very early cases has a low mortality and morbidity and a very substantial permanent cure rate; in moderate involvement of the parametrium and vaginal walls both the mortality and morbidity are increased and the cure rate decreased; in extensive parametrial involvement or vaginal wall involvement the mortality is definitely increased, the morbidity greatly increased, and the cures are very few; in fixed parametrial masses, in very extensive vaginal, bladder, rectal or in regional gland involvement there are practically no cures.

Radium by local treatment in the early cases has no mortality or morbidity, but a very substantial percentage of permanent cures; in the extensive borderline operable cases the percentage of mortality is low, if anything at all, the percentage of morbidity is low, that of short clinical cures is very high, and that of long clinical cures much less than in early cases, but much greater than by operation. In the extensive parametrial fixations, in involvements of contiguous parts of the bladder and rectum or of all or nearly all the vaginal wall, the percentage of immediate relief is high and may persist for months or years. Clinical cures are very common, but persist for five years in only a small proportion of the cases.

The combination of operative removal and radium topical applications as a preliminary would seem a sound procedure

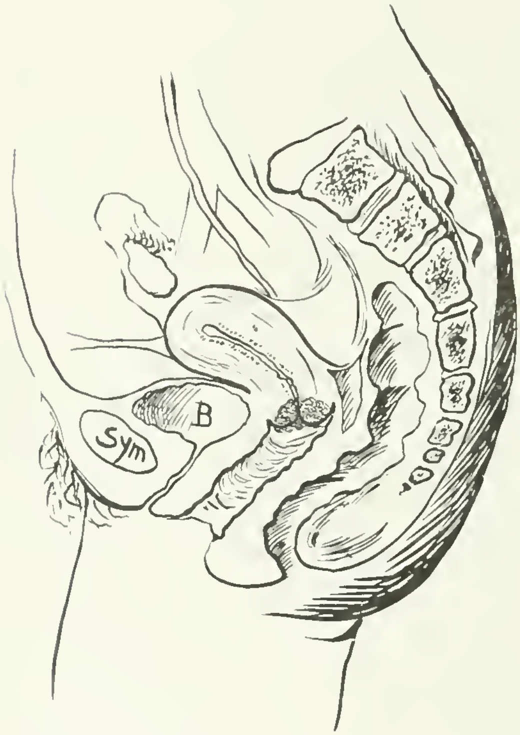

Fig. 1. Group I. Disease limited to the cervix.

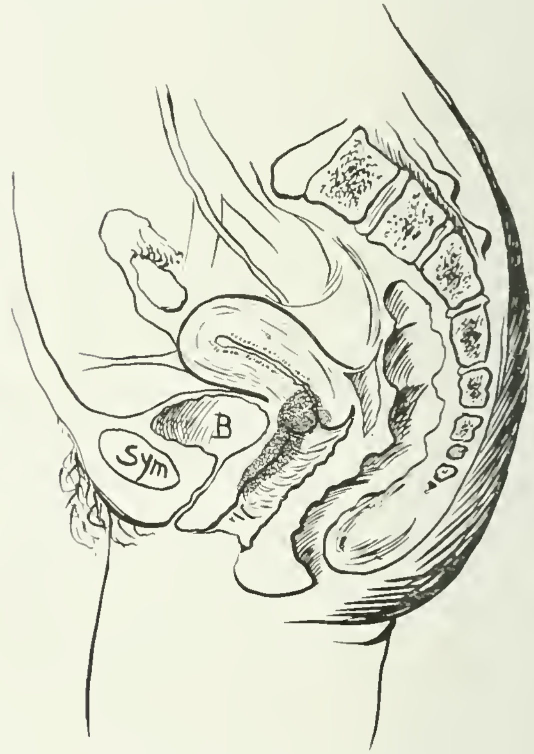

Fig. 2. Group II. Disease spreading from the cervix and involving the vaginal wall.

in the early operable cases. We do not yet definitely know whether this increases permanent cures. We do know that it increases the difficulty of the operation. However, if certain changes are made in operative technique, these difficulties can be largely obviated. Sharp knife dissection must replace blunt dissection, and the best time to operate is five or six days after the radium application.

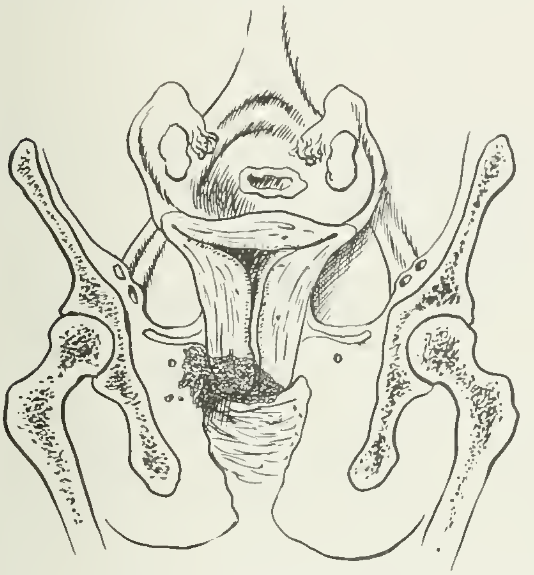

Fig. 3. Group III. Disease slightly involving the parametrium.

In advanced cases where clinical cure has followed radiation, we feel that operation is probably a mistake, but believe it highly desirable that a long series of these cases be undertaken by very expert surgeons to settle definitely whether, on the average, this is a helpful or a harmful procedure.

We feel quite certain that in the advance to be made in treating large intrapelvic masses by burying radium emanation, abdominal exploratory operations will be a great help. It is also probable that at the time of operation in early operable cases an extension of the operative possibilities can be accomplished by the same means.

Radiation from the surface of the body, abdomen, back, or perineum, has been employed chiefly as a method supplemental to other forms of treatment. We have never used this method alone in treating cervix cases, except those with extensive gland metastases, where marked relief of pain has sometimes been observed, as well as some shrinkage of the masses, but never anything approaching a cure. We have never pushed the method to its limits.

It is highly desirable, in view of the claims from Erlangen, that a series of fairly early cases be treated in this way.

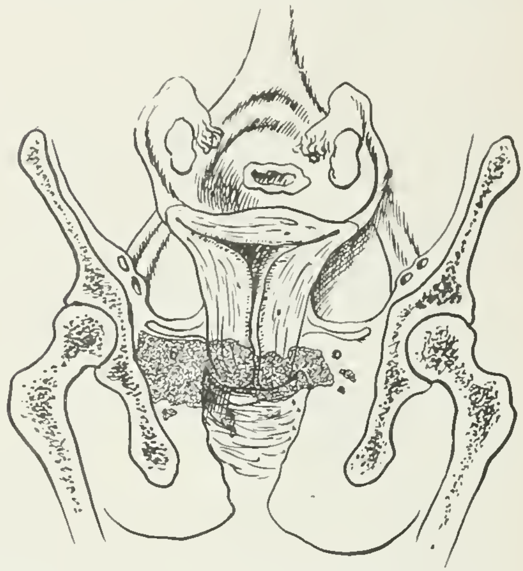

Fig. 4. Group IV. Involvement of parametrium with fixation to pelvic wall.

If a percentage of primary clinical cures approaching that of the topical application of radium is observed, it will give us very much more confidence in using it alone or in conjunction with other methods in the advanced cases. In this connection, it is easily possible, by using multiple portals on the surface, to give any radium gamma radiation desired in the pelvis. It should be possible, therefore, to compare the effects of gamma radiation through 2 mm. of lead with the *x*-radiation from a 220 kv. apparatus through 1 mm. of copper.

Should actual experience justify the belief in the efficiency of this external radiation, it will undoubtedly be an indispensable adjunct to operative and radium topical methods in treating early cancer of the cervix and bids fair to justify the claims of Wintz and his associates that it should replace all other methods now in use.

CLASSIFICATION OF CASES

A careful history is indispensable. Pain in the pelvis, back, or legs, coming on and associated with bloody vaginal discharge, not only suggests cancer, but indicates an advanced stage of the disease. Sometimes this pain is only brought out on carefully questioning the patient. Recent disturbances of either rectum or bladder are bad omens, as a rule.

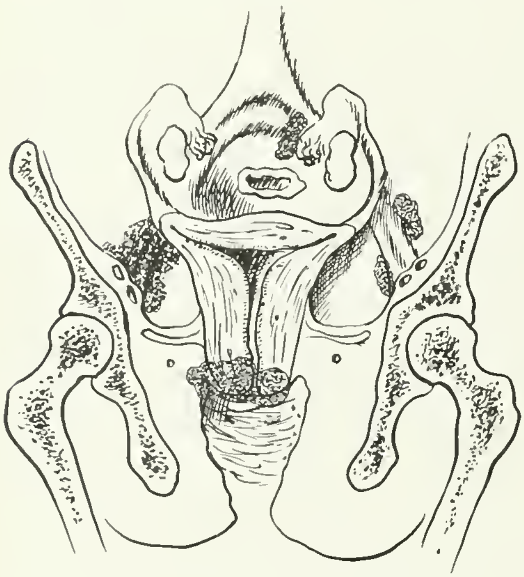

Fig. 5. Group V. Widespread regional gland metastasis

In the general interrogation and examinations, any complicating diseases should be discovered and their relations to any proposed line of treatment considered. Especial attention should be given the blood examinations.

A satisfactory examination of the pelvis can be made in thin patients without anesthesia. In fat ones and in all other cases where necessary, an examination should be made under anesthesia, nitrous oxide preferably. Notes should be made as to the appearance of the cervix, vaginal wall, rectal wall and bladder walls. Bimanual palpation, both abdominal-vaginal and abdominal-rectal, gives the extent of the growth in relation to the pelvic organs, its approximate volume, its distances from the cervical canal, vaginal vault, and abdominal and sacral walls. These measurements should be charted; and in this connection actual drawings or diagrams are most helpful. At the conclusion of the examination, tissue for microscopical study should be taken. On the basis of the examination, a complete plan of treatment should be formulated and the necessary apparatus for the treatment ordered. Usually the treatment is given the day following the examination.

The accompanying diagrams are employed for the purpose of conveniently charting the extent of the disease.

Group I. Early cases confined to the cervix (Fig. 1).

Group II. More advanced cases due to involvement of the vaginal wall (Fig. 2).

Group III. Moderately advanced cases due to involvement of the parametrium (Fig. 3).

Group IV. Extensive involvement of and fixation through the parametrium (Fig. 4).

Group V. Widespread regional gland metastatic condition (Fig. 5).

It is obvious that with such charts any number of groups may be made. An important inoperable group, not shown, is one with the entire vaginal wall involved. It is desirable to have a special diagram for the recurrent cases after hysterectomy.

TECHNIQUE OF TREATMENT

For a number of years we have employed radium emanation instead of radium element. Our applicators are extremely simple. They are shown in Figure 6. The small tube with open cap is 1 mm. thick, made of brass and is the container of the emanation tube. The emanation is usually in a bulb, sometimes in a small tube such as is shown beside the brass tube. When used in cervical cases it is put in a rubber cot with string attached. The clamp is a convenient one for picking up the tube. To the left of the tube is shown a simple cotton cloth applicator in which tubes are placed. These applicators are ordered and arranged to fit the individual case. This is a convenient one for the cervix alone. To the left of this applicator is an elliptical piece of lead about 7.5 mm. in thickness and covered by a piece of gauze. It is used as a screen between the radium and the normal vaginal wall. Sometimes a number of these can be superimposed and are a great help in obviating proctitis. Above are shown two types of needle carriers. The emanation tube is threaded

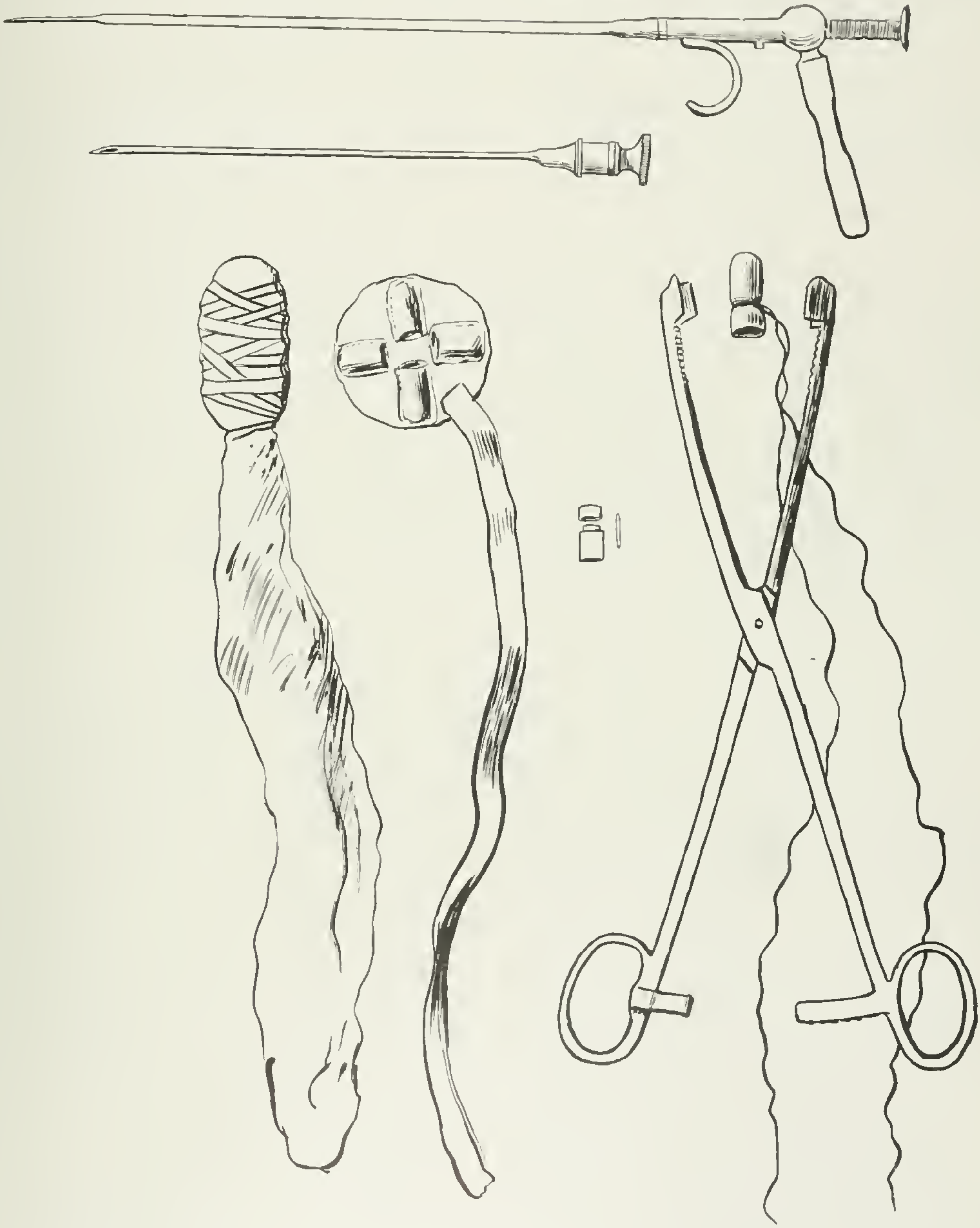

Fig. 6. Applicators employed in the treatment of carcinoma of the cervix with radium emanation.

into the end of the needle. The needle is inserted where it is desired to place the tube, and the tube is then pushed out into the tissue.

In a cancer limited to the cervix, one tube placed at the internal os, one at the external os and four on the cervix, as shown, with a total of 3,000 mc. hours' radiation, divided into 1,200 mc. hours in cervix and 1,800 mc. hours on cervix, is a curative single dose. It is better to give this in a single rather than in broken dosage. We frequently use 3,000 mc. of emanation in these tubes and complete the radiation in one hour. Where smaller amounts of radium are used and longer times employed, a somewhat greater mc. or mgm. hour treatment is necessary, perhaps a third more, where 100 mc. or mgm. is the amount of radium or emanation used.

Where the parametria are involved, the exposure should be increased 4 or 4½ gm. hours. For extensions on the vaginal wall, about ¾ gm. hour, evenly spread out, should be used for each square 2.5 cm. of surface, in addition to the cervical treatment indicated.

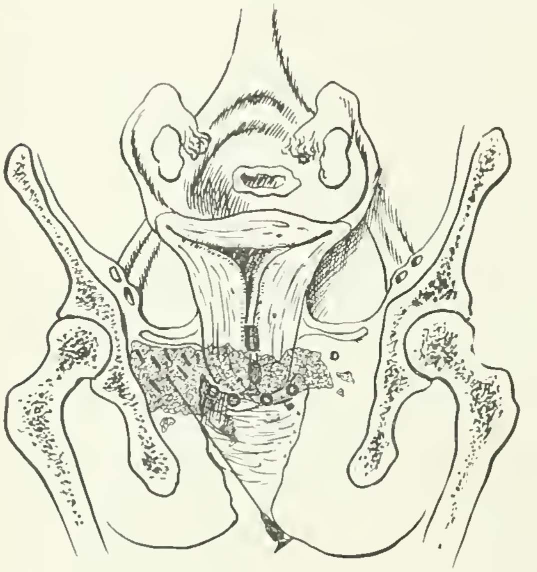

Fig. 7. Cervical cancer with tubes in place. Bare points implanted in deep parametrial involvement.

Deep parametrial or paravaginal nodules should be treated by the implantation of emanation points. With a finger in the rectum and thumb in the vagina, the points should be laid in so that each cubic centimeter of tissue gets from .3 to .5 mc. of emanation (Fig. 7).

In high abdominal masses, this implantation should be carried out through an abdominal incision (Fig. 8). It is possible in early recurrences in the parametria immediately after operation to use this technique with much greater precision and safety to surrounding tissues than with the applicators or tubes. The actual strength of the individual tubes in implantations of extensive areas may very likely be still further reduced.

Where the needles are used, the treatment is given under gas anesthesia. Where no needles are used, the normal procedure is to treat in the knee-chest posture, without anesthesia.

After the treatment, examinations are made at intervals of two weeks, and no further treatment given for at least ten weeks, unless there is obvious trouble outside of the areas treated. Retreatment in the heavily radiated areas, if given, must be much lighter. As a preliminary to operation, about two-thirds of the above dosage is given.

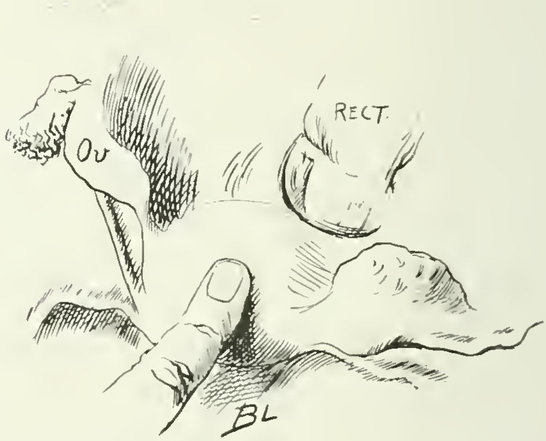

Fig. 8. Appearance from abdomen. Where there is high involvement, this route is necessary.

The primary results in cases treated according to the above plan are very good. Primary clinical cures in all but the advanced inoperable cases are almost invariable. Complications—proctitis, fistulae, sepsis—are much rarer than in our earlier cases. I am uncertain as to whether the permanent cure rate will be greatly increased, but believe it will.

FINAL RESULTS

With Dr. Howard A. Kelly, I collected and reported our results up to Jan. 1, 1915.* In a total of 213 cases there were 14 operable and 199 inoperable. Many of the inoperable cases were huge metastatic cancers. No case was refused. Of the operable cases, 10 were treated by a combination of

* *J. Am. M. Assn.*, Nov. 27, 1915, xlv, 1874–1878.

radium and operation, and 4 by radium alone. Seven were only one year old. All were living and well. Today a review of these cases shows that 5 and 2 survive in each class; that is a 50 per cent cure for over seven years, and the oldest case is eleven years.

Of the 199 inoperable cases, 53 were clinically cured. Of the 53 cases, 42 had been treated within eighteen months. Of these 53 cases, only 15 remain in the cured class. That some of these will ultimately have recurrences is suggested by a comparatively recent case. A patient treated in 1912 for recurrent squamous cell carcinoma of the entire vagina remained well for nine years, to die of iliac gland involvement. At the time of the original treatment this region was clear. There was no local recurrence.

Among the 15 cases left, 2 had circumscribed vaginal recurrences which might have been cured by surgical or cautery removals, but which we have personally never been able to cure. The other 13 were hopeless from the operative standpoint. In 4 of the 13 cases, combined procedures—radium operation and radium—were employed. In 9 of these 13 cases, radium alone was used. In 9 cases there was extensive parametrial involvement and fixation of one or both sides. In 4 cases, the parametria were clear but the entire vaginal wall was involved.

In all these cases the application of the radium was topical. Most of them were treated by repeated broken dosage. The dosage totalled from 2½ to 5 gm. hours.

CONCLUSION

The choice of treatment in early operable cases is, in my opinion, still with operation, with pre- and post-operative radiation; in late operable cases, the choice is with radium topical and perhaps external radiation; in advanced cases, radium topical and implantation of bare points. The use of radium alone in early operable cases is thoroughly justifiable. Operation alone is likewise justifiable. It is highly desirable that all methods be intensively studied today.

DISCUSSION ON PAPER BY DR. GEORGE E. PFAHLER: THE EFFECT OF X-RAYS AND RADIUM ON THE BLOOD AND GENERAL HEALTH OF RADIOLOGISTS*

Dr. Stewart. It was the purpose of the presiding officer as Chairman of the Program Committee to bring the messages of advancement in the past year to this meeting. In order to do so we had to accept communications from men who were unable to be present, especially those who have been making unusual investigations during the past year.

The next paper is one by Dr. Pfahler. We have all looked forward to the results of his investigations. The paper has been published and placed for distribution with the young ladies at the registration desk. I hope you all carefully read it over. The idea is now to devote the time assigned to the matter for pure discussion. Having understood that Dr. Portis had made some investigations along this very line, I am going to ask him to open the discussion on Dr. Pfahler's paper.

Dr. Portis. I am sure we all regret Dr. Pfahler's absence from this meeting. If he were here to present in his own pleasing and forceful manner the communication which I hope you have all read, it would carry greater weight, and, in addition, his presence at the meeting would be very desirable. It was my opportunity and privilege to read the manuscript which was sent to me, and I believe that his paper is the most complete and the most thorough of any communication on this subject today. He has gone into the entire literature very carefully and presents his own observations and studies. With some of this I agree, and with some I disagree.

I have been very much interested in the protection of the *x*-ray worker ever since my interest in roentgen-ray work. A number of years ago I stirred up a hornet's nest among friends who are working with *x*-ray, and attempted to carry on a rather extensive study, but did not meet with any success. The man who is washing windows on the 14th story knows his job is dangerous, but does not want to be told it is. We all get accustomed to the

*This paper appeared in the October number of the Journal.

dangers about us, and pay comparatively little attention to them, and that is possibly a good thing, for we are here to get as much joy out of life as possible, and not be worried every minute. I wish right here to say that I hope you will not consider me an alarmist by the statements I shall make today. Quite the contrary. Surface burns and other changes have brought me to see the danger of the thing we are attempting to do. Today very few men—probably none—burn or have the other changes that we saw in the unfortunate early workers, who, largely through ignorance, were exposed.

There is a real danger to the man engaged in radium and *x*-ray work, and I am sorry to add this statement that even today the majority of us are not taking proper precautions in having ample protection.

When I was actively interested in this work, it was particularly in the fluoroscopic room that I carried out my investigations; and I was surprised to find that a machine sent me by a very good manufactures not only did not protect me against the primary ray, but absolutely no consideration was given to the secondary ray.

Prof. Milliken, of the University of Chicago at that time was kind enough to suggest to me various ways of protection, and we modified the fluoroscopic machine until it was comparatively safe. I studied the blood of all the men whose blood I could get a sample of, and then attempted in one of our large institutions where a great many people are employed, to get some further studies; but the man at the head said he was afraid to carry out the careful blood examinations because he was afraid that those engaged at this particular place would become fearful of their occupation and he would not be able to get helpers. That does not mean that the danger is not present and that damage is not going on, whether or not we ignore that side of the question.

Some studies which we made in 1915 I summarized as follows: There has not been a uniform blood picture. Studies were made in individuals who thought they were well, but who were engaged in *x*-ray work to a greater or lesser degree. The majority show a diminution of the total number of leukocytes, which, in some cases, has been progressive. The lymphocytes were commonly relatively increased, and at times this was the most pronounced finding. Closer examination of the lymphocytes showed abnormal varieties described by some as unripe forms, and by others as irritation forms. Myelocytes were found in three of the cases in small numbers. The red blood corpuscles were not affected and the hemoglobin only slightly reduced.

Those observations I have confirmed from time to time in the past seven or eight years, but I am sorry to say that I have not had the opportunity to make the study which, to my mind, would be the conclusive one. We should make observations on a great many people who contemplate taking up *x*-ray work or radium work—physicians and others. We should make studies of their blood from time to time after they are engaged in the work. We should, in all of these cases, and probably correctly so, ask them all to carry out the dental film idea which Dr. Pfahler recommends in his paper, to see whether or not there is any evidence of change. That there is or is not should be a measure of the amount of exposure the individual is getting in his so-called protective atmosphere. Then, after these studies have been made on a great number of individuals, before they have engaged themselves in the work and after they have been in the work, we will be privileged to draw more rational conclusions. There is no doubt that a great many individuals without proper protection will show some changes, and if this is so, then we must admit that the number of deaths reported among *x*-ray workers, due to various types of blood change, especially so-called aplastic anemia, etc., include a certain proportion due to *x*-ray exposure. Not all, for these blood disorders occur in individuals who have not had any relation directly or indirectly with *x*-ray work. It can only be said that it is a factor in the production of these disorders.

I hope you feel that I do not consider the danger to the *x*-ray worker a maximum one and even not a definite one. There seems to be individual variation of susceptibility to the effect of *x*-rays. Some who are exposed a great deal show comparatively little change, while others with a minimum amount of exposure show definite change. That is a factor that we simply cannot explain, any more than we can so many other questions of susceptibility to different drugs and different pathological stimuli; but it seems to me that if we are to take the proper precautions for ourselves and our posterity, if we are interested in the development of *x*-ray and radium work, if we are to see it come into its own, then there is every reason why the manufacturer and we ourselves should combine in getting the maximum protection. This is particularly necessary with the advent of the new high-voltage machines.

We have two such machines at St. Luke's Hospital; and before the machines were used at all an enormous amount of protection was put in various ways about the machines. The superintendent of the hospital has been very kind and very much interested in the question of protection. It was he who devised my apparatus seven years ago which I have been using since, and which I think is the only one which protects me from the secondary ray in the proper manner. He himself is a man who understands the problems of physics and has had special training along those lines. I will not go into the manner of protection, but simply say that they put what looked like a foolish amount of protection around these machines. Then Dr. Jenkinson put films in various places and carried some; and we were utterly astonished at the changes the dental films showed. I should say that an electroscope would be far more accurate, but for clinical purposes, as Dr. Pfahler points out, the dental film is enough. It is the simplest thing we can do. Dr. Jenkinson himself expects to publish his observations. I cannot give the details, but I know that when I left Chicago two months ago, they did not feel secure as yet, after adding and adding protection, and yet the protection is so much more than I have seen at any other place in the country.

I was at the St. Louis meeting of the Radiological Society, and while there we visited a large hospital. The man in charge was very well informed on the subject. We asked about the question of his protection and he showed what he had. We immediately told him it was far from adequate.

We have the cooperation of splendid physicists in this country. A great many men are in position to help us scientifically in the matter; and I think it is our duty, whether or not we care about our own personal protection, to see to it that we do protect ourselves and those working with us, in a complete manner, against this insidious foe, which is lurking constantly about, and which in the end will bring destruction.

Dr. Case. I am very much interested in Dr. Pfahler's paper. I have been very much interested in this subject myself. At one time there was a meeting of the American Electrotherapeutic Association in our town, and a number of the men of the society had done considerable *x*-ray work—most of them with less protection than the average man here. I failed to find any significant changes in the blood-counts, and so I did not publish the evidences at that time.

With the amount of protection now afforded in the average laboratory of the men who are members of this society, the amount of danger from exposure is far less than the danger of close confinement associated with lack of exercise and long hours to which the *x*-ray men are subjected. I believe we can correct some of those things in the manner suggested by Dr. Pfahler.

I was much interested in a report of the Radium Co. stating that the health of the employes was unusually good, and the number of hours absent from work was less than the average in other factories. I assume that with deep therapy we will step to a field we have not yet covered. I heard some talk about deep therapy machines not being allowed in certain buildings unless they were in a corner room. I have had an *x*-ray tube pointed obliquely toward the room of my office for nearly two years, and I had a camera loaded with moving picture films on my desk—second wall beyond—without any lead on any of the walls, for two weeks and they made perfectly fine exposures.

I believe we should be perfectly rational about the questions of protection and be governed by electroscope measurements and not be afraid.

Although radiologists have proven in the past to be poor risks by life insurance companies, and perhaps ten or twenty men have lost their lives as a result of their calling, nevertheless thousands of lives have been saved through *x*-ray work.

Dr. Ullman. Dr. Pfahler's paper covers the question so thoroughly from the roentgenological standpoint that it leaves very little to say. There is one point that impressed me strongly, especially with our present work in deep therapy; that is, the lymphocytic and leucocytic reaction is not as important as some workers would lead us to believe. The red count is the more important. In doing some other work on rabbits we found no changes. Gastric ulcers would in some cases send the lymphocytes down and in others up. We did not do anything on the red count in those cases.

I had an opportunity to test the coagulation time. We were raying rabbits with the ordinary type tube stand at 120,000 volts, 5 ma. and the usual lead glass bowl. The machine stood in an ordinary room, and I was in a room about 30 ft. away with two walls in between. I had one exposure of one hour and the next night another hour. The following day I took my coagulation time; it was less than thirty seconds and it took seven days to come back to normal. These same rabbits just before death showed that the blood clotted very quickly.

I made some observations immediately following heavy radiation, on the leucocytic and lymphocytic reactions, and saw nothing very important. You get an immediate rise and fall to normal.

The question of protection—I think many of us and many manufacturers look at it from the wrong angle. We have inclosed both tube and machine with lead, also the floor, ceiling and sides. I think you will find that where there is not enough protection and you get fogging through 8 lb. lead, you have some wood exposed somewhere which is carrying secondary radiation around the corner. It does not require so much lead to cover everything.

Dr. LeWald. I would just like to call attention to a circumstance which has arisen in New York which may be of considerable help in determining the question of protection. The fact is this: The Commissioner of Health, City of New York, had an ordinance passed requiring a license to be issued to every *x*-ray laboratory operating within the city limits. That is an ordinance that will require considerable alteration in order to carry out the points in regard to protection.

I talked to Dr. P. about this, and while he had certain suggestions to offer, he had no set of regulations that he would say could be definitely enforced.

One point which Dr. Portis brought out is as far as we have gotten in actually enforcing one regulation, and that is, a filter must be put in every apparatus. We were surprised that a large number of machines, particularly the fluoroscope, were put out without any filter. A number of dental machines are without filter.

At the present time in New York City no license is issued without the inspector finding that a filter is in constant use in every laboratory. There are a number of interesting sidelights on this. For example, what constitutes an *x*-ray laboratory? Men who were using the fluoroscope alone said they did not have an *x*-ray laboratory, but the Health Department ruled that to use an *x*-ray machine on a human being constituted one, and that the amount of work done or the size of the laboratory had nothing to do with it.

The question also came up as to whether a physician was entitled to a license simply by having his medical license. Also the question of technicians—as to whether the making of radiographs was a medical act. These are points that have to be determined also. There seems to be some opinion among local men who have taken up this problem as to whether it is not a question of practice of medicine and the mere taking of radiographs without interpretation. The Commissioner of Education has taken that stand, but others who have been advised in this regard said that their operation of *x*-ray machine on the human subject is administration of a powerful agent, which is the same as the administration of drugs, and is therefore practicing medicine.

I was glad to hear what Dr. Ullman said about proper distribution of lead and its proper use. We have not been able to decide upon the minimum amount of lead.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor: H. M. Imboden, M.D.

Associate Editors: James T. Case, M.D. H. K. Pancoast, M.D. J. S. Shearer, Ph.D.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

THE TWENTY-THIRD ANNUAL MEETING

The Los Angeles meeting has passed into history, but it will be remembered long by those who enjoyed the privileges of the excellent scientific program and the unique social entertainments.

The attendance, while smaller than anticipated because of the strike disturbance, was fairly representative. About 25 per cent of the total membership of the society were registered. Familiar faces from the East and Middle West were missed, and their absence gave a false impression of small attendance; however, the Western Section, whose meeting this really was, attended almost to a man. Visiting physicians numbered 164, non-medical visitors, 22, ladies, 67 and exhibitors 35. The annual dinner was well attended.

The program was exceedingly full and, at first sight, it did not seem possible that it could be handled in four days. However, Dr. Stewart had studied the matter thoroughly, and had carefully arranged every feature of the program, so that the papers and discussions moved with clock-work precision. An unusual and highly appreciated feature was the presentation, in printed form, of the papers read by title, together with the showing of their illustrations in the scientific exhibits. Those attending were thus able to read the papers of invited guests from foreign countries, most of whom were unable to attend in person. The time allotted on the program to such papers, was then given over to discussions of the respective subjects considered.

The Caldwell Lecture by Professor Duane, of Harvard University, was attended by quite a number of local physicians, and his clear, logical presentation of some of the problems and effects of short wave-length rays was greatly enjoyed.

The scientific exhibits were the most comprehensive and elaborate ever shown before the society, requiring the construction of twenty-five extra lighting racks, in addition to the light boxes shipped to Los Angeles. The exhibits were all in place before the scientific sessions started on Tuesday morning.

The commercial exhibits comfortably filled the large banquet room of the Ambassador, featuring high-voltage therapy apparatus and accessories.

The social entertainments were unique, beginning with a preliminary dinner tendered the visitors and members by the Pacific Coast Roentgen Ray Society, at the Wiltshire Country Club, on Monday evening.

On Tuesday, the ladies were entertained at lunch by Mrs. Soiland, visiting the Busch Sunken Gardens, in Pasadena, in the afternoon. On Tuesday evening, the "Forty Niners' Camp" entertainment was held at the Ambassador. Albert Soiland gave an exhibition which showed an unholy familiarity with a supposedly dead art, while Bowman and Bonoff marshalled other devices in a manner which explained their opulence in a profession not noted for its millionaires.

Thursday evening was the occasion of the President's dinner; the arrangements were informal, including dancing and a movie comedy shown for the first time in honor of the occasion.

On Friday evening, the ladies and the men were taken in different directions, the former being entertained in small theater groups, while a stag party in Hollywood attracted most of the men. This party is reported by those who were able to recall the details as being beyond powers of description.

The closing feature of the session was the trip to Catalina on Saturday and Sunday. All members and guests were driven by auto to Wilmington, and served with lunch at the Yacht Club, after which they boarded steam yachts, loaned by members of the Club, and sailed to Catalina. After dinner at the St. Catherine Hotel, the "Flying Fish" boat trip about the island was taken, the feature of this being the illumination of "flocks" of flying fish by search lights. Sunday morning, a second trip was enjoyed, this time in the glass-bottom boats to the Marine Gardens, after which the party boarded the yachts and were brought back to Los Angeles Harbor.

The first Western meeting was a notable success, and it will not be difficult to enlist the enthusiastic support of the members attending, when the logical time comes for another meeting on the Pacific Coast.

The officers elected for the ensuing year were:

President-Elect: Dr. Hollis E. Potter, Chicago, Ill.

First Vice-President: Dr. John Edmonson, Birmingham, Ala.

Second Vice-President: Dr. Chas. L. Martin, Dallas, Texas.

Secretary: Dr. W. Warner Watkins, Phoenix, Ariz.

Treasurer: Dr. Wm. A. Evans, Detroit, Mich.

Librarian: H. W. Dachtler, Toledo, O.

Member of Executive Council: Dr. A. H. Pirie, Montreal, Can.

The Executive Council selected Chicago as the place for the 1923 meeting, the time to be in September.

W. Warner Watkins, Secretary.

EASTERN SECTION

Fourth Annual Meeting

The Fourth Annual Meeting of the Eastern Section of The American Roentgen Ray Society will be held in Atlantic City, at the Ritz-Carlton Hotel, on January 25th, 26th and 27th. It is contemplated to follow the precedent of last year in adding another day to the meeting. The first session will be held on Thursday evening at 8 o'clock. This is to be followed by morning, afternoon and night sessions on Friday, and morning and afternoon sessions on Saturday. There will be no meeting on Saturday night. The management of the Ritz-Carlton offer the following rates:

European plan:

Single room with bath, $5.00 daily, one person.

Double room with bath, $7.00 daily, two persons.

With meals:

Single room with bath and meals, consisting of club breakfast, table d'hote luncheon and dinner, one person, $10.00 daily.

Double room with bath and meals, consisting of club breakfast, table d'hote luncheon and dinner, two persons, $18.00 daily.

There will be a commercial exhibit, and those desiring space, who have not been notified by the President, can obtain same by communicating with him. It is to be hoped that the lantern slide exhibit will prove the same interesting feature of the program as in recent years, and it is earnestly hoped that more will take an active interest in this part of the program. Those desiring to show lantern slides please communicate with the President. The officers of the Eastern Section of the American Roentgen Ray Society are:

President:	C. A. Waters, 1100 N. Charles Street, Baltimore, Md.
Vice-President:	Thomas A. Groover, 1621 Connecticut Ave., N. W., Washington, D. C.
Secretary:	Charles Eastmond, 483 Washington Ave., Brooklyn, N. Y."

DR. HERBERT THRELKELD-EDWARDS

Dr. Herbert Threlkeld-Edwards died at his home on Delaware Avenue, Bethlehem, Pa., on the afternoon of September 30th, after an illness of one and a half years.

Dr. Edwards was born at Esher, Surrey, England, on March 30, 1870. He studied under tutors in England, also attending Surrey House, and at the age of sixteen years accompanied his father, George Clayton Edwards, to this country.

He studied at the University of Southern California, and subsequently enrolled in the medical department of the University of Pennsylvania, where he was graduated in the class of 1892.

Herbert Threlkeld-Edwards, M.D.

After serving his internship at St. Luke's Hospital, this city, Dr. Edwards became demonstrator of pathology at the University of Pennsylvania, remaining as a member of the faculty for two years.

He then returned to Bethlehem, where he engaged in extensive professional endeavor for many years. Notwithstanding the heavy responsibilities incident to his practice, Dr. Edwards retained his habits of study and scientific research, and developed the first American Intensifying Screen. Of recent years he was actively engaged in the manufacture of this screen.

He devoted special study to roentgenology, in which he was a pioneer in this section. Under his direction the modern x-ray laboratory at St. Luke's Hospital was founded, and he was the first director there.

The advance of medicine and surgery under the pressure of war conditions was a subject which Dr. Edwards studied carefully, at the same time giving prodigally of his time and labor toward the devoted effort that achieved this advance in the hospitals and laboratories at home and abroad. Dr. Edwards' Intensifying Screen was widely used by the American Expeditionary Forces in France.

Dr. Edwards was a member of the national, state, and country medical associations, the American Roentgen Ray Society, the Philadelphia Roentgen Ray Society, the Philadelphia Medical Club, the Alpha Mu Pi Omega Medical Fraternity, the Country Club of Northampton County, and the Baucon Valley Country Club.

He is survived by his wife, his daughter, Mrs. Gerald Thorp, and his grand-daughter Elizabeth T. Thorp of Bethlehem, his son, Herbert Threlkeld-Edwards, Jr., of the University of Pennsylvania, and three brothers in Southern California.

CORRESPONDENCE

To the Editor:

Anyone who has recently been to Vienna must have been deeply affected by the deplorable state of affairs, particularly among our colleagues, the roentgenologists. Their hospital laboratories lack equipment and their research work is made exceedingly difficult by lack of means and necessary apparatus. Nevertheless, they are trying bravely to carry on under these most trying and difficult circumstances.

It occurred to me that the American roentgenologists, particularly those who have enjoyed the courtesies of our Austrian colleagues, can do a great deal toward helping some of the workers to obtain the necessary equipment in the hospitals. My appeal concerns particularly Doctor

Haudek's hospital laboratory in the Elizabeth Hospital. As small a sum as $500.00 will enable him to buy a fluoroscopic apparatus.

I beg to enclose my check for $50.00 as a starter for this fund, and hope you will be able to obtain the full amount and forward it to him with the compliments of the American roentgenologists.

Very respectfully yours,
I. S. Hirsch.

New York City,
October 20, 1922.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page ix of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

BOOK REVIEW

Die Röntgendiagnostik der Magen- und Darmkrankheiten. By Emmo Schlesinger. Contains 402 pages, 228 illustrations and 8 tables. Second, revised edition. Urban and Schwarzenburg, Berlin, 1922.

In his introduction, Schlesinger argues ably in support of the conventional Continental view that the roentgenologic examination of the digestive tract should be regarded simply as an adjuvant of the clinical examination. He points out that even under the most favorable circumstances the *x*-ray can only present a faithful delineation of the lumen of the stomach and intestine—a relief of their internal surface—together with their movements and changes of position. It may show a defect, but whether this indicates a cancer, an artifact, extraventricular compression, a contraction, or adhesions, can be determined only by exhaustive investigation, partly roentgenologic and partly by other methods.

Although Schlesinger thus adheres in principle to correlated diagnosis, his book, nevertheless, more nearly approximates American texts than do most European publications. True, he describes indirect signs and the "small change" of diagnosis quite fully, but the still more important "direct" signs are given due emphasis. It is not a clinical, but a roentgenologic, text, and his confidence in the *x*-ray is evident.

Schlesinger considers both roentgenoscopy and roentgenography indispensable. Because of an *x*-ray burn he has recently been unable to use the screen, and, although he has endeavored to compensate for this by making eight or ten plates, he confesses that he has not the same feeling of certainty that he had when using the screen.

While Schlesinger was one of the pioneers in gastric roentgenology, he is not inclined to be dogmatic or contentious. Modesty and fairness are shown by his abundant references to the work of his colleagues in roentgenology, and by an exhaustive bibliography in which American writers are well represented.

Drawings illustrate the text, but these are well done, and are perhaps even more instructive than reproductions of roentgenograms would be. A few tables of roentgenographic prints are appended.

Criticisms might be offered and opposing views occasionally advanced by the reviewer, but these would seem captious and trivial in view of the general excellence of the book, which is one that every roentgenologist should have in his library.

R. D. Carman, M.D.

TRANSLATIONS & ABSTRACTS

Radiology in Montevideo. The annual report of the Instituto de Radiologia for 1920 appears in the *Anales de la Faculta de Medicina* of the University of Montevideo, v, 584.

The objects of this institution are to teach radiography, to aid in the diagnosis and treatment of disease, and to conduct scientific investigations. Two courses of instruction are given annually. There is no mention of the number and personnel of the students. The total number of patients seen for the year was 5,647. The total number of patients treated during the seven years was 25,853. The budget for the expired year was $9,252. The subjects which were investigated during the year were tracheobronchial adenopathy, diagnostic radiology of pulmonary tuberculosis, new congenital anomalies of bone, pneumoperitoneum, a new method of pyelography, medico-legal determination of age in the living, and treatment of varicose ulcers and of prostatic hypertrophy by radium. The affections treated during the year comprise miscellaneous cutaneous and gynecological lesions in the following order of frequency: Cancer, eczema, leucoplasia, fibroma of the uterus, exophthalmic goiter, tuberculous adenitis, angioma, nevus, lupus, etc. There has been a great increase in the number of precancerous conditions treated, including cutaneous keratosis, leucoplasia, papilloma, nevus and the initial stage of cancer itself. The Institution needs to be enlarged with especial reference to new departments of activity. Evidently the treatment of deep-seated cancers throughout the body and the location and removal of projectiles have thus far been deficient for lack of proper installation. The report is signed by Director C. Butler.

Pendergrass, E. P. and Pancoast, H. K. The Close Relationship of the Erythrogenetic and Leukogenetic Functions of the Bone Marrow in Disease. Report of a Case of Erythremia. The Roentgen-ray Treatment of Erythremia. (*Am. J. M. Sc.*, June, 1922, clxiii, No. 6, 797.)

Attention is called to the close relationship of diseases affecting the red and white blood corpuscles. Several instances are cited from the literature where conditions previously diagnosed leukemia were finally determined to be erythremia; and vice versa, conditions previously showing erythremia traits were ultimately determined to be leukemic in character. Conclusion is drawn that the erythrogenetic and leukogenetic functions of the bone-marrow are closely related.

A case is reported, giving the entire history, clinical findings and blood-counts in detail over a long period, in which very nearly the same picture is presented as those quoted from several different authors. With the assumption that the red and white blood-corpuscle-forming functions of the bone-marrow were closely related and that the spleen was the "graveyard of the red corpuscle," treatment was instituted, giving a complete course of inhibiting doses over the bones of the body, and a smaller, presumably stimulating, dose over the enlarged spleen itself.

As a guide in the treatment the following facts must be borne in mind:

1. The spleen is more sensitive to the roentgen rays than is the bone-marrow.
2. After moderate doses of the roentgen rays the leukocytes show an initial rise followed by a pronounced and subsequent rise to normal.
3. The red cells show an initial fall after moderate doses of the roentgen rays. This may last for long periods of time, or the cells may rise to normal in the course of a few days.

As to the ultimate success of the roentgen-ray therapy of erythremia, one must wait and see the results of the treatment of various cases and the observation of such cases over a number of years. However, roentgen-ray treatment is only an agent recommended in an effort to find something that will give relief to this class of patients where drugs are of no avail, and venesection, etc., only of initial improvement, the patient relapsing into the primary state in a comparatively short time.

If we accept the views of a number of pathologists, and assume that the disease is one primarily of the bone marrow and the lesion is a primary hyperplasia of the erythroblastic tissues, our treatment should be that of the bone-marrow, with the view of inhibiting the excessive formation of red cells; or if all cases of erythremia are secondary to some exciting cause foreign to all bone-marrow, as considered by some, roentgen-ray therapy is recommended in those cases in which no primary cause can be found and which have failed to respond to the usual method of treatment.

The treatment of the spleen is given with the view of stimulating the functions of that organ. There is some histological evidence that the spleen destroys erythrocytes by the phagocytic action of the cells of the spleen. The spleen is very susceptible to the action of the roentgen ray; hence we must make exposure a stimulative one. There is no experimental evidence to support the assumption that stimulative doses of roentgen rays over the spleen increase the hemolytic action of this organ, although a number of men have worked on this particular subject. However, we feel that theoretically the function should be increased, and we are therefore working on that basis.

The details of the technique are very similar to the treatment followed out in the treatment of leukemia recommended by Stengel and Pancoast which have been outlined in a previous paper.

CONCLUSIONS

1. Erythremia is a disease of the erythroblastic tissues of the bone-marrow.

2. Roentgen rays destroy or inhibit the formation of red cells.

3. Roentgen rays should be used in the treatment of erythremia.

4. Roentgen rays should be used in the treatment of secondary polycythemia when such cases fail to respond to other treatment, such as drugs, venesection, etc.

5. Roentgen-ray treatment has been efficacious in the case reported above, and it has proved of value in cases reported by other roentgenologists.

6. Roentgen-ray therapy effects more permanent results than any other therapeutic measure used or recommended up to the present time. L. R. S.

Matson, Ralph C. Diaphragm Irregularities. (*Am. J.M. Sc.*, June, 1922, clxiii, No. 6, 826.)

In a study of 3,754 chest cases, 4 per cent showed diaphragmatic irregularities. Heretofore, irregularities of the diaphragm having a tented appearance have been thought to be due to pleuro-diaphragmatic adhesion. However, in checking up examinations made at various times on the same cases, some observations were made which were inconsistent with the assumption that tenting of the diaphragm necessarily meant pleurodiaphragmatic adhesions. To determine whether or not these irregularities actually represent adhesions, many cases were studied, some having been normal before influenza pneumonia, and showing this tenting after the disease. To determine whether or not these were adhesions, a pneumothorax needle was inserted. As the air flowed in, the irregularity of the diaphragm disappeared, being entirely absent after introduction of 250 c.c. of air, a quantity so small that it could scarcely be detected in the roentgenogram. As the air absorbed, the tenting reappeared, being well established in ten days. The principles concerned in the production of a lung dimple, upon which diaphragm irregularities of the pseudo-adhesion type depend, were tested out experimentally. A bell jar was fitted with an inlet and an outlet at the top. A pair of sheep's lungs were inflated by exhausting the air surrounding the pair of lungs in the bell jar, a piece of stiff wire with a barb on the end being inserted into the lower bronchus to represent the rigid bronchus encountered in diseased condition. As the lungs expanded, a dimple formed on the under surface of the lung. From these experiments the following conclusions were drawn:

1. The assumption that tenting of the diaphragm always diagnoses pleurodiaphragmatic adhesions is unjustifiable.

2. Tenting of the diaphragm, frequently seen on plate and screen at the termination of the hili-diaphragm superfices, with characteristics which are associated with pseudo-adhesions, is a purely physical phenomenon brought about by two factors: (*a*) During inspiration the diminished elasticity or rigidity of the lower bronchial branches prevents descent of that area of the lung base in immediate relationship to the bronchus involved; thus a dimple effect is produced on the surface of the base of the lung. (*b*) The diaphragm being molded to the base of the lung by a negative intrathoracic pressure is held by suction in the dimple above referred to, producing a tented appearance (pseudo-adhesion).

3. Diaphragm irregularities of the pseudo-adhesion type are commonly found during the course of acute and chronic respiratory infections. In acute respiratory infections with peribronchial infiltration involving the lower bronchial branches, the irregularity disappears with restitutio ad integrum. In chronic respiratory infections with consequent connective tissue, proliferation appears to be permanent in nature.

4. It is reasonable to suppose that should infiltrative or proliferative changes incident to infection not halt at a point in the bronchial tree proximal to its termination, but instead, proceed to the pleura, then the diaphragm would become adherent and the pseudo-adhesion would be converted into a tree adhesion.

It is hoped that this contribution will excite interest and further study of the subject.

L. R. S.

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THE SCIENTIFIC BASIS OF SHORT WAVE-LENGTH THERAPY*

THIRD CALDWELL LECTURE

BY WILLIAM DUANE, PH.D., SC.D.

Professor of Biophysics, Harvard University

CAMBRIDGE, MASSACHUSETTS

RECENT advances in *x*-ray therapy have emphasized the great importance (*a*) of employing very penetrating radiation and (*b*) of accurately estimating dosage. More than eight years ago, I began studying the conditions necessary to produce penetrating *x*-radiation that would approach as nearly as possible the gamma radiation from the radioactive substances. About that time, the fundamental researches of Laue, Friedrich and Knipping, and the Braggs became generally known. The results of their investigations indicate that we may regard an *x*-ray as consisting of a series of waves following each other at a certain definite distance. We call the distance from one wave to the next the wave-length of the *x*-ray. Recently, the general public has become familiar with the idea of waves and wave-lengths in connection with wireless telegraphy and wireless telephony. Each broadcasting station sends out wireless waves of a certain definite wave-length. We hear, for instance, of wave-lengths of 400 meters (a little more than 400 yards) etc. This means that successive waves in the wireless wave train follow each other at a distance of 400 meters, etc. Researches in physical science have shown that wireless waves, light, *x*-rays and gamma rays consist essentially of the same *kind* of waves: further, that they differ from each other only in the lengths of their waves. Whereas wireless waves are usually several hundred meters long, light waves and *x*-rays have lengths of only a very small fraction of a centimeter. The lengths of *x*-rays ordinarily used amount to only a few billionths of a centimeter. Immediately after the discovery of the fact that *x*-rays had wave-lengths, it became evident that we should become accustomed to thinking and speaking of *x*-rays in terms of wave-lengths instead of in terms of voltages, of absorption coefficients, of "hardness" or of any of the suggested penetrometer scales. Following out this idea, I began immediately to investigate the wave-lengths produced under different experimental conditions—to investigate what we call the spectrum of the *x*-rays produced by various tubes and by various methods of exciting them, etc. I purpose in this lecture to give a brief résumé in non-technical language of some of these researches.

2. Before passing on to the main subject matter of the lecture, it may be advisable to state briefly the fundamental problem of *x*-ray therapy for those who may not have made a special study of the subject. The primary object of *x*-ray therapy in the treatment of malignant disease is the destruction of the tumor tissue by means of radiation absorbed in it. If the tumor lies some distance below the surface of the skin, the radiation projected into the

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

tumor must first pass through the skin itself and the intervening tissues. The amount of x-radiation that can be projected into and absorbed in the tumor depends upon the tolerance of the skin and intervening tissues for the radiation.

As an illustration of deep radiotherapy, let me compare the treatment with radium rays of a tumor lying, let us say, 10 cm. below the skin, with the treatment of the same tumor with x-rays. The diagram in Figure 1 illustrates the two cases. Let us suppose that a quantity of radium is placed at A, 10 cm. from the skin of the patient, and that the tumor to be radiated lies at a distance of 10 cm. below the skin, at B. Evidently the tumor lies at a distance from the source of rays that is twice as great as the distance to the skin. Owing to the spreading out of the radiation as it proceeds from the source, and in accordance with what is known as the inverse square law, a given small volume of tissue at B would receive only one-fourth of the radiation that the same volume of tissue would receive at the surface of the skin, even if none of the radiation were absorbed by the 10 cm. of intervening tissues. The gamma rays from the radioactive substances, as they are usually employed in deep therapy, are somewhat more than half absorbed in passing through 10 cm. of tissue, so that, owing to the combined effects of the spreading out of the rays and of the absorption by the tissues, the gamma radiation reaching the tumor is less than one-eighth of that passing through an equal volume of tissue at the skin. In other words, the amount of gamma radiation absorbed by the given volume of tissue at the tumor amounts to less than 12½ per cent of that absorbed by an equal volume of tissue at the skin. This proportion might be increased somewhat by increasing the distance of the radium from the skin. To get the same effect at the tumor, however, it would be necessary to increase the quantity of radium used, or the time of exposure. Practically 10 cm. is about the greatest distance that can be used effectively with the amounts of radium now at our disposal. In x-ray therapy we can employ far greater distances, for the x-ray tube radiates very much more powerfully than any obtainable amount of radium does. The diagram CD in Figure 1 represents the case of x-ray therapy. Let us suppose that the target has been placed at a distance of 80 cm. from the skin, a quite feasible distance. We will suppose, also, that the tumor, as in the radium treatment, lies at a distance of 10 cm. below the skin. In this case, the inverse square law shows us that about 79 per cent of the radiation that reaches the skin would reach the tumor, if it were not absorbed by the intervening tissues. (80 squared divided by 90 squared equals .79.)

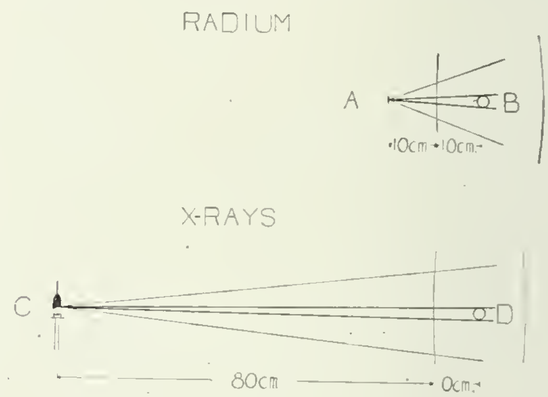

FIG. 1.

In the case of x-rays used in deep therapy (x-rays produced by 200,000 volts, or so, with heavy filtration) about four-fifths are absorbed in passing through 10 cm. of tissues. One-fifth of the radiation comes straight through the 10 cm. Hence, as one-fifth of 79 per cent equals about 16 per cent, 16 per cent of the x-radiation will reach the tumor, 10 cm. below the skin. Comparing this with the radium problem, we find that whereas, in the radium case, only about 12 per cent of the radiation reaching the skin penetrates directly to the tumor, 10 cm. below it, in the x-ray case, 16 per cent penetrates to the tumor. In other words, from this point of view, an x-ray tube appears to be a more effective instrument for deep therapy than a quantity of radium.

In the above problem, we have estimated the radiation reaching the tumor that travels in a direct line to it from the source of rays. In addition to this direct radiation, a lot of secondary radiation reaches the tumor, that comes from the surrounding tissues through which the rays pass. The fact that radiation produces secondary rays was discovered over twenty years ago. The recent researches carried on in central Europe have brought out the importance of the secondary radiation in deep x-ray therapy. It is on account of this secondary radiation that the total radiation received by the tumor depends to so large an extent upon the portal of entry. If we use a large portal, the total radiation received by the tumor, 10 cm. below the skin, may amount to more than 50 per cent of that received by the skin itself.

So much has been published recently in x-ray literature about the distribution of x-radiation in water phantoms, etc., that it hardly seems worth while for me to do more than to call attention to the great importance of the subject. We have begun investigations of the distribution of the radiation in phantoms having as nearly as possible the sizes and shapes of the portions of the body to be radiated. We hope to check the results obtained by measurements with small ionization chambers placed at various points in among the human tissues themselves.

To sum up, three factors determine the fraction of the radiation reaching the skin that penetrates to a tumor below it:

(*a*) The inverse square law.

(*b*) The absorption of radiation by the tissues.

(*c*) The effect of secondary radiation.

The first factor is a question of solid geometry only. Its magnitude does not depend upon the kind of x-rays that one uses. The other two factors, however, differ in magnitude for different kinds of x-rays. In general, tissues absorb less radiation if the wave-length is small, than if it is large. Similarly, the secondary radiation factor depends also upon the wave-length. If the wave-length is short, a larger amount of secondary radiation will reach the tumor than if the wave-length is long. It becomes, therefore, a problem of great importance in deep x-ray therapy to produce x-rays of short wave-lengths. It has been largely for the purpose of calling especial attention to this fact that I have dwelt so long upon the elementary problem of deep therapy,

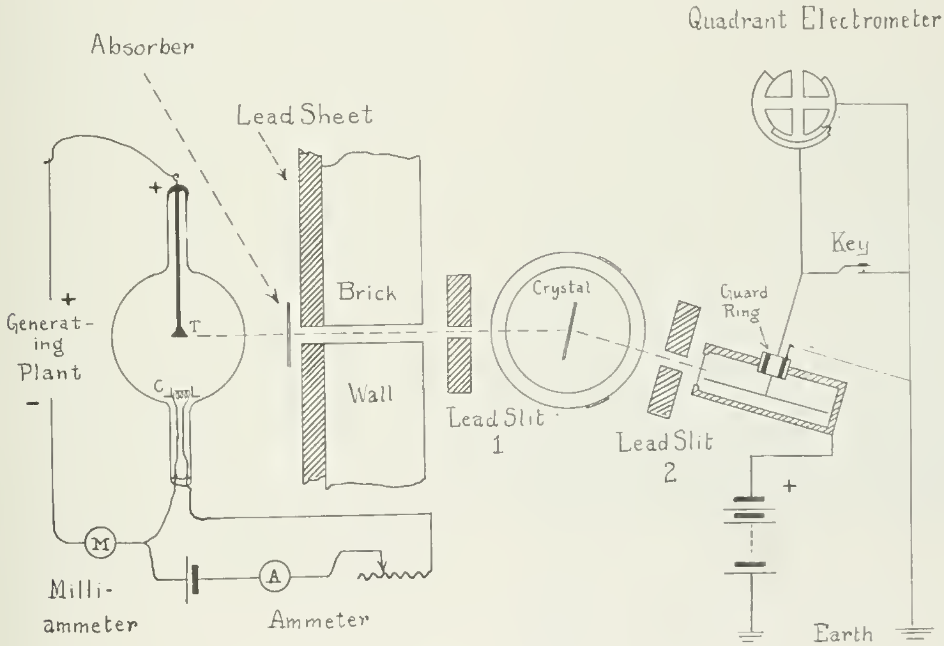

Fig. 2.

before describing our researches in *x*-ray spectra.

3. The method of measuring the *x*-ray wave-lengths is based upon the researches of Laue, Friedrich and Knipping, and the Braggs. Figure 2 represents the arrangement of the apparatus. A beam of *x*-rays coming from the target *T* passes through a small hole in the brick wall and then through a narrow slit between lead blocks. The *x*-ray tube and the generating plant lie in one room and the spectrometer in an adjoining room. The wall between the rooms gives good protection to the spectrometer and the operators against stray radiation from the tube. When high voltages are used, and, therefore, penetrating radiation, it is advisable to add a

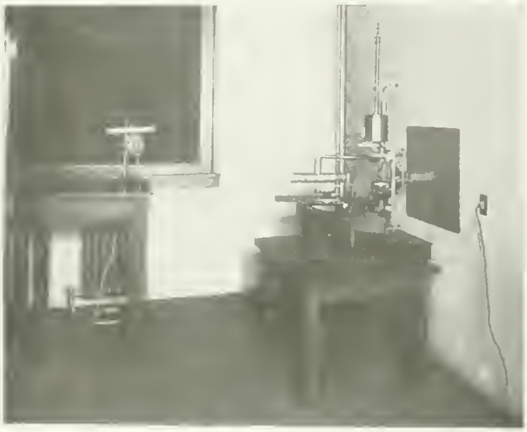

Fig. 3.

considerable thickness of lead to increase the protection, as illustrated in the figure. The *x*-rays, after coming through the lead slit, pass through a small crystal mounted on a spectrometer table. The spectrometer table can be turned through any desired angle, and the position of the crystal determined by reading the spectrometer scales. Part of the *x*-ray beam is reflected by the atoms in the crystal. *X*-rays of certain wave-lengths only are reflected at a given angle. By measuring this angle, the wave-length can be calculated. The reflected beam of rays passes through a second lead slit into an ionization chamber, and the current produced by them is measured by the quadrant electrometer. We take the current through the ionization chamber as an indication of the intensity of the *x*-rays having the calculated wave-length.

Figure 3 is a photograph of one of our *x*-ray spectrometers. The *x*-ray tube and generating plant are in a room to the right and the *x*-rays come through the metal tube that can be seen projecting from the wall toward the spectrometer.

4. The first problem that we took up some nine years ago was to determine just what wave-lengths an *x*-ray tube produces, when operated at a certain voltage; in other words, to investigate the spectrum produced by a given voltage. The curves in Figure 4 were published by Mr. Hunt and myself in 1915. They represent the radiation at different wave-lengths from a tube operated at a *constant*

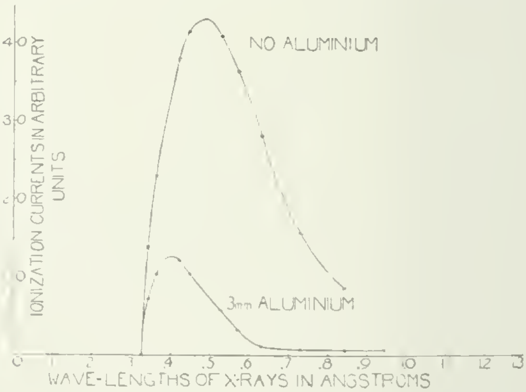

Fig. 4.

voltage. We used a high-tension storage battery to produce the current through the tube. The larger curve corresponds to a beam of unfiltered *x*-rays, and the smaller, to a beam filtered through 3 mm. of aluminum.

Three important conclusions can be drawn from these curves:

(*a*) A constant voltage applied to an *x*-ray tube does not produce *x*-rays of a single wave-length only; it produces a beam of rays having a great variety of wave-lengths.

(*b*) There is a certain minimum wave-length of the *x*-rays produced—no *x*-rays come from the tube having wave-lengths shorter than this minimum value. By making experiments at different voltages we have shown that the minimum wave-length depends only upon the voltage used.

It is always given by the law that the product of the voltage multiplied by the wave-length equals 12,354. According to this law, if we double the voltage, we halve the minimum wave-length; if we treble the voltage, we reduce the minimum wave-length to one-third its original value; etc.

(c) The effect produced by introducing absorbing materials in the path of the rays (filtration) is to decrease the intensity of the longer waves to a greater extent than that of the short waves. The filter does not change the value of the minimum wave-length. It does, however, reduce the value of the *average*, or what we may call the *effective* wave-length of the beam.

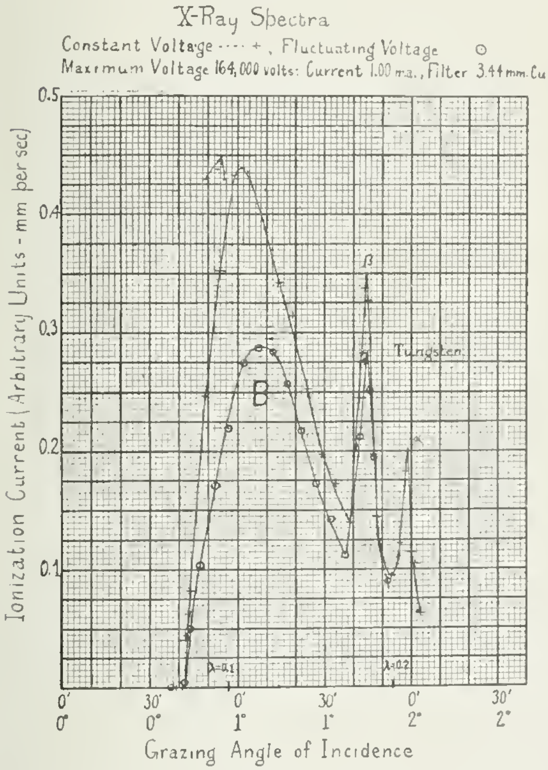

Fig. 5.

These conclusions have been confirmed since the original publication of the curves by a number of investigators.

5. The next problem was to determine whether or not the x-ray spectrum depended much upon the mode of exciting the tube. We have made a large number of experiments with constant voltages applied to the tube and with alternating voltages having the same crest values as the constant voltages. Two of the spectrum curves obtained appear in Figure 5. They show that the intensity of the x-radiation is much larger for the constant voltage than for the alternating voltage, and also that there is a perceptible shift in the wave-lengths toward the shorter values. In other words, although the current through the tube, the filtration, the focal distance, and the maximum voltage as determined by a sphere-gap, remain the same, yet the amount of x-radiation and the average wave-length differ from each other in the two cases. These results are important, as indicating that neither the intensity nor the average wave-length of the x-ray beam can be determined simply by measuring the current through the tube, the maximum voltage, the focal distance and the filtration.

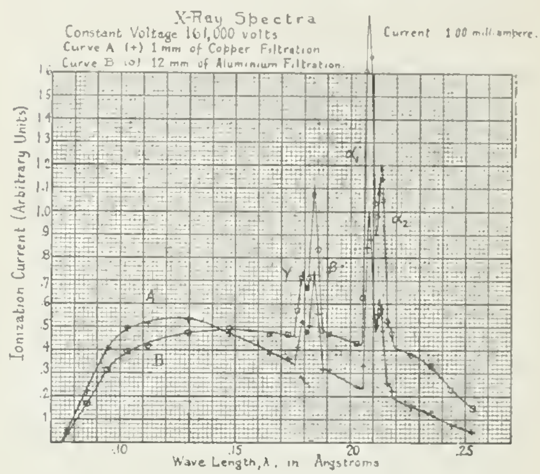

Fig. 6.

6. An important problem has been the investigation of the spectrum of x-rays that have passed through different kinds of filters. The curves in Figure 6 represent the spectrum of the x-rays that have passed through 1 mm. of copper and 12 mm. of aluminum, respectively. It will be seen that in the region of short wave-lengths a larger amount of radiation passed through the 1 mm. of copper than through the 12 mm. of aluminum, whereas in the region of longer wave-lengths, more radiation passed through the 12 mm. of aluminum than through the 1 mm. of copper. From this we

conclude that, if we desire to produce a beam of short wave-lengths, copper is a better substance to use as a filter than aluminum.

The peaks on the curves represent the characteristic radiation of the tungsten target.

Experiments indicate that silver, and some of the rare chemical elements with atomic weights a little larger than silver, would, if used as filters, give somewhat

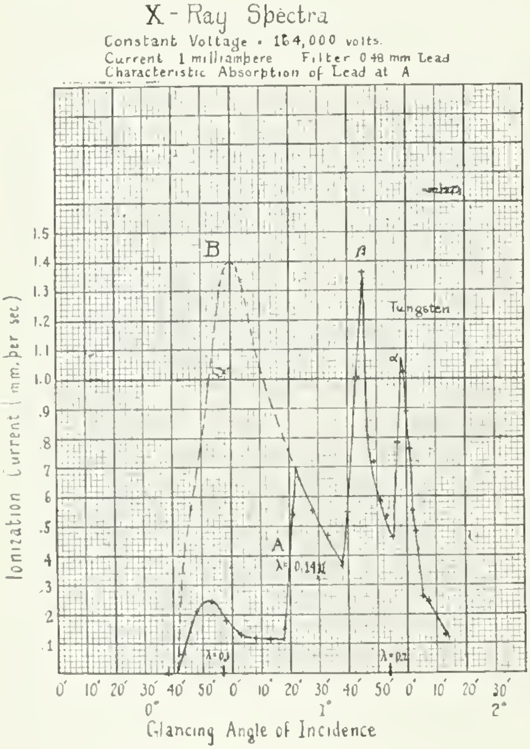

Fig. 7.

better spectra than the copper. The difference between these rare chemical elements of higher atomic weight and copper, however, is so small that the additional expense, etc., incurred would scarcely justify their use as filters.

It might be supposed that chemical elements of still higher atomic weight would, when used as filters, produce still better *x*-ray spectra. This, however, does not appear to be the case. The curve in Figure 7 represents the spectrum of the *x*-rays coming through a thin sheet of lead. It will be seen from the shape of this curve at *A* that the *x*-rays of shorter wave-length than 0.1411 are largely cut off by the lead. If the lead had not this peculiar property of cutting off short *x*-rays, the curve would have taken some such form as that represented by *B*. Since, therefore, the lead cuts off a great deal more of the shorter wave-lengths than of the longer, lead should not be used as a filter. In general, no chemical elements of very high atomic weight should be used as filters, if we desire to produce a beam of rays of short wave-lengths. The exact wave-lengths at which the various chemical elements cut off the shorter rays may be found in published tables.

7. We have been experimenting recently with *x*-ray tubes having targets composed of thorium and of uranium. Uranium is the chemical element of highest atomic weight known, and thorium is the chemical element of next highest atomic weight. At voltages in the neighborhood of 80,000 or 100,000 volts, the uranium and thorium target tubes do not project through a filter of several mm. of aluminum quite as intense a beam of *x*-rays nor of quite so short an effective wave-length as does a tungsten target tube operated under the same conditions. At much higher voltages, however, and with fairly high filtration, the advantage lies on the side of the uranium and thorium tubes. These tubes produce much more intense beams of rays and shorter average wave-lengths than tungsten tubes do. These peculiarities are doubtless due to the fact that 80,000 or 100,000 volts produce the characteristic radiation of the tungsten target, but do not suffice to produce that of either thorium or uranium. It requires nearly 110,000 volts to produce the characteristic radiation of thorium, and nearly 115,000 volts, that of uranium. Further, preliminary estimates of the principal wave-lengths of the characteristic *x*-rays give the values .117, .134 and .139 for thorium, and the values .111, .126 and .131 for uranium. These are very much shorter than the corresponding wave-lengths for tungsten, as indicated by the peaks on the curves of Figure 4. Had a thorium or an uranium target tube been employed in the experiments, the peaks would have come about where the maximum of the copper filtration curve lies.

Such a curve would indicate a much better distribution of energy in the spectrum than that for the tungsten target.

The fact that the radiation at high voltages from uranium and thorium is much more intense and of much shorter average wave-length than that from the tungsten under the same conditions, is an additional indication that, in estimating dosage, we should use some method of measuring the radiation that comes from the tube, rather than trust to measurements of voltage, current, filtration and focal distance.

8. Some eight years ago I was using an ionization chamber and galvanometer to measure the intensity of *x*-ray beams. I gave a brief description of the apparatus at the meeting of this society in 1914. Since then, owing to the improvement in the construction of galvanometers and to the increased intensity of *x*-rays as now used, I have been able to reduce the sizes of the ionization chambers, and make them more convenient. Figure 8 contains a sketch of one of these instruments. The ionization chamber is at *A*. It consists of a number of very thin aluminum plates alternatingly joined together. Hard rubber insulation separates the two sets of plates from each other. Wires running through two flexible insulation cables, *C*, join the ionization chamber with a battery, *B*, and galvanometer, *G*. A flexible metallic shield joined directly to the earth, as indicated in the figure, covers the cables. The ionization chamber, also, is shielded by a very thin sheet of aluminum. This shielding is important for purposes of electrostatic protection. The long, flexible cables allow the ionization chamber to be placed in any desired position in the *x*-ray beam, while the battery and galvanometer lie on a conveniently placed shelf. When the ionization chamber lies in a beam of *x*-ray, the rays make the gas between the sets of plates a conductor of electricity, and a current from the battery flows around the circuit through the galvanometer. This current depends upon the intensity of the *x*-ray beam, and we take the magnitude of the current as a measure of that intensity. We do not have to measure a time interval by means of a stop watch, as in some instruments, but simply read the deflection of the galvanometer, and use it as the indicator of the beam's intensity at the moment.

In order that the measurements of ionization currents by means of a chamber of this kind shall represent accurately the intensity of *x*-ray beams, it is necessary to calibrate the ionization chamber by means of a standard instrument, in which the rays pass through a large volume of

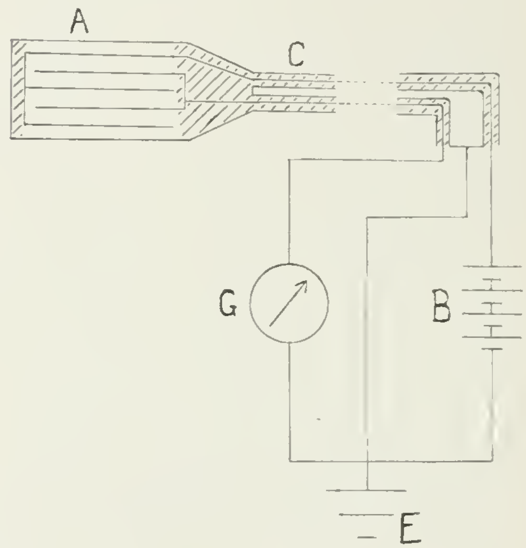

Fig. 8.

air without striking any of the electrodes inside of the chamber. The standard ionization chambers that I was using in 1913 and 1914 had volumes ranging from 500 to 2,000 c.c. The size of the chamber depends upon the precision with which we desire to make the calibration.

To express suitably the intensity of a beam of *x*-rays we must adopt some unit of measurement. I have chosen for our own work to take as the unit of intensity a beam of *x*-rays that would produce an ionization current of one electrostatic unit in each cubic centimeter of air, if the rays did not strike any of the electrodes in the ionization chamber, and if all of the secondary radiation from the molecules of the air were absorbed in the air. This unit we call E. It is a unit of radiation intensity, and not a unit of dosage. To get the dosage, we must multiply the number of units of intensity that we are using by the length of time of exposure. If the length of the exposure is expressed in seconds, then the product of the intensity expressed in the above units multiplied by the time in seconds equals the dosage, as expressed in the German researches by the letter "e," following Friedrich.

By way of illustration, I shall mention a few intensities of x-ray beams under various conditions as expressed in these units. If an ordinary x-ray tube is operated at 82,000 volts with 5 ma. passing through the tube and with a filter of 2.6 mm. of aluminum, the intensity of the radiation at a distance of 40 cm. from the tube is about .38 E. If we operate the tube at 200,000 volts with 4 ma. and a filter of ½ mm. of copper, the intensity at 80 cm. from the target amounts to about .21 E.

To get the dosage, we have to multiply the intensity expressed in E by the time of exposure expressed in seconds. The unit of dosage we may call ES, indicating that the intensity is expressed in E and the time in seconds. It seems to me important in estimating and recording dosages to determine and state the magnitudes of both the intensity and the time factors. Although for small changes in the factors it may not make much difference, yet, in general, the effects produced by radiation are not exactly proportional to the product of the two. Exposure to very weak radiation for a long time does not produce the same changes as exposure to very intense radiation for a correspondingly short time.

The ionization chamber, as described, measures the intensity of the x-ray beam. In order to get an estimate of the penetration factor, I have adopted the idea of using the *effective* wave-length of the beam. The effective wave-length of the beam may be defined as the wave-length of the monochromatic ray that has the same absorption in a given case as the whole beam itself has. In order to measure the effective wave-length of an x-ray beam I use either one of the methods described in the March number of THE AMERICAN JOURNAL OF ROENTGENOLOGY, pages 170 and 171. By means of the ionization chamber I measure the fraction of radiation that gets through a plate of copper or aluminum, and then read off the corresponding wave-length by means of the curve in Figure 9.

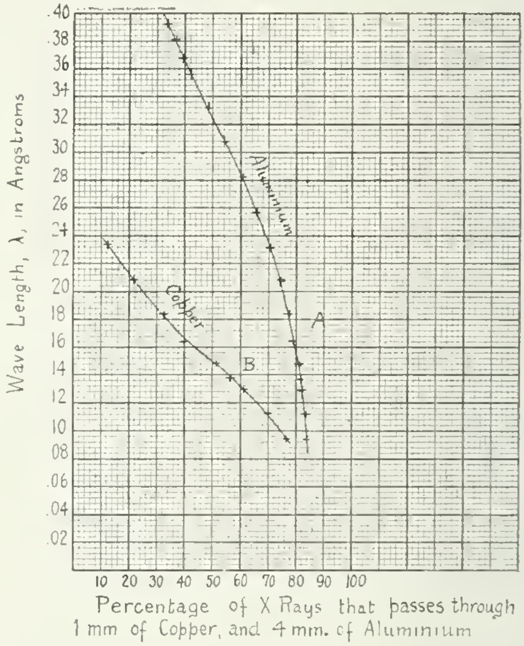

FIG. 9.

In the second method of measuring the effective wave-length, I determined the thickness of aluminum that is equivalent in absorbing power to a given thickness of copper, and read off the wave-length from the curve of Figure 10.

The effective wave-lengths of the beams of rays coming from an x-ray tube operated at 80,000 to 100,000 volts and with filters of several millimeters of aluminum usually range from .22 to .28 Ångströms. A constant voltage of 165,000 volts or alternating voltage of 200,000 volts (peak value) produces a beam of x-rays having an effective wave-length in the neighborhood of .16 after it has passed through ½ mm. of copper. At about 200,000 volts constant voltage the effective wave-length lies in the neighborhood of .145.

I find, on examining different generating plants, and also the same generating plant under different weather conditions, etc., that there are considerable variations in the intensity and effective wave-lengths of the x-ray beams produced, even though the currents, as measured by the millimeter, and the voltages, as determined by a sphere-gap, are the same.

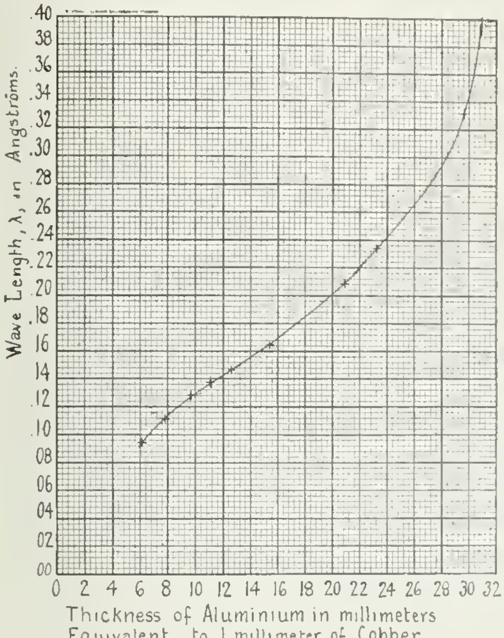

Fig. 10.

Owing to the great advances that have been made in our knowledge of x-radiation and to the improvements in physical measurements of x-ray beams, it would seem desirable for an association such as the American Roentgen Ray Society, to organize in the various centers of our population intensive courses of lectures on the physics of x-radiation.

9. A brief description of the generating plant I have used for producing a constant voltage to be applied to the x-ray tube may not be out of place. The fundamental principle of the plant is old. I saw a machine based on this principle in operation in London as early as 1905.

A diagram representing the electrical circuits may be found in The American Journal of Roentgenology, July, 1922. One end of the secondary coil of a transformer, delivering current at a maximum voltage of V volts, is connected to ground; the other end is joined through electrical valves to the two plates of a condenser respectively. One valve lets the positive electricity through, but not the negative. The other valve lets the negative electricity through, but not the positive. Thus the condenser plates become charged to plus V volts and minus V volts respectively, and there is a constant voltage of 2 V volts between them. The x-ray tube is joined to the two plates of the condenser, as indicated, and operates, therefore, at twice the maximum voltage generated by the transformer. I have found no better instruments to use as valves for high-voltage work than the new, large Coolidge x-ray tubes.

The advantages of using a constant voltage generating plant of this kind are not only that it produces a better x-ray spectrum (Fig. 5) but also that it appears to be less hard on the x-ray tubes and runs almost noiselessly.

10. It appears to be very fitting in a Caldwell lecture to lay especial stress upon adequate protection for the operators. For the last nine years we have adopted the plan of placing the x-ray tube and the generating plant in one room and radiating

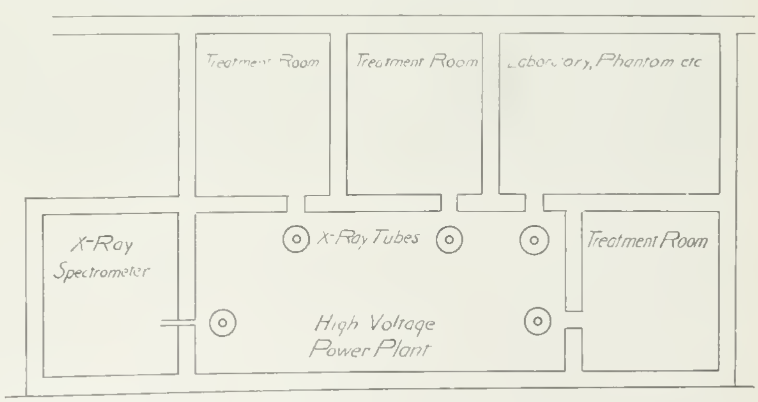

Fig. 11.

through the walls or the ceiling into adjoining rooms. Figure 11 is a rough sketch of the arrangement of the rooms in our new building that has just been completed. The generating plant and x-ray tubes are in a central room, surrounded by five other rooms which are used for treatments and for laboratory investigations. The x-ray tubes hang opposite holes in the walls and ceilings, through which the rays pass and which contain the various filters, etc. The patients to be treated lie on mattresses on the floors of the rooms above the x-ray room, or on a table in the room alongside of the x-ray room. With this arrangement, no odor or noise can be perceived in the room where the patient lies. In fact, he does not know whether the x-rays are turned on or off. This arrangement apparently reduces the nausea of the patients, although it does not completely eliminate it.

Figure 12 reproduces a photograph of a part of the x-ray room itself. The high-tension electrodes can be seen and an x-ray tube suspended by silk cords from the ceiling opposite one of the holes.

Figure 13 represents ionization chambers placed in position to measure the intensity and effective wave-length of an x-ray beam coming through the hole in the floor. The small one has been described in Figure 8. The larger ionization chamber is one of the standards used to calibrate the smaller chambers. The galvanometer and battery, etc., rest on the shelf in the corner.

Figure 14 is a photograph of the patient's bed in one of the treatment rooms above the x-ray room. One section of the bed consists of a wooden framework covered with canvas. This section lies over the hole in the floor through which the beam of x-rays comes. The ionization chamber, seen close to it, may be thrust through the small hole and thus placed in the line of the x-ray beam to measure its intensity at any time during the treatment. The ionization chamber, also, may be held above the patient to determine how much radiation passes through, or at the sides to measure the secondary radiation, etc.

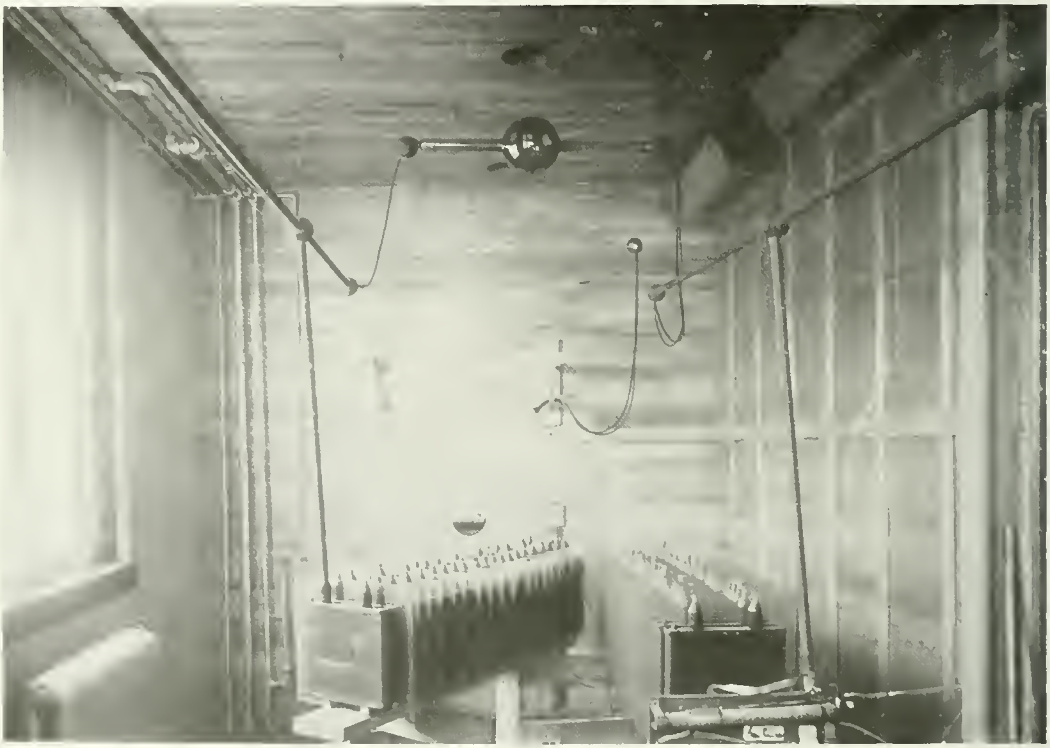

Fig. 12.

11. We have begun an intensive investigation of the biological effects of these x-rays of short wave-lengths. So far, the results do not differ essentially from those published in the recent literature on this subject. We have seen very large tumors melt away under the action of the rays. Some of these have been internal tumors,

the sizes of which have been estimated from x-ray photographs. Just how permanent the retrogression of the tumors may turn out to be, no one can tell at present, for these penetrating rays have been used for a short time only. There can be no doubt, however, but that the temporary palliative effects in some cases are far superior to those that can be produced in any other way.

Fig. 13.

Fig. 14.

At present we are examining, in particular, the blood changes produced by radiation. These changes seem to be somewhat irregular, the most regular being the changes in the white cell count. The clinical findings appear also to be quite irregular. Sometimes the temperature rises, sometimes it falls, and in other cases it remains normal. The same may be said of pulse and respiration. The great irregularity in the effects produced by the rays suggests that either the methods of examination are too uncertain, or else we do not yet understand all of the conditions required to produce the different effects. The irregularities are probably due to a combination of both of these. The subject demands an extensive and profound series of investigations.

The present methods of measuring x-ray intensities and wave-lengths have far greater accuracy than those employed in the determination of the biological effects produced by the rays. As is well known, the x-ray expert today possesses one of the most important and far-reaching methods of diagnosis in existence. Owing to the increase in the accuracy of estimating dosage, he now possesses, also, a method of treating certain types of disease that is not excelled in precision of measurement in any other branch of medicine or surgery.

ON THE FUNCTION OF THE MUSCLES OF THE STOMACH SOME ELECTRICAL EXPERIMENTS*

BY A. E. BARCLAY, M.D.

MANCHESTER, ENGLAND

WE live in an utilitarian age; every new discovery is at once seized upon and turned to practical account. The application of the *x*-rays to the study of the gastrointestinal tract has been no exception to the general rule, and great have been the resulting advances in the diagnosis of abdominal disorders; so much so that a laparotomy ceases to be the usual description of an abdominal operation, and the surgeon now opens the abdomen with a very shrewd idea as to what he is going to find, and what operation he is likely to perform. The efforts of radiologists have naturally been focussed on the pathological subjects, and the radiographic reports are almost always to the effect that the examination is negative thereby meaning negative from the surgical point of view—or that such and such a pathological condition is present. And yet we all know that in a large number of the cases in which our report is negative, the patient is suffering from definite gastric symptoms. I am not for one moment suggesting that all gastric symptoms emanate from the stomach, for everyone now realizes that the stomach is, more often than not, just the fuse box that responds to faults at any point in the complicated system that deals with digestion, including the nervous system, and the extraordinarily varied psychological factors that act through the mentality of the subject. I do, however, suggest very strongly that we, as radiologists, have focussed our attention on pathology, overlooking the fact that there is such a thing as disordered physiology, which may quite likely account for troubles of very real moment to the welfare of the patient. In other words, I think we have neglected the very foundations on which we should have built our study of pathology. It is true that the study of gastric pathology has become a wonderfully exact science in expert hands. I am certain, however, that it would be of still greater value, and would already have reached a far greater degree of finesse, had we been able to preface our study of pathology by an extensive study of the physiology of that most elusive entity, the normal stomach, an organ so easy to

FIG. 1. Peritoneum stripped and the t an, outer longitudinal coat exposed, which is the direct continuation of the longitudinal coat of the esophagus, and is not of great strength.

FIG. 2. A larger view of another dissection.

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.

describe in the old days of descriptive anatomy, and so difficult in these days of the study of the living anatomy.

Recently I read a paper on the normal stomach (*Lancet*, July 29, 1922). How simple it seemed before one really tackled the subject in the light of modern physiology! One always realized that the varied appearances of the stomach were largely dependent on variations in tonic action, but one did not realize how difficult it was, and is, to lay real hold of the conception of this function of muscle of which we speak so glibly and know so little. We always think of a muscle as a bundle of fibers which, by contraction, does certain work. Vaguely we realize that muscle has also another function, that of tonic action. Tone, (derived from the Greek τειγω I stretch,) we regard as mechanical tension exerted by muscle fibers, and so it is, to a certain point; but this is only a half-truth, and we must go a great deal further to get at the whole truth. Muscle fibers exert their tonic action irrespective of whether they are stretched or in a state of contraction, namely, whether the stomach is large or small—it is not a contraction, but a *posture* of muscle, the nearest word that Sherrington finds to describe the action. I would strongly recommend to all who are interested in studying the foundations on which we are working, the masterly paper by Sherrington, published in 1915, on Postural Activity of Muscle and Nerve. (*Brain*, xxxviii, part 3, p. 191.)

Our conception of a stomach as hypertonic or atonic is quite likely incorrect. A muscle fiber probably has the same power of tonic action in either state, namely, of attempting to maintain the posture or general contour of the stomach against the various forces that act upon it. To speak of an atonic stomach is therefore incorrect, as such a thing is inconceivable while the muscle fibers are living cells. "Hypotonic" is certainly better, but is still only half way. "Dilated" certainly does not describe the condition, which is rather a "stretched" condition of the muscle than either a dilated or hypotonic organ. The tension inside the hypertonic and the hypotonic stomach may be identical—the tone, as I have said, is a posture of the muscle wall. However, I did not start this paper with the intention of dealing with this very difficult subject,

Fig. 3. Stomach opened down the great curvature and mucous membrane dissected off. Note the innermost coat, the oblique band running down either side of the lesser curvature and branching out fanlike, but confined to this portion of the stomach, leaving a narrow gap along the lesser curvation between the two sides. Jefferson has shown that in the upper 2 inches, this band is quite free from the underlying muscle wall, but lower down it spreads out on either side, fanlike, and its fibers intermingle and fuse with the fibers of the circular coat, forming a network in which the actual fibers appear to join each other.

Fig. 4. Fusion of the fibers. Note the tangle of the fibers which form the circular coat.

although I felt a few words were necessary in order to make clear the interpretation of the small experiments to be described.

It is also essential to remind you of the anatomy of the stomach. We have always been taught that there was an outer serous coat, the peritoneum, inside which were three muscular layers bounded internally by the mucous membrane. We realized that the lesser curvature was thicker than the greater because of the greater thickness of the muscular wall. We also knew that there was an outer longitudinal coat, a middle circular and an inner oblique coat, but apart from examination purposes, they meant nothing to us. Forssell, in his book, describes these admirably, and Jefferson has some beautiful dissections shortly to be published in the British Journal of Surgery.

We all know the appearance of the so-called atonic stomach (the organ that is stretched by the weight of the food it carries) and the ptosed stomach, which, although it descends low into the pelvis, is still able to maintain its contents in tubular form. Often these two types run into each other, but the pure "atonic" (hypotonic) and ptosed stomachs differ from one another very markedly in one respect, namely, the lesser curvature. In the stretched hypotonic stomach, the lesser curvature is not elongated. It is practically of the same length as in the normal, although the greater curvature is enormously increased. But in gastroptosis the condition is different—the lesser curvature is lengthened considerably and the greater curvature is only increased more or less correspondingly, (together with the anterior and posterior walls, of course). It seems to me that the length of the lesser curvature is the fundamental difference in the two types, both of which are variations of the normal.

There is a type of stomach which I have always called the "cup and spill" type, which has been named in the States the "drain trap" type, in which the upper part of the stomach forms a cup, and the food spills over into a more or less normal lower pyloric portion. Generally the cup is spilling forward, but sometimes it is seen spilling to the inner side, and occasionally to the outer side. Quite frequently the condition is not present on the following day. I have seen all these types of "cup and spill" in stomachs which were giving rise to no symptoms, and I came to the conclusion that they also were, for the most part at any rate, variations of the normal. One day, my partner, Dr. J. M. Morison, was inflating a perfectly normal J-shaped stomach with CO_2, and the result was that as the gas distended the fundus and pressed the diaphragm up, the upper portion of the stomach formed a cup, and the food spilled over to the inner side, giving a typical "cup and spill" stomach. This showed that the condition

FIG. 5. Gastroptosis.

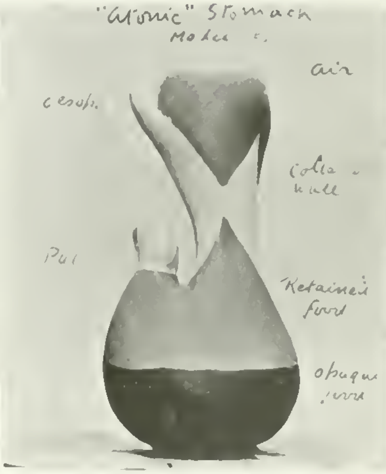

FIG. 6. "Atonic" stomach.


FIG. 7. Variations of the normal.

could be produced in a perfectly normal organ.

How could this curious appearance be produced? I was already much impressed by the behavior of the lesser curvature, as I have said, and it occurred to me that this exceedingly well-formed band of oblique fibers might give the explanation if we premised that it was capable of action independent of the other muscular coats. It was the only explanation that would meet the case, so far as I could see, and therefore I thought it worth while to attempt to test the reaction of various parts of the stomach wall by electrical methods. By the courtesy of Mr. E. D. Telford, we carried out a series of tests in his operating theater at the Manchester Royal Infirmary on a man in whom we had diagnosed a duodenal ulcer, but who was in good condition otherwise. A rather larger incision than usual was made and the anesthesia was as light as possible as soon as the abdomen had been opened. A large indifferent electrode was placed under the patient's back, and, with an olivary pointed electrode, we applied the stimulus direct to the stomach walls. At first we tried the interrupted galvanic current, but this met with no response—possibly the anesthesia was too deep at this period. We then switched over to an interrupted sinusoidal current, and at once obtained contraction of the stomach wall. Wherever we stimulated on the greater curvature and anterior wall, a band of contraction occurred, a typical incisura, the greater curvature being drawn in towards the lesser curvature in every instance. This appeared to be entirely due to contraction of the circular fibers drawing in the free greater curvature towards the thicker and comparatively fixed lesser curvature, which was what one expected. We then applied our stimulus to the lesser curvature at various points in the lower third, and obtained no contraction of gastric muscle, so far as we could see. There was, however, a very definite tendency to retching and straining; so much so that we thought the patient was coming round. However, on cutting off the current, the spasm at once relaxed, and did not recur when we applied the electrode at other points. The reaction seemed to be a general spasmodic contraction of the diaphragm and abdominal muscles.

Fig. 8. Normal J-shaped stomach.

Fig. 9. "Cup and spill" produced by inflating the stomach with CO_2.

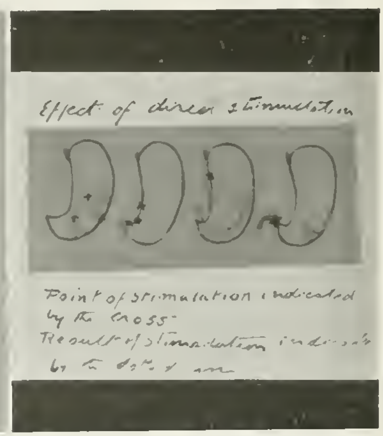

Fig. 10. Effect of direct stimulation.

The liver was then drawn aside and the electrode applied to the lesser curvature in its upper third. The result of this was a very definite response which we obtained with each stimulation: the stomach, which was bulging out of the wound, was drawn up into the abdomen, descending again slowly as soon as the current was cut off. There was apparently no suggestion of the formation of an incisura, and the reaction seemed to be due to a contraction of the oblique band acting entirely by itself.

One other point of stimulation was tried, namely, the peritoneal surface of the duodenal ulcer. There was no local response whatever, but an incisura appeared in the lower third of the stomach such as would give, on the screen, the hour-glass appearance which we so often see in connection with duodenal ulcers.

The way in which the reaction occurred was interesting. It was not immediate, but took perhaps ten seconds to show itself, attaining its maximum in another ten seconds and relaxing in about fifteen seconds, I should judge. At no period of the experiments did we obtain any contraction that was suggestive of peristaltic action.

These experiments, therefore, go a very long way toward confirming my hypothesis that the oblique band can act entirely independently of the circular and longitudinal coats; and if this is correct, I think we can say that gastroptosis is due to elongation of the oblique band, while hypotonus, or so-called atony, is the relaxation, lengthening and possibly stretching of the fibers of the circular and longitudinal coats, the oblique band retaining its normal length. In the case of the "cup and spill" stomach, one can explain the mechanism most easily in the case that was artificially produced—the oblique band remained in its normal state of posture or tone while the gas distended the fundus, stretching the thin wall above it so that the oblique band held up the lip of the cup. Why some of these "cup and spill" stomachs should empty forwards or to one side or the other is a mechanical problem; when we consider that the fundus of the stomach has ample room for rotation and that the cardiac orifice is the only comparatively fixed spot, I think we can picture the way in which it is formed; particularly so if we take our hypothesis a little further and suggest that the two sides of the oblique band can act independently of each other just as we have separate control of the two sides of the face. This, moreover, has the slight support of the textbooks of anatomy in which it is stated that the nerve supply of the stomach is through the terminal branches of the two pneumogastrics with the addition of various off-sets from the sympathetic: that the left supplies the anterior wall, while the right supplies the posterior wall. If this possible independent action of the two sides of the oblique band is taken into consideration, and also the fact that in the upper 2 in. it is quite free from the underlying muscular coat, I think we can allow the possibility that it is the persistent contraction of this band in the presence of relaxation of the other muscular structures that allows the formation of the varied types of "cup and spill" stomachs which are met with.

I believe that the chief function of the oblique band is to carry the weight of the stomach and its contents, that the functions of the other two coats are concerned with peristalsis and with that ligamentous action of muscle which we call tonic action, but which is better described as posture.

This communication is an attempt to give one small side of a very difficult subject. I am fully alive to the value of the splendid experimental work that Alvarez is doing, and I am sure that his and other work done on the physiology of the alimentary tract is the real hope of further progress in a realm of diagnosis which has almost jumped the study of the physiological elements and yet made a startling success in the elucidation of pathological abdominal conditions.

WHAT IS THE BEST METHOD FOR THE TREATMENT OF UTERINE FIBROMYOMATA BY MEANS OF THE ROENTGEN RAYS?*

BY M. BÉCLÈRE, M.D.

Academy of Medicine

PARIS, FRANCE

Mr. President and my dear Colleagues:

I greatly appreciate the recognition I was so fortunate as to receive from the leading roentgenologists of the United States, and only regret that I am not in a position to thank them personally.

Many of you I know only by name and from your achievements, but I would like to enter into more intimate relations with you, take part in your work, and attend your Congress. Being deprived of this pleasure, I beg you to accept my sincere regrets and to receive this unpretentious essay, which I present to you, my colleagues of the United States, as a token of my admiration, gratitude and friendship.

BÉCLÈRE.

It was in France that the roentgenotherapy of uterine fibromyomata was inaugurated with the appearance of the first essay of Dr. Foveau de Courmelles, of the Academy of Sciences, published in January, 1904. Since then, thousands of observations, made in all countries, have demonstrated the efficacy and harmlessness of this new treatment. The statistics of 700 cases which I reported show that but one per cent of cases was unsuccessfully treated, while in only 9 cases was roentgenotherapy wholly ineffective and obliged to give place to the knife. This shows the efficacy of the new treatment. There remain only two questions which must be discussed, namely: (1) the contraindications to the roentgen rays, and (2) the best method of their employment.

Before the great experience of the radiotherapists and the improvement of their instruments and technique, most of the contraindications which were formerly, and some of which are still, advanced today, against the roentgenotherapy of myomata, have successively disappeared. By reversing the ancient formula, one might say that today roentgenotherapy is contraindicated only in cases in which, for some urgent reason, surgical intervention becomes absolutely necessary.

Now, which is the best method for the employment of the roentgen rays? Should only the ovaries be exposed to irradiation, or the whole myomatous uterus, together with the ovaries? Is it best to give the whole treatment in one or several sittings? This is the technical problem which I propose to elucidate.

Regarding the action of the roentgen rays in the treatment of uterine fibromyomata, two theories prevail at present. One is that held by the majority of the German radiotherapists, the other that of almost all the French radiotherapists. For brevity's sake, we will designate one as the German and the other as the French theory.

The German theory has been stated many times, but never elsewhere as clearly as by Seitz and Wintz. They declare: "In the treatment of uterine myomata, the roentgen rays are only efficacious through their action upon the ovaries. After castration by means of the roentgen rays, the retrogression of the myomata takes place in exactly the same manner as after a surgical castration or after the onset of the natural menopause. The muscular fibers of the myomata are not affected by the same dose as is sufficient to produce castration." In the opinion of these authors, the diminution in the size of the irradiated myomata generally does not begin until four or five months after the treatment. According to other German authors, it takes place sooner and begins after one or two months. But almost all of them hold that it is exclusively due to ovarian activity, and does not manifest itself before the cessation of the menses.

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.

In contradiction to these assertions, unbiased clinical observations have revealed to the majority of French radiotherapists that the reduction in the size of the myomata which have undergone roentgenotherapy is quite often more rapid and momentous than that which follows the natural menopause. It has been shown that this reduction manifests itself before the treatment has brought about the suppression of the menses. As for me, I have only verified the findings of my predecessors. The observation of a large number of cases, the regular weekly sittings, the invariable habit of measuring in centimeters, before each sitting and after the emptying of the bladder, the distance between the upper pole of the uterine tumor and the pubic symphysis, have led me to form the conclusion which, in 1913, at the International Congress of Medicine, at London, I announced, which I formulated in 1919, at Brussels, at the first Congress of French-speaking gynecologists and obstetricians, and which I repeated in 1921, before the Academy of Medicine of Paris: *The reduction in the size of palpable uterine tumors begins with the inauguration of the treatment; in most instances it becomes noticeable at the third, sometimes even after the second sitting. From week to week the upper pole of the uterine tumor approaches more or less rapidly the pubic symphysis; in the most favorable cases it may approach at the rate of about one centimeter in a week.*

This retrogression of the myomata, which constantly precedes for one, two or even three months the suppression of the menses, is, in my opinion, a convincing proof of the direct action of the roentgen rays upon the myomatous tissue. The objection may be raised that the ovarian activity is before its suppression gradually attenuated, that the rapid reduction in the size of the uterine tumor is only due to a diminution of the secretions of the ovaries and the endocrine glands, to a diminished production of hormones of ovarian origin which, through the circulation of the blood, stimulate the growth of the uterine myomata, and that thus the retrogression of the latter is but an indirect result of the irradiations. This objection is easily refuted. It may happen that after the physiological menopause a myomatous uterus continues to grow gradually and slowly, or, several years after the natural menopause, it may, of a sudden, show a more or less rapid increase in size. I have seen several cases of this kind. In women in whom for a considerable period of time the ovaries had been devoid of all activity, as well as in menstruating females, the irradiations resulted in a reduction in the size of the uterine tumor.

This is a convincing proof of the immediate and direct action of the roentgen rays upon the fibromyomata of the uterus, and no further doubt can be entertained in this regard. Moreover, I had the pleasure of learning that some of the German clinicians of the highest repute, such as Wetterer, of Mannheim, and some of the most eminent pathologists, as Haendly, of Berlin, unreservedly admit this direct action upon the myomatous tissue.

According to the French theory, the treatment of uterine myomata by means of the roentgen rays forms a separate chapter in the roentgenotherapy of neoplasms in general, while, according to the Germans, it is but an appendage to ovarian sterilization.

The logical result of the French doctrine, at least as it applies to young females, is the destruction of the myomata without permanent suppression of the menses, and the maintenance and restoration of the possibility of pregnancy. But this ideal can be realized only very exceptionally, and I came across but one authentic observation, published by my friend, Dr. Pfahler, of Philadelphia. In practically all the cases the treatment results in ovarian sterilization, because it is impossible to subject the myomatous uterus to the rays without exposing the ovaries to the rays at the same time. In practically all the cases, the treatment must be carried out systematically until the menstrual function is suppressed definitely, for experience shows that the return of the menses, after a cessation of shorter or longer duration, is always the signal of a recrudescence of the myoma, which was retrogressing, and of a renewed increase in its size, if it has not been completely destroyed by the preceding irradiations. Thus we see that in practice, the German as well as the French radiotherapists have the same end in view, namely, the suppression of the menses, the former as well as the latter considering the roentgen rays as a sterilizing agency. But, while the German school denies any other rôle to the rays, the French school credits them principally with the capability of destroying the neoplastic cells of which the myomata are made up. This theoretical difference regarding the action of the roentgen rays entails differences as to the technique and method of treatment.

In principle, according to the German school, only the ovaries are the target towards which all the irradiations must be directed. The French school, on the other hand, thinks it is necessary to expose to the rays the whole uterine tumor, whatever its form and size, and not to pay any especial attention to the ovaries, because by raying the entire uterus, however increased in size or more or less deformed, one can be certain that all its adnexa, though more or less displaced, are subjected to the action of the rays. Moreover, in the majority of cases, it is impossible to determine the exact location of the ovaries, which may lie at a greater or less depth under the integument. As a matter of fact, looked at from this point of view, the actual technique employed in Germany is—after many fluctuations—not different from the original technique to which I have always faithfully adhered, for its new features consist in the small number and the large area of the portals of entry of the irradiation.

I was able to ascertain this fact last year, during a visit paid to Professor Seitz in his gynecological clinic, at Frankfort. The irradiation, which, theoretically, aims only at the ovaries and their sterilization, comprises four portals of entry, namely, two for each ovary—one abdominal and the other dorsal. Each of the two abdominal portals of entry has the form of a quadrant, the top of which is limited by the line which joins the iliac spinae, inside by the linea alba, outside and below by the inguinal fold. The two dorsal portals of entry are of the same form, and extend as do the abdominal ones to which they correspond. Thus the whole of the uterine tumor is always irradiated, together with the ovaries, and—as I was able to observe—even in those cases in which the tumor is quite large and its upper pole rises above the line which joins the iliac spines; in order to irradiate it entirely, a third abdominal irradiation field is added to the regular fields.

In other gynecological clinics of Germany they have adopted a different technique, in which the irradiation comprises only two portals of entry, one abdominal and the other dorsal, each one representing a square 14 × 20 cm.; but the result is the same, as the whole of the uterine tumor is always irradiated, together with the ovaries, a procedure which I have constantly advocated.

Thus, in spite of the difference in their theoretical view, the German and the French radiotherapists agree in regard to the treatment, namely, to irradiate simultaneously the myomatous uterus and the ovaries. It cannot be denied that this procedure is excellent.

Now, having disposed of the first point, let us deal with the second question,—whether it is preferable to give the irradiations in only one or in several sittings.

The ovarian sterilization at one sitting was inaugurated in 1915, at the University of Freiburg, in Breisgau (Baden), as the result of Kroenig's and Friedrich's investigations, to be soon followed by those of Seitz and Wintz, of the University of Erlangen (Bavaria). I shall merely report the conditions under which this method has been made possible: From a physical point of view, the employment of more penetrating and better filtered rays, introduced through larger portals of entry so as to increase the radiation quantity of energy which is absorbed by the ovary as compared with that absorbed by the skin; the employment of an ionization chamber attached to an electroscope, as a measuring device, has made possible the exact estimation of these two quantities. From the biological point of view, the above-mentioned authors have endeavored, on the one hand, to determine the maximum dose which is compatible with the integrity of the skin—the "erythema dose"—and, on the other hand, the minimum dose which is sufficient, whatever the age of the patient, to destroy the ovarian follicles—the "castration dose." According to Kroenig and Friedrich, the "castration dose" equals one-fifth of the "erythema dose." According to Seitz and Wintz, it is equivalent to a little more than a third; the "erythema dose" of the latter is somewhat less powerful than that of the former. Be that as it may, in Freiburg, Erlangen, Frankfort and quite a few other German universities, under the direction of the professors of gynecology, the ovarian sterilization at a single sitting is practiced and recommended as a simple, rapid method, uniformly applicable in cases of hemorrhagic metropathies and to uterine myomata and to myomata of all sizes, whatever their location, in females of any age; in short, to all clinical cases without any distinction.

The possibility of destroying at a single sitting and in a few hours the menstrual function, and, at the same time, checking all losses of blood, represents, from a technical point of view, remarkable progress. That this method of irradiation offers advantages in certain cases is undeniable, but, on the other hand, we must take into consideration the nature of these advantages and the price paid for them, before we decide whether the treatment of myomata at a single sitting is always the best method.

Taking into consideration the therapeutic results, we must ask the following questions: (1) Is a single castration dose always sufficient? (2) Is it always immediately followed by amenorrhea? (3) Is the menopause thus obtained always permanent? From a study of the articles written on ovarian sterilization at a single sitting we are forced to answer in the negative each of these three questions and to formulate the following propositions:

1. A single castration dose given according to the teachings of Seitz and Wintz is not always sufficient for the production of ovarian sterilization; in a certain number of cases, the percentage of which is by no means negligible, a second irradiation becomes necessary. Regarding the treatment of myomata through castration at a single sitting, it is impossible to affirm that a single irradiation will produce the desired result and that it will not be necessary to repeat it.

2. When a single castration dose is sufficient for producing ovarian sterilization, immediate amenorrhea does not always follow, having been observed in only a small number of cases. Frequently menstrual hemorrhages appeared once, more often twice, and, in certain cases three times before they were suppressed. In this regard, the results do not differ essentially from those obtained by the administration of repeated and smaller doses.

3. The menopause obtained at a single sitting is not always permanent. The return of menstrual hemorrhages, after they have ceased for a longer or shorter period of time, is not of rare occurrence. In these recurrences, as seen among patients treated with the same dose, age is an important factor. Thus Frederic Winter, of the University of Munich, who performs ovarian sterilization at a single sitting with a dose, which, it is true, is smaller than that employed by Seitz and Wintz, has observed no recurrences in women beyond the age of fifty-one, but he has seen recurrences in 10 per cent of cases between forty-one and fifty, and in 30 per cent of cases between thirty-one and forty years of age.

To sum up: viewed from the standpoint of the therapeutic action, in the proper sense of the term, ovarian sterilization at one sitting does not produce results superior to those that, with our improved modern instruments, we obtain today from several sittings. The advantages are, as a matter of fact, not of a medical but of an economic nature. The fact that they have to be absent from home only once, means a considerable saving of time and money for patients who live far away from the city where they are to be treated. The public clinics with a limited number of beds, where congregate a large number of less opulent patients, are interested in keeping these patients in the hospital as short a time as possible. But we must consider the price at which these advantages are bought.

Experienced radiotherapists observed long ago that the suppression of the menstrual function is easier in a woman of forty than in younger females. Nevertheless, Kroenig and Friedrich, and then Seitz and Wintz, from the very first, have maintained that the castration dose is the same for all women, regardless of age. But today, from the most exact examinations, we know beyond the shadow of a doubt that the dose varies, not only with the age as reckoned from the date of birth, but also according to more mysterious factors, by virtue of which a woman of forty-five years of age may appear and really *be* younger than another woman who was born only thirty-five years ago. As a matter of fact, before we have treated a woman, we can never know the exact degree of the "radio-sensibility" of her ovaries.

Sterilization at one sitting requires that every woman coming under treatment receive uniformly the maximum quantity of the "castration dose," which varies within such wide limits that often the minimum, or at most a medium quantity, would be quite sufficient for bringing about a cure.

Moreover, we would attach little importance to the administration of a dose which exceeds that strictly necessary for effecting a cure, if the maximum dose given at one sitting were exempt from causing any untoward effects. But this is not the case. The majority of patients subjected to this treatment experience a more or less pronounced form of indisposition which the Germans designate as "Roentgenkater" and for which I have proposed the designation "mal des irradiations penetrantes" (the penetrating-irradiations sickness).

Moench, of the University of Tuebingen, describes this trouble as follows: In the majority of cases, intense headache; coated tongue; nausea and vomiting; often long-continued anorexia; sometimes articular pains; slight and temporary elevations of temperature. Moench also asserts that in quite a number of his patients he has observed intestinal troubles, diarrhea, colic, meteorism and painful tension of the abdomen; some suffered from such a severe and prolonged diarrhea that they were obliged to interrupt their regular work for two weeks. In most of the articles dealing with the subject of sterilization at one sitting these troubles are passed over in silence, or only briefly mentioned as though they were of no importance. They nevertheless do occur, and to me they seem not to be negligible. I observed their commencement in several of my patients every time I tried to exceed my usual moderate doses, and on the appearance of these troubles I always desisted from my attempts.

If we compare the employment of the maximum dose at one sitting with that of smaller doses given in weekly sittings, we see the great advantage of the latter in not producing any functional troubles, or only those of such slight degree that the patients are not obliged to alter their mode of living, or to give up their usual work. An additional advantage in the weekly sittings is in the fact that their employment does not produce any inflammatory reaction of the integument of women whose skin, like their ovaries, presents a variable "radio-sensibility." On the appearance of the slightest redness or itching, all that is necessary is to postpone the intended sitting for at least a week.

The chief advantage of the method consists in the direct action of the weekly irradiations upon the myomata—if we admit at all that this is the principal object of the treatment. Since the diminution in the size of the irradiated myomata shows itself at the beginning of the treatment and becomes more manifest from week to week, the retrogression undoubtedly commences with the most superficially situated neoplastic elements, which are bound to receive the most powerful dose. Thanks to the method of weekly sittings, each new irradiation—even if the portals of entry for the irradiations are not modified—will never encounter the same zones nor the same thickness of the myomatous tissue. Thus these repeated sittings offer a better assurance of the progressive destruction of the neoplastic tissues than we could expect from a single sitting. We also can feel more certain of the total destruction of the ovarian follicles, the "radio-sensibility" of which varies according to the different stages of their evolution.

The method of weekly sittings presents still other advantages. It enables the radiotherapist, during the entire course of treatment, from its beginning to the incipience of the menopause, whether preceded by one, two or even three appearances of the menses, to make repeated examinations, and to devote his constant attention to the patients entrusted to his care. He can advise them as to the rest they need, or administer the injections and remedies appropriate to their condition. To those who are alarmed by the slightest untoward incident, or the slightest disturbing malaise, he gives reassuring explanations and comforting advice. This psychic and moral part of the task is by no means the least important.

Thus the treatment may be continued till the suppression of the menses and the appearance of the hot flushes, or also beyond this stage, when the patient's age causes the apprehension of the possibility of a recurrence, or if the condition of the myoma makes the prolongation of the treatment advisable.

The task of the radiotherapist is even not ended with the supposedly last irradiation. He has to reckon with the possibility of a reawakening of the ovarian function which is heralded by the premature disappearance of the hot flushes, suggesting the possibility of a renewal growth of the myomata. He also should take into account, even after the permanent suppression of the menses, the occurrence of metrorrhagias which, though always slight, call, just as does the renewed growth of the myomata, for a resumption of the irradiations. It is, therefore, of importance that the radiotherapist impart to his patients suitable information and keep them under his observation for a certain period of time.

Each sitting, according to the size of the tumor, requires usually ten minutes, or, in rare instances, twenty minutes. The total duration of the irradiations sometimes does not exceed one and a half hours, most frequently it varies between two and three hours, and in exceptional cases it may exceed four hours. Attention must be called to the fact that these indications refer to patients treated with the old-fashioned instruments and with only a moderately penetrating irradiation, corresponding to a spark which is equivalent to 23 cm. With a modern equivalent the total duration of the irradiation is certainly shortened. Thus the treatment with small doses given in short intervals yields the same therapeutic results as the "one-sitting" method of sterilization, if the former is not superior to the latter, and I believe it is, taking into consideration the retrogression of the myomata and the prevention of recurrences. Moreover, the desired end is attained without exceeding the sufficient dose, which is often quite small, and does not expose the patients to the disagreeable "irradiation malaise." In other regards the method may still be improved.

In conclusion I want to state that each of these two methods has its advantages and its drawbacks and that each fits different requirements.

The choice of the one-sitting method is most frequently influenced by reasons other than medical, namely, the consideration of saving time and money. It is not chosen for a truly medical reason, as, for instance, in cases of extreme anemia where the prevention of a new loss of blood is of the utmost importance; in fact, in cases of this kind one can never be certain of obtaining an immediate amenorrhea. For the large majority of cases of uterine fibromyomata I would prefer the treatment with small doses given at short intervals.

In my opinion, this conclusion may be generalized and applied to all departments of the vast domain of roentgenotherapy. The judicious employment of a pliable method which can be adapted to the exigencies of each particular case is always preferable to the blind acceptance of a uniform formula; but after all, we must insist that the radiotherapist be not only an able technician, but also an excellent clinician.

PROTECTION IN RADIOLOGY*

BY GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

IT is always an honor to be chosen as leader by one's colleagues. This honor is greater when each of the members is a leader in his own community, and many are world-wide known and distinguished, and many have national or international reputations. This honor is augmented by the record of the distinguished presidents who have preceded me. I was surprised when I received the announcement, and have been overwhelmed by the feeling of gratitude, by the sense of unworthiness, and by the weight of responsibility, which always goes with such great honors. There are others among us who are more deserving, but for some reason you have decided to hold them in reserve for future service. I can, therefore, only express to you my thanks. Fortunately, all the officers and committees have been most loyal, and have performed their duties in a manner that will reflect credit, not only upon themselves, but upon the society. The program committee has arranged a series of scientific papers by men, each one of whom is recognized as an authority upon the subject of his discussion; and no radiologist can afford to miss these papers.

There have been too many martyrs to the science of radiology. The loss of each one of these has produced a gap in the rank of leaders, and has delayed progress. There are still among us many who are being damaged physically, and who are being interfered with financially. It has seemed to me, therefore, that "Protection in Radiology" would be one of the most important subjects for our consideration.

PHYSICAL PROTECTION TO THE RADIOLOGIST

The radiologists who began work in the early days of roentgenology were practically all more or less damaged by the radiation. Nearly all have suffered more or less, from some skin degeneration. Some have practically recovered; some are still suffering from these effects; and others have given their lives as a result of earnest enthusiasm, in developing this new science. We have gradually developed means of protection against such radiation as has been used in the past. This does not mean that these past radiations have been modified, or made more safe, but it means, distinctly, that knowledge is at hand, which if used, affords protection to both radiologist and patient.

Radiations have, however, become more and more powerful, and more and more damaging in their effects; and unless proper protection is provided, more serious results will follow than have ever been recorded. This is especially true since the gamma rays of radium and the high voltage roentgen rays have come into the field. These rays produce their effects without noise, without sensation, and without visualization. They act constantly and insidiously, and unless they are guarded against, harmful results will follow. Because the roentgen rays have been more than doubled in their power within the recent years, their dangers are also more than doubled. It is therefore, clearly our duty to provide every protection possible, to be over-cautious, and to use more protection than is actually necessary, rather than repeat the experiences of the past. The early radiologist suffered, not only because there was no recognizable need of protection, but also because there was not even a rudimentary knowledge of the means of protection.

Radium and the roentgen rays are so closely associated in practice, that it is impossible to consider one without the other, even though we are meeting for the special consideration of radium and its usage. During the past year I have been trying to collect data from about 1,500 radiologists throughout the country, with

* Presidential Address. Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

NOTE.—The attention of the reader is called to Dr. Pfahler's article in the October JOURNAL, containing a questionnaire which was widely circulated among workers in radiology.

the object of eliminating unnecessary dangers, and providing more efficient protection for our operators. The replies are gradually being accumulated, but they have not all been returned, and I have not yet had the time to make the proper analysis. I can, however, say that those who are working with radium and with the more deeply penetrating rays are receiving more radiation on their bodies than are the others; which would indicate in a general way that this group of workers must find added protection. We have demonstrated that these rays will pass through $\frac{1}{4}$ in. of lead at 18 in. distance from the target.

The most definite step toward organized protection in radiology has been the appointment of the X-Ray and Radium Protection Committee in England. This committee, up to the present time, has made two reports.* There was also appointed a "Safety Committee," by the American Roentgen Ray Society, at its annual meeting at Minneapolis, September, 1920. The late Professor John S. Shearer, Cornell University, Ithaca, N. Y., was chairman. His loss will be felt by many to whom he was a personal friend, but his death leaves a gap in radiology which cannot be filled, and the work of this important committee will be delayed. No matter what the authority of the committee, iron-clad rules cannot be laid down. The principles of protection must be given, and general guides or suggestions established, but the individual institution and the individual workers must make their application according to the circumstances, in each instance. The number of working hours to be permitted, and the duration and time of vacation must be determined by the actual amount of work done, and the amount of actual exposure to the radiation. In some laboratories, more strenuous work and more actual exposure is obtained in five hours than in other laboratories where the work is only casual and less strenuous, even though ten hours are passed in the laboratory.

* 1. Preliminary Report of the X Ray and Radium Protection Committee. *Arch. Radiol. & Electroth.*, June 1921. 2. X-ray and Radium Protection Committee. Chairman, Sir Humphrey Rolleston, Care of Royal Society of Medicine, Wimpole Street, London.

The following general recommendations have been made by the Protection Committee of England.

GENERAL RECOMMENDATIONS

It is the duty of those in charge of x-ray and radium departments to ensure efficient protection and suitable working conditions for the personnel.

The following precautions are recommended:

1. Not more than seven working hours a day.
2. Sundays and two half-days off duty each week, to be spent as much as possible out of doors.
3. An annual holiday of one month of two separate fortnights.

Sisters and nurses, employed as whole-time workers in x-ray and radium departments, should not be called upon for any other hospital service.

PROTECTIVE MEASURES

It cannot be insisted upon too strongly that a primary precaution in all x-ray work is to surround the x-ray bulb itself as completely as possible with adequate protective material, except for an aperture as small as possible for the work in hand.

The protective measures recommended are dealt with under the following sections:

I. X-Rays for diagnostic purposes.
II. X-Rays for superficial therapy.
III. X-Rays for deep therapy.
IV. X-Rays for industrial and research purposes.
V. Electrical precautions in X-Ray Departments.
VI. Ventilation of X-Ray Departments.
VII. Radium therapy.

It must be clearly understood that the protective measures recommended for these various purposes are not necessarily interchangeable; for instance, to use for deep therapy the protection intended for superficial therapy would probably subject the worker to serious injury.

I. X-RAYS FOR DIAGNOSTIC PURPOSES

1. SCREEN EXAMINATION

(*a*) The X-ray bulb so to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead. The material of the diaphragm to be equivalent to not less than 2 mm. of lead.

(*b*) The fluorescent screen to be fitted with lead glass equivalent to not less than 1 mm. of lead, and to be large enough to cover the area irradiated when the diaphragm is opened to its widest. (Practical difficulties militate at present against the recommendation of a greater degree of protection.)

(*c*) A travelling protective screen, of material equivalent to not less than 2 mm. of lead, should be employed between the operator and the x-ray box.

(*d*) Protective gloves to be of lead rubber (or the like) equivalent to not less than $\frac{1}{2}$ mm. of lead, and to be lined with leather or other suitable material. (As practical difficulties militate at present against the recommendation of a greater degree of protection, all manipulations during screen examination should be reduced to a minimum.)

(*e*) A minimum output of radiation should be used with the bulb as far from the screen as is consistent with the efficiency of the work in hand. Screen work to be as expeditious as possible.

2. RADIOGRAPHIC EXAMINATION ("overhead" equipment)

(a) The x-ray to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead.
(b) The operator to stand behind a protective screen of material equivalent to not less than 2 mm. of lead.

II. X-RAYS FOR SUPERFICIAL THERAPY

It is difficult to define the line of demarcation between superficial and deep therapy.

For this reason it is recommended that, in the reorganization of existing, or the equipment of new, x-ray departments, small cubicles should not be adopted, but that the precautionary measures suggested for deep therapy should be followed.

The definition of superficial therapy is considered to cover sets of apparatus giving a maximum of 100,000 volts (15 cm. spark gap between points; 5 cm. spark gap between spheres of diameter).

CUBICLE SYSTEM

Where the cubicle system is already in existence it is recommended that:

(a) The cubicle should be well lighted and ventilated, preferably provided with an exhaust electric fan in an outside wall or ventilation shaft. The controls of the x-ray apparatus to be outside the cubicle.
(b) The walls of the cubicle to be of material equivalent to not less than 2 mm. of lead. Windows to be of lead glass of equivalent thickness.
(c) The x-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead.

III. X-RAYS FOR DEEP THERAPY

This section refers to sets of apparatus giving voltages above 100,000.

(a) Small cubicles are not recommended.
(b) A large, lofty, well ventilated and lighted room to be provided.
(c) The x-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 3 mm. of lead.
(d) A separate enclosure to be provided for the operator, situated as far as possible from the x-ray bulb. All controls to be within this enclosure, the walls and windows of which to be of material equivalent to not less than 3 mm. of lead.

IV. X-RAYS FOR INDUSTRIAL AND RESEARCH PURPOSES

The preceding recommendations for voltages above and below 100,000 will probably apply to the majority of conditions under which x-rays are used for industrial and research purposes.

V. ELECTRICAL PRECAUTIONS IN X-RAY DEPARTMENTS

The following recommendations are made:

(a) Wooden, cork, or rubber floors should be provided; existing concrete floors should be covered with one of the above materials.
(b) Stout metal tubes or rods should, wherever possible, be used instead of wires for conductors. Thickly insulated wire is preferable to bare wire. Slack or looped wires are to be avoided.
(c) All metal parts of the apparatus and room to be efficiently earthed.
(d) All main and supply switches should be very distinctly indicated. Wherever possible, double-pole switches should be used in preference to single-pole. Fuses no heavier than necessary for the purpose in hand should be used. Unemployed leads to the high tension generator should not be permitted.

VI. VENTILATION OF X-RAY DEPARTMENTS

(a) It is strongly recommended that the x-ray department should not be below the ground level.
(b) The importance of adequate ventilation in both operating and dark rooms is supreme. Artificial ventilation is recommended in most cases. With very high potentials coronal discharges are difficult to avoid, and these produce ozone and nitrous fumes, both of which are prejudicial to the operator. Dark rooms should be capable of being readily opened up to sunshine and fresh air when not in use. The walls and ceilings of dark rooms are best painted some more cheerful hue than black.

VII. RADIUM THERAPY

The following protective measures are recommended for the handling of quantities of radium up to one gram:

(a) In order to avoid injury to the fingers, the radium, whether in the form of applicators of radium salt, or in the form of emanation tubes, should always be manipulated with forceps or similar instruments, and it should be carried from place to place in long-handled boxes lined on all sides with 1 cm. of lead.
(b) In order to avoid the penetrating rays of radium all manipulations should be carried out as rapidly as possible, and the operator should not remain in the vicinity of radium for longer than is necessary.

The radium when not in use should be stored in an enclosure, the wall thickness of which should be equivalent to not less than 8 cm. of lead.

(c) The handling of emanation should, as far as possible, be carried out during its relatively inactive state. In manipulations where emanation is likely to come into direct contact with the fingers, thin rubber gloves should be worn. The escape of emanation should be very carefully guarded against and the room in which it is prepared should be provided with an exhaust electric fan.

With the object of increasing progress toward the protection of radiologists, I would recommend that the American Radium Society appoint a committee, known as the Committee for Protection in Radiology, which can with advantage cooperate with the Safety Committee appointed by the American Roentgen Ray Society; and together they may be able to formulate certain problems which can be worked out by the Bureau of Standards at Washington, D. C. The Bureau of Standards has already rendered us a great and indispensable service, by making definite measurements of the radium specimens which we purchase, thereby providing a standard product with which to work.

It would seem to me that protective devices could be standardized in the same manner, by the same bureau. The opaque rubber, rubber gloves, rubber aprons, and rubber protective material used to cover patients should be standardized, and we should know the equivalent value of lead in protective power. The insulating value of this same rubber material could also be examined by the Bureau of Standards, realizing, of course, that this insulating value will change with the deterioration of age. The lead glass used for protection could be tested as to its protective value and its insulating value. Each particular specimen would not need to be tested, but instead, the product as supplied from the manufacturer could be tested from time to time, and a requirement made that the specifications be complied with.

It should likewise be possible to obtain the services of this same Bureau of Standards to send a representative to the various laboratories, especially those engaged in deep therapy, to measure and calibrate the output of the various machines. It should be practical to calibrate each type of machine in a factory and not necessarily calibrate each duplication. Either the same officer or an equivalent officer should be able to pass judgment and make recommendations with regard to the electrical equipment and its safety, both to the operator and the patient.

PROTECTION TO THE PATIENT

1. This form of protection is provided for by preventing any possible escape of electricity to the patient with the use of the roentgen rays. When using the deep therapy machines, it would seem desirable to have them so equipped that the patient would be able to touch any part of the outfit without obtaining any shock or current. This can be provided for by having a grounded screen or grounded encasement between the electrical conductors and the patient.

2. The patient must be protected against any stray or unintentional radiation.

3. Some safety device or arrangement should be provided, so that at no time can the filters be omitted or a lesser quantity of filtration used than is intended. Other forms of protection to the patient, as far as injury or discomfort is concerned, will vary according to the clinical conditions and the treatment necessary.

PROTECTION AGAINST LOSS OF RADIUM

This subject has become a serious one during the past year, because of the frequent loss of radium, usually as the result of some one's carelessness. This has caused the rates of insurance, as furnished by Lloyd's in London, to rise from 2 to 5 per cent. This unjustly penalizes the careful radiologists, who are compelled to bear the expense of those who are careless or indifferent, because they are carrying full insurance.

With the thought of forming a mutual protective organization, consisting especially of the members of the American Radium Society, or others who are careful and responsible, inquiries were sent to the members by your president. This idea received an enthusiastic response from nearly all. A few, however, stated that they were unwilling to enter any mutual insurance company, and especially one managed by physicians. I therefore, enlisted the cooperation of the radium producers, and we are indebted to them, in great part, for the results which have been accomplished. I would especially mention The United States Radium Corporation of New York, The Colorado Radium Chemical Company, and the Pittsburgh Radium Chemical Company. Nearly all the radium owners have expressed the willingness to bear part of their own risk. This had been my recommendation because I believe it would tend to eliminate carelessness; for when the owner is willing to take at least one-fourth of the total risk, in the case of loss of radium, he will at no time avoid taking proper steps and practical precautions, and I believe the losses under such management will be very small. As a result of our efforts we have been able to obtain from the Insurance Company of North America, a policy, which, I believe, is the best yet offered to the society. This, briefly, consists in furnishing insurance at 2 per cent, providing the owner will bear 25 per cent of any particular loss. I have had this policy reviewed by eminent authority and we believe that it contains no flaws, and is fair in every respect. Since the above announcement, the Pennsylvania Fire Insurance Company have announced a similar policy with same conditions. By this process of insurance all objectionable clauses should be eliminated and I am sure that the owner can well afford to take his risk for the money saved.

LEGAL PROTECTION

There is no branch of medicine in which protection of this character is needed more than in the field of radiology. The science is comparatively new, and enthusiastic recruits have entered the field. Many of the effects are mysterious in their character, that is, the rays produce no immediate effect, and there is no sensation. Frequently the patient sees nothing and hears nothing; and because of the mystery to the layman, and frequently because of the mystery to the general practitioner, any symptom or unusual development that occurs to a patient who is under treatment is apt to be ascribed to the treatment, or its effects. It should be borne in mind that all the ailments of the human body which can occur independently of radiation treatment or examination, may also occur conjointly in connection with such treatment. This basic fact is forgotten too often. If every radiologist in the country will do his part toward helping to educate the general public to the idea that other causes should be searched for in a case of unusual symptoms, there will be less annoyance by complaints, and patients will get relief from symptoms which are at present not relieved by the mere explanation, "They are due to the rays."

Protection against unjust claims on account of these developments should be provided for by every radiologist, in making use of the insurance companies organized for this purpose; but best of all, every radiologist should keep in close touch with his colleagues in his county medical society and depend more upon them for loyal support than upon anything else. The loyal support from our colleagues is of more value than the monetary and legal support furnished by insurance companies. Of equal value is the protection provided by membership and association in the organized radiological body. This is useful in establishing educational standards, which act automatically in teaching the various members what is expected of them and what is expected for their patients. Association with colleagues in these societies enables one at least to become acquainted with others and develop personal confidence and respect, and will enable each and every one to assume that proper procedures have been followed, until there is definite proof to the contrary.

Unfortunately, if many accidents occur, the time will come when the insurance companies will refuse to issue policies to those engaged in radiology. At present there is no means of separating the inexperienced and careless from the experienced and careful ones. No standard of requirements is today in existence. To meet these conditions, and to raise the general standard of radiology, for the protection of our specialty against ill reputation, and to protect the general public, I recommend the appointment of a committee to consider the advisability of the formation of a National Examining Board for radiologists for the purpose of examining applicants to determine their efficiency, and to issue certificates in roentgen diagnosis, roentgenotherapy, and radium therapy to physicians, and certificates to technicians who are to work under the direction of physicians.

In conclusion, therefore, I would recommend (1) that the principles of radiology be thoroughly mastered, so that they can be adapted to the individual establishment, for the protection of both the operator and the patient.

(2) That a committee of this society be appointed to cooperate with other similar bodies of national organization, to study and formulate definite directions and rules of protection.

(3) That these committees cooperate so far as possible with the Bureau of Standards at Washington, in order to secure definite and permanent products, and possibly definite calibration of our outfits.

(4) I would recommend that radium be insured against loss, so that men will not

be suddenly hampered financially and be prevented from carrying on the good work which has been started.

(5) I would recommend that every radiologist be provided with legal protection, with protection from insurance companies and the protection and cooperation of his county medical society.

(6) That every radiologist in the country associate himself with the American Radium Society, both for his and our good.

THE TREATMENT OF CANCER OF THE PELVIC ORGANS WITH MODERATE IRRADIATION*

BY JOHN G. CLARK, M.D., AND FLOYD E. KEENE, M.D.

PHILADELPHIA, PENNSYLVANIA

IN our paper of last year, presented before the American Medical Association, (*J. Am. M. Assn.*, 1921, lxxvii, 613) we dwelt comprehensively upon every phase of our experience in irradiation therapeutics of carcinoma of the pelvic organs. The further results of this treatment which we now report are but an extension of that series, which then comprised 313 cases, but has now reached 412, leaving a sufficient number of survivors who have passed over the five-year period to give us an approximate estimate as to what we may anticipate from the application of the smaller quantities of radium, (100 mgm.) which we have routinely employed. Set forth on a percentage basis, we may state in the following sentence what our records reveal. Of the patients treated over four years ago for inoperable carcinoma of the pelvic organs, there are 163 dead, 45 living, and 7 not traced, giving a percentage of 20.9 living; of those treated over five years ago, there are 125 dead, 4 not traced, and 31 living: a percentage of 19 plus still surviving and free from manifest evidences of the disease. However, one should qualify these figures by the statement that a five-year period does not necessarily place the patient within a zone of absolute safety, for a very small percentage of those now living may still succumb; but this observation has been identical with our surgical experience. With irradiation, just as with surgery, cancer of the cervix yields the poorest results, and our percentage, as we now estimate it, of this class of cases which are now approaching, or are beyond the quinquennial limit, will be approximately 16 to 18. We venture the hope, however, that our present method of treatment, which has fully been described in our previous paper, may yield a better ratio of cures. Upon this point, however, we venture no positive assertion, for this whole question has been quite too freely dealt with in high percentages of fanciful hopes on one hand, or crass pessimism on the other.

It is, however, a very great satisfaction to realize that of our 412 patients, the vast majority of whom were in the advanced stages of this disease, quite beyond the possibilities of surgical intervention, a large number have had their symptoms mitigated, or completely held in abeyance for a time; the frightful hemorrhages have been stayed for variable periods, and frequently absolutely stopped. In a lesser percentage, pain, when present at the time of treatment, has been actually relieved. This temporary relief of symptoms has been a splendid and an inestimable boon to many of these wretched individuals, even though the checking of the growth may have been but temporary. However, transcending this beneficent value of the remedy in the partial relief of symptoms, stands the incontrovertible fact that a larger number have actually been cured as reckoned on a five-year basis than we had forecasted. In the earlier years of our experience, we dwelt only upon the palliative aspects of this treatment, but last year our report proved that a sufficient number of patients were well after five years

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

to make it an assured fact that even among the inoperable patients occasional cures may be effected. At that time, we hazarded the assertion that cancer of the cervix might finally be transferred from the surgical clinic to this new field of therapeutic endeavor. As yet, however, we are not in a position to clinch this tentative forecast by unassailable statistics, and for this reason we do not advise the abandonment of a modified radical hysterectomy in cancer of the cervix in the clearly operable cases, if the surgeon is really skilled in this very difficult and hazardous operation. Surgery certainly maintains its place, for it has justified its position as a life-saving measure in the hands of the thoroughly trained devotee, by saving a large number of cases in the clearly operable type. Yet, after all that has been done to warn the laity of the dangers of cancer and the necessity for early intervention, the number of those to whom surgery can offer no hope is tragically large. It is to this class that we have devoted our attention.

Our list of cases of cancer of the pelvic organs comprises the following: Cancer of the Cervix, 291; Cancer of the Fundus, 41; Chorio-epithelioma of the vagina and uterus, 4; Cancer of the Cervical Stump, 11; Recurrent Cancer of the Vagina after hysterectomy, 22; Cancer of the Vagina (primary), 29; Cancer of the Urethra, 8; and Cancer of the Bladder, 6. In this list cancer of the cervix overshadows by far the combined aggregate of all other types of cancer of the pelvic organs which we have treated, and, as considered individually, shows the worst results so far as our experience goes. The cases of cancer of the fundus were, with possibly three or four exceptions, all inoperable, as judged clinically, and yet they demonstrate, in comparison with cancer of the cervix, that same favorable difference as exhibited in the surgical results in the same localities. While we always follow our rule in cancer of the cervix to withhold operation and to advise irradiation if the growth is of questionable operability, we still urgently maintain that in the same questionable situation, cancer of the fundus unqualifiedly demands a hysterectomy, unless there is some grave systemic contraindication to this procedure. There is ample ground for surgical optimism in advanced cases of carcinoma of the fundus, and we, therefore, hold fast to this assured method of attack. Were it possible to attain comparable results in cancer of the cervix by even a very radical hysterectomy, we could be classed as ultra-conservative so far as this newer treatment is concerned; but only the surgical enthusiast, who possibly scans his one-year results more fully than the small train of survivors who pass over the five-year line, can maintain his optimism when he compares the vast outlay of surgical energy expended with the paucity of results, even in a discriminately chosen series of cases. Of the various organs invaded by malignant growths there are but few that show worse results from operations than the cervix, or better than the fundus. We emphasize this point before this representative body of radiologists, for this class of specialists, of all others, should always keep in the foreground the excellent salvage which surgery has yielded in properly selected cases of cancer in all parts of the body. These two plans of treatment, therefore, must not be brought into conflict if the therapeutic effects of irradiation are to find worthy credence in our fight against cancer. With all available plans of treatment that we now have, we are but marking time, or, as it were, at best have "dug in," in our fight against cancer; for, up to the present, the most enthusiastic radiologist may not justifiably claim any startling advantage over surgery, except in limited localities. A big advance in the treatment of cancer, therefore, must come through some absolutely new method of attack, which is as yet undiscovered. As matters now stand, however, irradiation has unqualifiedly won its right to a place along with surgical means, for it has stepped into the inoperable breach with hopeful assurance of a large alleviation of suffering and a minimum probability of cure.

In the following tables we have recorded our results as verified by a careful follow-up system, which comprises all cases treated up to May, 1922:

Table I

CANCER OF PELVIC ORGANS TREATED BY IRRADIATION

	Living	*Dead*	*Not Traced*
Carcinoma of cervix...........	56	217	18
Carcinoma of fundus..........	21	17	3
Chorio-epithelioma of vagina and uterus..................	4	..	..
Carcinoma of cervical stump...	7	4	..
Recurrent carcinoma of vagina after hysterectomy..........	6	16	..
Epithelioma of vagina.........	10	17	2
Carcinoma of urethra..........	1	6	1
Carcinoma of bladder..........	2	4	..
	107	281	24

followed, so likewise we also note that postradial vesical irritability and rectal tenesmus and proctitis have largely been eliminated, as only a very few of this series have complained of these symptoms. The relief from hemorrhages and various discharges still stands in the same favorable ratio as set forth in our paper of last year. For full details bearing upon our methods of applying radium, we refer the reader to this same source. While, as we have constantly maintained, the treatment of cancer by irradiation falls far short of the ideals toward which the whole medical world so hopefully strives, nevertheless, it holds out the possibility of a cure for at least a few inoperable patients, and a vast alleviation of distressing symptoms and sequelae for those who must inevitably pass into the shades. Certainly, with such relief and actual cures, even though of a relatively small number, there can be no ground for the unfortunate expressions of pessimism which have been uttered by the occasional malcontent.

Table II

SUMMARY OF LIVING CASES AFTER IRRADIATION

	Under 1 yr.	1 to 1½ yrs.	1½ to 2 yrs.	2 to 2½ yrs.	3 to 4 yrs.	4 to 5 yrs.	5 to 6 yrs.	6 to 7 yrs.	Not Traced	Total
Carcinoma of cervix...........	8	7	6	5	7	8	6	9	18	74
Carcinoma of fundus...........	5	5	2	4	1	3	0	1	3	24
Carcinoma of cervical stump.....	1	..	1	2	2	1	..	..	..	–
Chorio-epithelioma of vagina and cervix......................	..	..	..	1	..	1	..	2	..	4
Recurrent carcinoma of vagina after hysterectomy...........	2	..	..	.	1	1	1	1	..	6
Epithelioma of vagina..........	2	1	..	4	.	..	2	1	2	12
Carcinoma of urethra...........	..	..	..	..	..		..	1	1	2
Carcinoma of bladder...........	..	..	..	..	1	..	1	..	..	2

Table III

SUMMARY OF DEATHS AND DURATION OF LIFE AFTER IRRADIATION

	Under 1 yr.	1 to 1½ yrs.	1½ to 2 yrs.	2 to 2½ yrs.	2½ to 3 yrs.	3 to 4 yrs.	4 to 5 yrs.	5 to 6 yrs.	6 to 7 yrs.	Not Stated	Total
Carcinoma of cervix	118	35	10	15	9	7	3	1	1	9	217
Carcinoma of fundus	10	1	1	2	0	0	.		..	3	17
Carcinoma of cervical stump...	1	2	..	..	..	..		1	..	..	4
Chorio-epithelioma	..	..	..	..	..	..			.	..	0
Recurrent carcinoma of vagina after hysterectomy.........	12	4	..	..	.	..			..	..	16
Epithelioma of vagina.........	9	5	1	1	1	..	..	..	.	..	17
Carcinoma of urethra..........	2	4	..	..	..	..	..	..	..	..	6
Carcinoma of bladder..........	2	2	..	..	..	..	..	..	..	..	4

Since the adoption of our improved method of application, we have anticipated that vesical and rectal fistulae as a result of irradiation would be of much less frequent occurrence, and we are happy to state that this forecast has been realized, for since August 1, 1920, this distressing sequel has occurred but once. We therefore, maintain more strongly than in our previous papers that irradiation, when properly applied, actually shields the cancer victim against this ugly accident. For the same reason that fistulae have not

We submit our conclusions of last year, with slight modifications, as those to which we now adhere. However, this question in all its phases is still in flux, and we realize that our experience does not as yet justify us in making any fixed or unchangeable assertion, for we are but seekers for some better solution of this problem so destructive to the human race.

CONCLUSIONS

1. Radium in 100 mgm. amounts will yield most gratifying results if properly applied.

2. To pursue a set course without variation in the frequency of treatments, regardless of the progress of the healing, is hazardous.

3. To attain the best results, the first application should be done under nitrous oxid anesthesia, because a more careful examination may be made, and the radium can more advantageously be brought in contact with the malignant areas, either through radium tubes or by radium needles. Gauze packing instead of metal shields has proved of much greater value for protective purposes.

4. The process of cure passes through three stages: local destruction, connective tissue formation, and hyalinization.

5. A hysterectomy after successful irradiation of an otherwise inoperable case is hazardous and does not promote the best interests of the patient.

6. Results of irradiation in cancer of the cervix may remove this class of cases from the surgical field, although we have not yet completely yielded this point.

7. Cases of cancer of the fundus, unless too far advanced, or unless there is a critical surgical contraindication, should be submitted to hysterectomy, followed, from fourteen to twenty-one days later, by a light irradiation of the vaginal fornix.

8. Irradiation is dangerous immediately before or after an operation, or when employed in fresh operative fields.

9. Frequent repetitions of irradiation are probably unnecessary and possibly hazardous, as our observations point to the fact that the chief blow is struck at the first application. In no case that has required three successive treatments has there been a recovery.

10. The frequency of irradiation fistulae may be reduced to a minimum or almost completely avoided by the application of a well-placed vaginal pack, which pushes the healthy tissues away from the zone of intensive radiation.

STATISTICS AND TECHNIQUE IN THE TREATMENT OF FIBROMYOMA OF THE UTERUS BY RADIOTHERAPY*

BY JAMES A. CORSCADEN, M.D.

Attending Surgeon, Sloane Hospital for Women. From the Department of Obstetrics and Gynecology Columbia University

NEW YORK CITY

THE object of this study is to present an outline of the procedures employed in treating fibromyoma of the uterus and hemorrhage from other benign causes, to present a series of statistics giving the effects of the treatment on the symptoms and lesions, and more especially to study any late symptoms which might be ascribed to the methods used. There is much material available concerning the effect of radiotherapy on uterine hemorrhage and on the size of myoma, but not a great amount of accurate information concerning the artificial menopause and other late manifestations attributed to it.

The present information is derived from 250 cases, of which 203 were treated between June, 1914, and July 1, 1922. From the latter the statistical tables were compiled. The follow-up system at the Presbyterian Hospital requires that the operator examine his own cases in the follow-up clinic. Accordingly, about 80 per cent have been personally examined. One case has been completely lost. The remainder have given information through the social service or by correspondence.

Technique will be discussed from the broader standpoint. The application of radium or roentgen rays is simple compared with the problem of deciding on the proper treatment, preparing the patient for operation, and caring for her afterward. We have become convinced that in these benign conditions one individual or organization should care for the patient, and be prepared to carry out the proper treatment from start to finish, whether medical, operative or radiotherapeutic. Often the final decision must be left until the examination under anesthesia and diagnostic curettage. We have had two cases of dermoid cyst treated by roentgen rays for long periods, during which the error in diagnosis, possibly justifiable in the first instance, should have been corrected. One fibromyoma with associated adenocarcinoma was treated for two years without a diagnostic curettage. Operation in the first place would probably have cured it.

One phase of the preparation of the patient is not usually brought out, and that is the mental preparation for the menopause. This is emphasized because of the many misconceptions concerning the actual nature of this state and the more or less severe stress put on the patient by her sensations and her knowledge and by the love of the average individual for discussion of sexual matters.

The menopause has certain symptoms, and, in unfortunate individuals who have inherited a "neurotic constitution," others may follow. By recognition of the possibilities and proper handling of the patient, these can be avoided, for the most part.

The following is an outline of our procedure:

I. The most careful history and physical examination.

II. Preparation of the patient for all procedures (hysterectomy, radiotherapy).
   - A. General: rest in bed, transfusion, salvarsan, etc.
   - B. Psychotherapeutic: instruction of the patient in the nature of menstruation, the menopause, and the symptoms to be expected; outline of what she may expect in the way of predictions and observations from friends, lay and medical; instruction as to her reactions toward these.

* Read at the Seventh Annual Meeting of The American Radium Society, St. Louis, Mo., May 22-23, 1922.

III. In the operating room, which is prepared for all procedures.
   A. Examination under anesthesia, including diagnostic curettage.
   B. Final diagnosis and decision:
      1. Some form of excision is performed if the patient is a good surgical risk; if she is under thirty-eight years of age; if the mass is over 15 cm. in diameter; if the diagnosis is obscure (especially if ovarian tumor is probable); if there is evidence of degeneration or inflammation in the growth; if there are submucous pedunculated myomata; if the pain or urinary symptoms are the important factors.
      2. Radium is used if the woman is over thirty-eight years of age and bleeding is the important symptom; in younger women with definite myoma where operation is contraindicated; and in young women without myoma suffering from uterine bleeding associated with tuberculosis or other serious disease, where subsequent pregnancy would not be advisable.
      3. Dilatation and curettage, followed, if necessary, by roentgen rays, are employed in young women where it is desired to cause a temporary menopause or merely lessening of the flow. Even moderate doses of radium in the uterus cause sclerotic changes which predispose to dystocia. Roentgen rays are therefore preferable.

Radium is given in doses of about 1,200 to 1,500 mgm. hrs. in women of forty years or more, with the uterus and ovaries in normal relationship. This is increased if the bleeding is thought to be due to ulceration, if the tumor is of such size as to increase the distance from radium to ovary (according to the law of inverse squares), and in young women where a permanent menopause is desired. The radium acts on the endometrium, the uterine muscles and the ovary. It is distributed, therefore, in small units so as to minimize as much as possible the slough in the endometrium. It is placed well in the fundus to avoid the cervix if possible. A chronic cervicitis started by radium and made persistent by a secondary infection may prove troublesome. The Dominici tubes are placed in rubber tubes 1 mm. thick.

Supplementary roentgen-ray treatment is given to a large tumor where it is believed that a permanent menopause will not result from the intrauterine application of the radium. It is used whenever there is a recurrence of bleeding after it has been once stopped, more especially if the recurrence seems to be persistent.

The effects of radium on the symptoms are indicated in Table I. The columns represent the different problems which present themselves: that of the adolescent or young woman, that of the woman in the active childbearing period, and that of the woman in whom the question of childbearing is negligible. The ages given represent the general averages. The important matter in making the decision as to a woman's sexual age is her general appearance and behavior. Some of mature years have all the youthful characteristics of women much younger, and desire children.

The last two columns represent cases where the lesion itself overshadows the question of age. The submucous pedunculated myoma is arbitrarily so named when the height of the protruding mass equals its diameter. This standard is made for practical purposes, because I believe that with so much protrusion, ulceration may exist, as in a definitely polypoid mass. From such an ulcer, bleeding will continue even after the onset of the menopause. Myomata are called large when they exceed 15 cm. in diameter.

The results of roentgen-ray and radium treatment are given together. The only difference noted is that the roentgen rays are slower, especially in fat patients, and that radium is less reliable in large tumors. One method has often been used supplementary to the other. With the intrauterine application there is the added element of aseptic surgery and usually anesthesia.

In women under twenty-five years of age, an attempt was made, in all but one (followed seven years). In the odd case a successful deliberate menopause was pro-

TABLE I

Bleeding	Total Number of Cases	No Myoma Present			Myoma Definite			
		Under 25 Yr.	25–38 Yr.	38 Yr. and Over	25–38 Yr.	38 Yr. and Over	Sub-mucous, All Ages	Large, All Ages
Became normal	12	8	2	..	..	1	1	..
Became normal (excess recurred after 7 years)	1	1	..	..	..	..	..	..
Stopped immediately	70	..	5	23	2	28	5	7
Stopped after 1 month	41	..	4	18	..	15	1	3
Stopped after 2 months	26	1	0	8	1	10	..	6
Stopped after 2–6 months	20	..	3	5	1	5	..	6
Stopped after 6–12 months	1	..	..	..	..	..	..	1
Stopped and recurred later and								
Became normal	5	..	2	..	3	..	..	..
Stopped spontaneously	9	..	..	2	2	4	..	1
Stopped after radiotherapy	6	2	..	1	..	..	1	2
Failed to stop with first dosage and								
Stopped after radiotherapy repeated	2	..	2	..	..	..	..	..
Became normal after radiotherapy repeated	7	..	..	3	..	3	..	1
Satisfactory result from radiotherapy	200	12	18	60	9	66	8	27
Operation required for bleeding	3	..	..	..	..	..	..	..
Total number of cases	203	..	..	..	..	...	..	..

TABLE II

Other Symptoms	Total Number of Cases	No Myoma Present			Myoma Definite			
		Under 25 Yr.	25–38 Yr.	38 Yr. and Over	25–38 Yr.	38 Yr. and Over	Sub-mucous, All Ages	Large, All Ages
Dysmenorrhea:								
Relieved	13	1	3	3	2	2	..	2
Unrelieved	0	.	..	..	..	..	.	..
Total number of cases	13	1	3	3	2	2	0	2
Pain of other nature:								
Relieved	14	..	.	3	1	7	..	3
Unrelieved	23	1	1	5	..	11	..	5
Total number of cases	37	1	1	8	1	18	0	8
Urinary symptoms:								
Relieved	10				2	7	..	1
Unrelieved	10	1		2		6	1	..
Total number of cases	20	1	0	2	2	13	1	1

case, simply to regulate menstruation. This was accomplished in all but one case, which has a permanent menopause duced. It is interesting to note that one girl began to bleed after seven years of normal menstruation. This is now controlled by pituitary extract. In women over twenty-five years of age, the results have been fairly uniform. Three women were operated upon because of continued bleeding, due, we believe, to insufficient dosage. In two, the calculation was incorrect (400 and 500 mgm. hrs. respectively) and in the other a broken radium tube was used. One case of a large myoma with many submucous nodules

Table III

	Totals	No Myoma Present			Myoma Definite			
		Under 25 Yr.	25–38 Yr.	38 Yr. and Over	25–38 Yr.	38 Yr. and Over	Sub-mucous	Large
Immediate Symptoms and Conditions								
Death	1	0	0	0	0	0	0	1
Pain	4	1	0	2	0	0	0	1
Discharge	32	1	5	6	1	10	5	4
Local infection	3	0	0	0	0	2	0	1
Slough	2	0	0	2	0	0	0	0
Pathology overlooked	2	0	0	1	0	0	0	1
Remote Symptoms and Conditions								
No hot flushes	23	3	3	4	3	8	0	2
Hot flushes, mild	129	6	11	45	6	38	5	18
Hot flushes, severe	17	1	2	5	0	4	2	3
Total observed	169	10	16	54	9	50	7	23
Nervousness, unchanged	33	4	1	5	4	14	0	5
Nervousness, improved	60	4	11	18	2	14	0	11
Nervousness, slightly increased	48	1	2	25	3	10	2	5
Nervousness, greatly increased	5	1	1	0	0	2	0	1
Total observed	146	10	15	48	9	40	2	22
Age appearance, unchanged	55	5	..	..	..	34	3	13
Age appearance, younger	20	3	3	5	0	2.	1	6
Age appearance, older	7	3	2	1	0	0	0	1
Total observed	82	11	5	6	0	36	4	20
Secondary sexual characteristics, changed	2	0	..	2	..	..	..	..
Secondary sexual characteristics, unchanged	102	6	13	35	19	7	4	18
Total observed	104	6	13	37	19	7	4	18
Libido, unchanged	36	3	5	9	3	10	2	4
Libido, increased	2	1	..	1	0	0	..	..
Libido, diminished	2	..	..	..	0	2	..	..
Total observed	40	4	5	10	3	12	2	4
Blood pressure, unchanged	82	5	12	23	2	24	4	12
Blood pressure, increased	16	..	0	6	0	8	1	1
Total observed	98	5	12	29	2	32	5	13
Subsequent pregnancy	2	1	0	0	1	0	0	0
Subsequent disaster, preventable by operation	1	0	.	1	0	0	0	0
Final result, satisfactory	161	7	13	55	6	52	7	21
Final result, qualified by errors of physician, etc.	11	3	2	3	1	..	..	2
Final result, unsatisfactory, because of radiotherapy	6	2	1	..	..	..	..	3

and pedunculated myomata needed operation in the first place, but had a severe anemia, continuing hemorrhage, and a septic thrombophlebitis. After the temperature had quieted down, she was given radium and then *x*-rays. The excessive hemorrhage stopped immediately, and all bleeding stopped at the end of a year. After her general condition had become normal she was operated upon because of continued pelvic pain and urinary distress.

A general summary of Table I shows that the bleeding either ceased or became normal in 40 per cent of the cases after one radium application of *x*-ray series, within a month after operation in 21 per cent, within two months in 13 per cent, and within six months (usually three) in 10 per cent. Fourteen and one-half per cent had recurrences and required supplementary treatment or stopped spontaneously, leaving about 1.5 per cent (three cases) of complete failure. Among the different types of cases the results were more or less the same, except that they were uniformly slow in tumors of large size.

Dysmenorrhea stopped in all cases, showing that the pain did actually depend on menstruation. On the other hand, pains in various parts of the body and unassociated with menstruation were not satisfactorily relieved, nor were urinary symptoms. Many of these had known causes, such as gall-stones, but they are included because they form part of the problem. The effect on the size of the mass varied greatly; so much so that a clean-cut table could not be made. In 105 cases in which the mass was large enough to measure, there was reduction in all but one. This woman had a moderate radium dose which made menstruation become normal. The mass had not reduced in size. The most rapid reduction was in a mass 20 cm. in diameter which could not be made out after six months. The slowest was in a mass 15 cm. in diameter which was reduced to 8 cm. at the end of three years and has remained so through four more years. It has seemed that when the effect of the radiotherapy in the ovary was slow and the artificial menopause late, there was a similar slow diminution of the mass. While radiotherapy will almost universally cause a reduction in the mass after a time, it is, at best, slow. I feel, therefore, that if size or other mechanical difficulties furnish indication for treatment, excision is the procedure of choice.

The immediate effect of the treatment on the individual has been slight in the majority of cases. With the roentgen ray there has usually been a little malaise; one patient had diarrhea. Most of them were nauseated; rarely one vomited. Following the intrauterine radium application the symptoms were the same, together with those which depend upon the surgical procedure. Death from pulmonary embolism occurred in one case. I believe this accident would not have occurred, had our present practice been followed; that of keeping in bed for a few days before operation, all cases with large tumors, or with any symptoms suggesting inflammation or degeneration. Postoperative pain has been severe in only one case. There was usually some discomfort immediately after operation, which we attribute more to the packing than to the radium. There was also a vague sense of heaviness, which often lasted for several days.

Discharge was important in 30 cases. It seemed to be of two kinds. One was a profuse watery flow, either intermittent or continuous, and was stopped by supplementary roentgen-ray treatment. This I believe to be a flow due to a perversion of the menstrual mechanism. The other discharge is mucopurulent, continuous for a long time, and is like that from any ulcerating surface. I believe this to be due to the superficial slough caused by the radium. In one patient there was a gross slough due, we think, to the combined effect of the radium and the disturbance of the circulation in the cervix caused by the removal of several pieces of tissue for examination to exclude carcinoma. In 3 cases there was a distinct infection. In one case the cause was faulty technique. In the others we think it was due to the opening up of an old infected cervix. There has been no sign of inflammation in the cases treated by *x*-ray. The inflammation is apparently due to the surgical procedure, and not to the action of the rays on the latent foci.

More interesting than the immediate results after the radium are those which are expected and sometimes feared as sequelæ to the termination of menstruation. Certain symptoms seem constant, whether the cessation has occurred at the expected time or has been precipitated artificially. In addition, there is a long list of inconstant symptoms and conditions which occur coincident with or following the normal menopause, whether they are due to changes in the reproductive system, merely incident to the time of life, or what not.

Radium and *x*-rays produce in the ovaries and uterus changes which closely simulate those occurring in old age. There follows the same effect on menstruation. Here is presented, then, an opportunity to study experimentally the secondary effects of the menopause.

In preparing an outline, the literature was searched to find what the symptoms of the normal menopause were, and, if taken from the beginning, they were found to include everything from alopecia to zoster. With increase of medical knowledge this list has diminished greatly. The symptoms and conditions in the accompanying tables indicate those which are usually discussed today.

Hot flushes, whether felt as a distinct flush, a sweat, a rush of blood to the head, sudden tingling or numbness, seem to be of the same nature. This symptom is the one constant manifestation, and by it one can almost determine the presence or absence of the menopause. In analyzing the figures, one is struck by the fact that while nearly all have some degree of flush, there are only a few who are greatly disturbed by them. When they are present, they usually insure the permanency of the result. When they suddenly disappear, there is often a return of menstruation.

The study of blood-pressure has not been satisfactory. There has been such variability in the readings on the same individual within short periods that I feel that in ambulatory patients better standardization of the conditions under which the readings are made must be devised before the data will be accurate enough for serious study. In one woman the systolic pressure dropped from 190 mm. to 120 mm. in two hours.

Secondary sexual characteristics (changes in figure, contour of face, loss of attraction to the opposite sex, atrophy of the breasts and external genitalia) have not changed, with the exception of one woman whose breasts definitely shrank. In two others there was a constriction of the vaginal outlet, due, we believe, to the use of irritating antiseptics. As in the normal menopause, sexual desire has been affected almost not at all. The two with diminished and the two with increased desire are not explained. Several women took on weight. An equal number lost. The former gained, we believe, because of restored health; the latter lost because, although in fair health, they had been kept inactive by the continued loss of blood, while with the return of normal life they were able to get the proper exercise.

Ageing (loss of ambition, wrinkling of the skin, graying of the hair) is difficult to estimate. In the course of seven years one is likely to look older. On the other hand, many haggard women with restored health and gain in weight looked and behaved very much younger after the treatment. As far as can be judged, the cessation of menstruation has neither hastened nor retarded old age.

Nervous symptoms, mild or severe, are the symptoms most thought of and feared by the average woman who thinks at all about the menopause. In this series, the majority of the patients were either unaffected or more or less improved in their general reactions, emotional control and so-called nervousness. A goodly number were more irritable and became more nervous. The sensations of the former group may be explained by the fact that many of them were so depleted by the bleeding and worn out by the worry of its significance, fear of operation, etc., that the mental relief, after the cure was established, more than offset any natural irritability that would follow the cessation of menstruation. There are some, however, in whom this would not apply. It may be said, then, that a certain amount of irritability will often, although not always, follow the cessation, and should be expected.

Severe nervous disorders of a degree to demand special attention have occurred in five of the series. One patient was the only unmarried daughter of a moderate-sized family, had always been pitied and protected by her brothers and sisters, had become hypochondriacal, and had developed a definite anxiety neurosis. She was antagonistic and distrustful, and had a minor hysterical attack during the first consultation. At the diagnostic curettage she awoke, screaming that she had been operated upon against her will. After *x*-ray therapy she developed hot flushes, began to brood over their significance and developed a psychosis of the melancholic type. She was kept in a sanitarium for about six months and has been at her previous normal level ever since (five years).

The second case was one of frank melancholia. The symptoms were overlooked in the diagnosis. She developed acute symptoms while in the hospital and was sent to an institution three weeks later. The case has little to do with the question of the menopause, but shows how, in outlining the treatment, one must be on the lookout for symptoms of nervous disease which may readily be overlooked when the anamnesis comes from the patient herself. Subsequent changes may be readily blamed on the operation.

The third and fourth cases were treated with full knowledge. Along with their bleeding, they presented well-marked psychic symptoms. At the suggestion of Dr. Samuel W. Lambert, one of them, suffering from a psychoneurosis of the paranoid type, was treated in the hope that the neurotic symptoms, present for twenty years, but exaggerated for one year, might be reduced to their previous state by the completion of the menopause changes. After the radium, there was considerable increase in the intensity of the symptoms for about six months. After that, they became much less severe, and now have only periodic mild recurrences (four years). The other was a case of dypsomania which had existed for years and was unaffected by the precipitation of the menopause. The fifth case is of a woman always of low mentality who developed an anxiety neurosis coincident with the cessation of menstruation. The previous nervous condition could be estimated with difficulty because of the poor responses to questions.

The causes of these various phenomena are of course involved in the causes of psychoneurosis in general. I can only give an outline of them as they appear from observation in the present series.

Causes of psychoneurosis of the artificial (radiotherapeutic) menopause:

I. Actual physiological changes due to loss of or alterations in secretions from the ovary or other organs concerned in menstruation.

II. Causes of psychoneurosis in general:

- A. Heredity; previous nervous disorders.
- B. Physiological and anatomical changes due to intoxications, syphilis, vascular changes, etc.
- C. Bad mental environment:
  1. The development of bad mental habits in general.
  2. The development of bad mental habits concerning menstruation and the power of reproduction, and their importance to the individual; especially the consequences of their cessation.
     - a. Traditional confusion of the importance of menstruation to the species with its importance to the individual: the attitude of the community toward the woman as a breeder and little else, up to a few decades ago: the practice of "Suttee"

in India where the widow is burned on the funeral pile of her dead husband: the automatic divorce of the Chinese wife who fails to become pregnant within a year after her marriage. The traditional stigma resting on the childless married woman and the "old maid."

b. Fear of disease: those incident to age (cancer, insanity, cardiorenal disease) and those diseases in which amenorrhea is an early symptom (tuberculosis).

c. Fear of senility with loss of good looks, attractiveness to the opposite sex, libido, etc.

d. Fear of losing the feminine characteristics (broad coarse features, hair on the face, bass voice).

e. The vague tradition that the change of life involves the enduring of discomforts and dangers of a nature unknown or very vague to the woman.

3. The constant arousing of one or more of these thoughts by

a. Frequent hot flushes.

b. Actual slight increase in nervousness.

c. Bad advice from gossiping friends and relatives and careless physicians.

One of this group of patients consulted a prominent surgeon who told her to avoid radium by all means, because the last patient of his who had had radium was "crazy as a bedbug and hunting . . . (one of our esteemed members) with a hatchet."

In trying to prevent these nervous manifestations, we should avoid giving the treatment to one who is definitely psychoneurotic. We should further protect those receiving it by proper teaching of the truth about the menopause as we see it, and we should counteract the external influences which will, in the majority of cases, tend to arouse these anxieties.

Concerning the actual physiological effect of the radium on the ovary, and thereby on the individual, the tabulated evidence is only partly helpful. It may be safely argued that the action being most severe on the ripe follicles may spare enough to permit a supply of internal secretion sufficient to prevent the various changes which might be expected to occur after a total destruction. The process is in close imitation of nature, however, and the information therefore suggestive.

There have been two pregnancies, one normal and the other terminated after six months following a fall. There was a dead macerated fetus.

Of the various accidents and changes which might occur in a fibromyoma (toxemias, degenerations, inflammations, sloughing, etc.) none has occured. One patient died in another city, shortly after the treatment, with a diagnosis of carcinoma of the uterus. This was either a mistaken diagnosis, or else we overlooked the carcinoma at the curettage. There was no tumor, so that the only influence of this case on the future procedure will be to question the absoluteness of the information obtained by curettage and from the microscopic examination.

An attempt was made to form a general estimate of the desirability of the method, balancing the harm done with the benefits obtained as tabulated above in each case. Such a survey shows that the method was unqualifiedly successful in 91 per cent of the cases. In 3 per cent, more harm than good resulted from the treatment, and in 6 per cent, errors in judgment or technique qualified the result.

CONCLUSIONS

I. Radiotherapy of a myomatous or grossly normal uterus will
   a. Stop all bleeding not due to ulceration.
   b. Cause a myoma to shrink more or less rapidly.
   c. Stop dysmenorrhea.

II. Radiotherapy will give only partial results in the relief of
   a. Pain not associated with menstruation.
   b. Urinary distress.

III. As a result of the artificial menopause from radiotherapy
   a. Hot flushes are the rule.
   b. There is in some patients an increased nervous irritability.
      1. In the majority of patients nervousness is diminished probably because of the improvement in their general condition.
      2. Patients suffering from nervous disorders may be made worse.
   c. Changes in secondary sexual characteristics and in sexual appetite and satisfaction are negligible.
   d. Blood-pressure studies are unreliable. There seems to be an elevation in blood-pressure in 16 per cent of the cases treated.
   e. Normal pregnancy is possible after temporary menopause

DISCUSSION ON PAPERS OF DRS. STACY, SCHMITZ, FIELD, BURNAM, CORSCADEN AND CLARK*

Dr. Case. It seems to me quite futile to attempt to discuss these papers. I enjoyed hearing these reports from workers in the radium field. I wish to mention in regard to the benign conditions, that we appreciate very much the technique and combined treatment.

Our attention is more or less focused on malignant conditions, and it seems to me that one can in a few words summarize the lesson that comes to us from these papers. It is that, first of all, we need a careful examination. Following this, based upon our experience, we must have a plan. This plan must include the use of every known means to combat cancer, and we must work it in a grand effort to put the offensive over at the first assault. At no subsequent treatment do we have as good a chance of conquering the disease as we have at the first application. We must therefore plan to give a complete dose at the first seance. I do not mean by this, in the first twenty-four hours; but during the first series of treatment, which ought to be completed within the shortest reasonable time. It seems to us that the work of Clark, Burnam and others proves this. Then we must follow up the case in order to know what to do in the future.

As to radium or operation, it seems to me we have our answer. The tendency is toward more radiation and less operation; and if the cases are such as Dr. Clark and Dr. Burnam recite to us—Burnam had 15 cases of inoperable cancers alive after eight or nine years—how much better agents should we have than radiation in the operable cases? It seems to me, Burnam has taken the stand that we must support, that radiation is justifiable in all of these cases, and that for the present we must use a combination of radiation and operation in cases permitting.

I am glad to hear the discussion concerning pre- and postoperative radiation. My feeling is that pre-radiation is more valuable than post-radiation. I am in favor of the filtered needles in preference to the bare. The filtered have to be withdrawn, the bare do not, but I think the results are better with the filtered.

I have been rather impressed by a number of inoperable cases that have lived three, four or five years without anything being done. Is it possible to get some statistics for comparison?

I wish to express my appreciation and the appreciation of the whole society to these essayists for giving us such a splendid résumé of the entire subject.

Dr. Bowing. It is encouraging to compare the new cases with the old cases in which we gave one treatment, and then another in two or three months, and so on. Eventually the entire vagina was cicatrized, with or without a

*Papers read at Twenty-third Annual Meeting of The American Roentgen Ray Society, St. Louis, Mo., May 22–23, 1922. Those of Drs. Stacy, Schmitz and Field appeared in October, that of Dr. Burnam in November, and those of Drs. Corscaden and Clark precede this discussion.

vesicovaginal or rectovaginal fistula. In the group that has been treated according to our present method, we have not encountered a single fistula that can be attributed to the treatment alone. I am sure that the ultimate results will be better. The medullary, proliferative type of cervical carcinoma responds more readily with a return to normal appearance of the structures previously involved. The infiltrating schirrous type is less favorably treated.

Since 1919 we have been using the knee-chest position with a Sims speculum and direct light, so that we can see just what we encounter. With a uterine sound one can palpate and measure the involvement. Then it is easy to fill the vaginal cavity with gauze. One does not have to traumatize to pack away the vaginal or rectal walls. The walls balloon out with the inrush of air. If there is a good perineal floor, the radium applicator will be retained in position. If not, we place adhesive strips over the perineum, which gives support to these structures. The cervical and uterine canal is divided for convenience into three parts: an anterior part includes the face of the cervix and one inch of the cervical canal, a middle part includes the second inch of the cervico-uterine canal, and a third part includes the lumen of the fundus.

In favorable cases for radium treatment, a 2,400 mgm. hours' dose is placed in each area and three vaginal treatments of 700 mgm. hours each, making a total of 9,300 mgm. hours. The broken dose method is used with an interval of forty-eight hours between treatments. The Universal silver tube applicator containing 50 mgm. radium sulphate is used. No added filtration, except 1 mm. brass, is used in the vaginal applicator. Very little trauma, if any, occurs in inserting the applicator into the canal. It is essential to treat the deeper portions of the tumor area.

I have discontinued using lead in the vagina because I think it is detrimental on account of its secondary rays. In cases in which it has not been used, there is less vaginal irritation. When the radium applicator is placed in deep cavities, we use a copper wire, which not only offers a way of putting it in and holding it, but facilitates and insures removal. Radium causes a characteristic reaction in the tissues exposed, similar to nature's own method of combating the disease.

I am confident that our present methods will give more lasting results, and that a combination of irradiation and surgery is best in well-selected cases.

Dr. Boggs. We are often led to believe that because gynecologists use radium alone, it is not necessary to use *x*-rays from the outside. As Dr. Burnam said, we would like to have some cases treated with *x*-rays alone from the outside and note the effect. We know we get a decided effect on the lymphatic glands. I agree that it is not necessary to treat the local growth with *x*-rays, but the great majority of cases have no glandular metastasis; and in many of those cases that we are treating, we are getting no effect on the metastatic glands because there are none present; however, we know that some primary cases have metastatic glands at operation. In those cases that are treated with radium alone, we will not have the same result as when we use *x*-ray upon the outside.

Dr. Stacy. A review of all cases of carcinoma of the cervix treated at the clinic has recently been made. This series includes all methods of treatment employed; such as the use of the simple cautery, the Percy cautery, the Percy cautery followed immediately by hysterectomy, the cases treated with radium only, and with radium and surgery. The results have not been very encouraging. This review brings out the importance of making an early diagnosis and instituting early treatment, as the duration of the disease and the age of the patient influence the ultimate results more than the method of treatment employed in the individual case.

Now we are trying out a series of 100 cases of early carcinoma of the cervix, using the full dosage of radium, and following this in two or three weeks' time by hysterectomy.

Dr. Clark. Great care should be taken to avoid losing a radium needle in the cervix or adnexa, for, unless soon found and removed, the result will be serious. Such an accident did occur in my hospital, but happily, the needle was quickly found and removed. On this occasion, twelve 10-mgm. needles had been threaded on heavy braided silk and inserted into a neoplasm of the cervix and vagina. All except one were removed without trouble. With this one, however, the thread must have been cut or damaged by the special forceps with which the needle had been inserted, as it broke, and all idea of the position of the needle was lost. In this emergency it occurred to me that an ordinary sewing needle might be threaded and inserted as near as possible where the radium needle was thought to be, and stereoscopic radiographs made. This was done, and the position of the lost needle found to be about one-half an inch from that of the sewing needle. A small incision was made, and the needle readily withdrawn, within twenty minutes of the discovery of its loss.

Dr. Schmitz (closing discussion). I wish to say that the vulnerability of cancer of the cervix is very low. In other words, the majority of patients that come to us come when there is invasion of the contiguous tissues and of the lymph-nodes. It is necessary to find a means of attacking this, and I believe that lies in the combination of *x*-ray and radium. We are just now doing a series of cases with *x*-ray alone, and if we can reach fifty cases, I will report the results.

So far as the results of radium and operation are concerned, I feel that the more I see of either method, the more I am inclined to give all the credit to radium and *x*-ray, and not to results of operation. In our cases in which we have followed the operation with radium, we have had disastrous results, and since we have learned to leave them alone, they have done well.

It also seems to me that in carcinoma of the uterus, the action of the radium is not spent on the ovary at all, but on the endometrium. The ovaries are at some distance from the canal, and the intensity of the radium is so small with the milligram hours used, that they are not disturbed, and that explains why these patients will often begin to menstruate again, having a perfectly normal menstruation. We do not attempt to radiate the whole uterine cavity for the reason that we wish to avoid cicatrizing the internal os. We have seen several cases where this has resulted in stenosis, and, in a few cases, in atresia.

Dr. Burnam (closing discussion). I am much interested in the comments and discussion. What I meant by radiation and its effects on squamous cell carcinoma of the cervix was that in order to evaluate this method, it should be used in some cases alone. That is the only way to determine its value. If, as is contended by the Erlangen School, the method is very effectual, there will be nothing lost by radiating and watching for a few weeks. If the method is a failure, we can then have recourse to local radiation or to operation, or to both.

I was interested in the dosage which Dr. Stacy reports in her cases. We use 1,500 mc. hours as an average dose, and we have had a great many patients who began menstruating after a period of a year to several years, some as late as four years.

Dr. Field's case interested me very much because I had sent to me a patient whose brother-in-law had amputated the cervix, which, on microscopical examination, proved to be the seat of a squamous-cell carcinoma. When I saw her, there was a well-healed scar, and no sign of cancer. I gave 3 gm. hours of radiation over the vaginal vault and opening to the uterus. This patient went for some months without menstruating and then became pregnant. The question of what to do became a pressing one, and I advised that she go to a good obstetrical hospital and be prepared to have a Caesarean section done at full time. That was not done. She was delivered of a normal child, but on the third day following delivery, for reasons which I have not yet learned, she died of hemorrhage.

Dr. Corscaden (closing discussion). The question of the mode of action of radium has interested me greatly. I do not believe that a permanent cessation of bleeding will occur unless there is a permanent menopause, brought about through the destruction of the Graafian follicles. We have four specimens to study, two from hysterectomy because of failure to cure, and two uterine removed because the microscopic findings suggested adenocarcinoma. In one specimen, there was, three weeks after the application of radium, only the most superficial action on the endometrium. The ten-day specimen shows an eschar 2½ cm. long by 1 cm. wide. Beneath the mucous membrane were spots of tiny extravasations of blood for a depth of 1 cm. In all specimens, there was marked thickening of the lining of the vessels and considerable thrombosis. The two specimens of ovary showed definite, distinct changes, in that the action on the endometrium is limited to the narrow zone about the radium; so that with normal endometrium present, menstruation may occur, unless the ovarian element is removed.

ESTIMATION OF CARDIAC VOLUME BY ROENTGENOLOGY*

BY C. R. BARDEEN, M.D.

University of Wisconsin

MADISON, WISCONSIN

DR. Stewart has kindly invited me to present at this meeting a paper on the estimation of the size of the heart by roentgenology. I regret that I cannot attend the meeting to present it personally and take part in the discussion.

Estimation of the size of the heart is only one of the ways in which roentgenology helps in the diagnosis and treatment of cardiac conditions. Note that I add "and treatment" here. Roentgenology offers real aid in study of the action of drugs, rest and exercise on the heart. Fully to treat of the subject of this paper would require an extended review of the whole field of cardiac roentgenology, of the anatomy, the physiology, and the pathology of the heart and of the treatment of heart disease. This, of course, is out of place here. I shall confine myself as strictly as possible to a discussion of cardiac volume from the standpoint of roentgenology.

The first question to be considered is that of the value of a knowledge of cardiac volume in the diagnosis and treatment of heart disease. Is there value in a more exact method of estimating heart size than that offered by the usual method of percussion? This question should be answered before taking up that as to whether or not roentgenology offers this more exact method. That there is value in an estimation of the size of the heart is shown by the persistence and general use of cardiac percussion. If there is use in estimating the size of the heart, it seems clear that the more accurate the estimate, the better it should be. The value of the estimation of the size of the heart lies in the fact that the normal heart is closely adjusted in size to the size of the body. Probably no other organ in the body has so uniform a task to perform as the heart, or is so uniformly fitted to this task. In my paper in the *American Journal of Anatomy* for 1918 I have given a summary of the literature relating to the relation of the weight of the heart to weight, stature and age. All investigators of this subject have shown that there is a close correlation between heart weight and body weight, due probably to the need of a given mass of heart muscle to pump the blood to a given mass of tissue. The value given to heart weight in relation to body weight by different investigators varies somewhat because of different methods used. At death, the body is apt to be emaciated, especially during childhood. If heart weight is compared to cadaver weight the heart weight averages relatively high. If it is compared to estimated normal body weight it averages relatively low. The mean between the two probably approximates the normal relations. From the data referred to above I concluded that the weight of the heart throughout life approximates $\frac{1}{200}$ of the body weight (.55 per cent in males, .53 per cent in females). In estimating the ratio of heart weight to body weight at birth, the weight of the fetal membranes should be included with the body weight. In addition to the slightly smaller average relative weight of the female heart there are individual variations in heart weight within normal limits. Just how wide these limits are, obviously cannot be determined from cadavers. Observations on related animals such as apes might be of help here, but dogs are of comparatively little value, because, undoubtedly, variation in relative weight of dogs' hearts is vastly greater than normal variation in weight of human hearts.

The volume of the heart relative to heart weight depends partly upon the specific gravity of the tissues composing the heart, partly upon the fluids within the chambers of the heart and in the intrinsic vessels of the heart. The volume of the heart in diastole is therefore greater than the volume of the heart in systole. The specific gravity of the human heart is about 1.050. The volume of the heart tissue

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.

in cubic centimeters is thus about 5 per cent less than the weight in grams. In experiments on dogs, I found that in diastole the heart wall constitutes about 60 per cent of the total volume of the heart, the heart content 40 per cent. In the human heart in diastole, the heart wall appears to constitute about 50 per cent, the heart content about 50 per cent of the total volume, The methods used in making these estimates are given in the paper referred to above.

The normal heart is prepared to meet not only the usual demands of daily life, but also the exceptional demands of unusual exertion. After birth the left wall of the heart becomes much thicker than the right because of the greater force needed for the general than for the pulmonary circulation. As the child grows in size, the heart grows likewise to meet the needs of the body. In those called upon to do a large amount of muscular work, the heart probably normally enlarges slightly to accommodate itself to the special demands put upon it. Growth of the kind mentioned is called physiological hypertrophy.

In contrast to alterations in the size of the heart due to physiological hypertrophy, there are those due to a failure of the heart to meet in a normal manner the demands put upon it. On the one hand, we have acute dilation, in which the heart becomes over-distended in diastole, and loses the power to contract normally in systole. On the other hand, when the heart is subject to a constant load beyond the normal capacity of the heart muscle, as in case of valvular disease, or too frequently repeated great strains, as in case of athletes or mountaineers, the quantity of heart muscle may increase in amount, but with a loss of quality. This is called pathological hypertrophy. The borderline between physiological and pathological hypertrophy is not a definite one, but apparently most pathologists are inclined to consider that hypertrophy sufficient in amount to make the heart noticeably larger in size than normal is likely to be pathological. In the study of cardiac dilatation and of cardiac hypertrophy it is obvious that the more accurate the method of determining heart volume, the more valuable it should be. It is clear also that very accurate methods are needed if a study of heart volume is to include the study of volume in systole as well as in diastole and an estimate of cardiac output.

Does roentgenology furnish such a method? Smith and Bloedorn (*U. S. Nav. M. Bull.*, Feb., 1922) in a teleroentgenographic study of the hearts of naval cadets, came to the conclusion that the individual variability in size of normal hearts is so great that "any conclusion as to the relative size of a heart based on comparative dimensions, ratios, or relations to body landmarks is fallacious and should be applied clinically with great reserve," and state that they are "tempted to take sides with Lewis in his belief that the position of the apex beat indicates as well as any means at our command the relative size of the heart." They believe that the variation in size of normal hearts so far overlaps the variation in size of pathologically enlarged hearts that there is no great clinical value in an accurate determination of the size of the heart. That roentgenology offers the most accurate methods which we have of determining the size of the heart in the living, they do not dispute.

These authors are quite correct in concluding that the normal range of variation in size of the heart overlaps the field of variation in size due to pathological conditions. Hearts may be dilated or hypertrophied, and still be smaller in proportion to the size of the body than are some normal hearts. Relatively small hearts may be insufficient in size to meet the demands of the body, or they may be composed of exceptionally efficient musculature. Hypertrophy of the left ventricle is most likely to be diagnosed early by the roentgenologist by observation in the fluoroscope of a prominent apex; heart muscle weakness by the resemblance of the heart shape in diastole to that of a sack partly filled with fluid or by the bulging of the sides of the silhouette area in diastole during expiration as compared with that during inspiration; right ventricular dilatation or hypertrophy by the systolic contraction of the lower right border of the heart shadow; auricular distention by the bulging of the auricular regions of the silhouette contour. Zehbe's recent contributions along these lines are of great value.* On the other hand, an accurate method of determining heart size is clearly necessary in studying the return of a dilated heart to normal size, or in studying whether a large heart is increasing in size under given conditions, and similar phenomena. At the University of Wisconsin we have found it of great value in following the hearts of athletes. As a rule, in a healthy athlete, the heart does not enlarge during the training season. On the contrary, it becomes more effective in systole. For effective work in study of cardiac conditions, repeated observations over an extended period are necessary. Accurate study of heart size is of importance here.

Admitting that accuracy in the estimations of heart size is of value in clinical medicine, and that roentgenology furnishes us with the best available means for this purpose, the next subject is that of the methods to be used in applying these means. While for various purposes in the study of the heart the fluoroscope and orthodiascope are invaluable, for the study of heart size the teleroentgenogram offers advantages which appear to make it the method of choice.

The distance from anticathode to plate commonly taken for this purpose, two meters, appears in general to be the most practical. Even at this distance, there is sufficient dispersion of the rays to make it necessary to allow for enlargement of heart silhouette over cardiac outline. At less distance a corresponding increase in allowance must be made. While less allowance need be made if a greater distance is chosen, the gain thus made does not compensate for the increased technical difficulties.

The position of the body is of importance. The chest wall must face the plate in order to reduce error from ray dispersion. The prone position presents technical difficulties in obtaining tubal distance, is somewhat uncomfortable for the patient, and tends, except in case of thin people, to press the abdominal viscera upward and thus obscure the diaphragmatic portion of the heart. The standing position is difficult to adjust and have maintained with uniformity. The sitting position with the patient leaning forward against an inclined plate-holder is superior to either the standing or the prone position, and should be used whenever conditions permit. Standards of heart size should be based upon this position, and when it is necessary to take pictures in other positions, due allowance should be made for variation in silhouette area. It is important that the plate-holder should be inclined, and not vertical. The slant of the plate-holder should be such that when the tube is at the top of the tube-stand and the anticathode is two meters from the plate, the central rays will be perpendicular to the surface of the plate-holder. The patient should sit well back on an adjustable stool. The chest wall should be against the plate-holder and the abdominal wall should be somewhat stretched by the backward tilt of the pelvis. The hands should rest on the top of the plate-holder. In this way, the heart is brought as closely as possible to the plate by force of gravity as well as by position, the pressure of the abdominal viscera on the diaphragm is relieved and the diaphragmatic portion of the heart is made more clear. The breath should be held at the end of a moderate inspiration while the picture is being taken. This insures greater distinction of outline and greater uniformity than to take the pictures by chance during quiet respiration. In general, deep inspiration at the time of taking the picture is not advisable, but for fat individuals it is the position of choice. Swallowing water so that air is introduced into the stomach, or the use of a small amount of Seidlitz powder frequently aids in making clear the apex of the heart. Otherwise, the less there is in the alimentary canal at the time of taking the picture, the better the picture is likely to be. The tube should be centered as nearly as possible over the center of the heart.

For routine work the diastolic silhouette of the heart is taken. For this purpose an exposure of a second is preferable to a shorter exposure. For special purposes, where it is desired to take one or more

* *Deutsche Med. Wchnschr.*, 1916. *Fortsch.*, 1918, p. 424. French roentgenologists have likewise added greatly to this field of work. See Martinez, AM. J. ROENTGENOL., 1921, viii, 491, and Vaquez et Bordet, de Coeur et l Aorte. Paris. 1918. Karshner and Kennicott have recently contributed an important paper. AM. J. ROENTGENOL., 1922, ix, 305.

pictures at definite intervals during a single beat, the exposure is reduced to a minimum and the period of the exposures is recorded on simultaneous electrocardiograms. Into the details of the technique of the methods for doing this I cannot here enter. Dr. Eyster and Dr. Meek are actively at work in this field.

Having taken the heart silhouette, the next step is to determine from it as accurately as possible the size of the heart. First, one should decide on the formula to be used in making reduction for the magnification of the silhouette due to ray dispersion. The most accurate simple method for doing this, when the two-meter distance has been used, is to measure in centimeters the anteroposterior diameter of the chest wall in expiration at the level of the sixth thoracic vertebra, divide this distance by three, and utilize the quotient to designate the percentage of area reduction; half this the percentage of linear reduction. Thus if the chest wall is 21 cm. thick, the silhouette area should be reduced 7 per cent, and the transverse diameter 3½ per cent to get the value of a sunlight silhouette. In my paper referred to above I have gone more into detail concerning this method. Unless the silhouette area is reduced for each individual to the sunlight area, variability of heart size will appear to be much greater than it is in reality.

Having now the silhouette and the formula for makng proper reductions in its measurements, the next thing is to make such measurements as will give the most accurate practical estimate of cardiac volume. Of the various methods of measuring the heart silhouette, the most widely used is the linear measurement of transverse width of the heart. This is popular because it appears to be objective. It does not, however, represent a definite diameter of the heart, but a measurement which varies with the shape and position of the heart. It is correlated with the transverse diameter of the thorax, the width of the heart being about one-half of that of the thorax. Different investigators, however, have come to different conclusions as to the exact ratio. For those who prefer a rough and ready estimate of relative heart size the cardio-thoracic ratio probably offers the best method but it gives no help in determining heart volume.* The transverse width of the heart, since it represents a variable measurement, not a definite diameter, cannot be used for this purpose. Efforts have been made to outline definite diameters, especially the long diameter of the heart. All these have suffered, however, from the difficulty of measuring these diameters between corresponding points of the heart in different hearts. By completing the outline of the heart and measuring the area we include all possible diameters within the field of the silhouette, and thus reduce to a minimum the error of comparative diameters. It is naturally more difficult to complete the margins of the heart silhouette than it would be to complete the margins of the shadow of an egg looked at through a slit, but by continuing the curves of each lateral margin into one another across the base of the heart and by connecting the lower ends of the lateral margins by a slightly curved line, the silhouette area can be completed with a fair degree of exactness. The same observer should be able to come within 2 per cent in estimating area at different times from the same photograph, and observers used to one another's methods should come well within 5 per cent. A variation of 5 per cent in area is approximately equivalent to an error of 7½ per cent in volume and to one of 2½ per cent in any given diameter. The area is measured readily by means of a planimeter. I give here four figures to illustrate the outline of the heart as seen from in front. Figure 1 illustrates a cadaver heart. Note that the transverse diameter of the heart is broad and the the great vessels at the base are short. The positions of the semilunar valves are marked by three short curved dotted lines meeting at a point. The position of the proximal origins of the mitral and tricuspid valves are roughly indicated by oblique curved lines. Figure 2 is from the silhouette area of the heart of a stocky individual. The outlines of the silhouette are drawn in heavy lines. The chambers of the heart and the great vessels are drawn in light lines as imagined seen from the front. The valves are indicated

* Hammer, G. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1918, xxv, 510. A good account of the relations of the transverse width of the heart to body weight, stature, chest-girth and age.

as in Figure 1. The base of the cardiac silhouette is shown by a curved dotted line. Figure 3 gives a similar representation of the heart of an individual of average build; Figure 4, that of the heart of an individual of relatively slender build. In the latter case the silhouette is taken at the end of deep inspiration to illustrate marked lengthening of the heart. The diaphragm is high on the left side because of a large gas bubble in the stomach. It is to be noted that the great vessels are much more elongated in the living than in the cadaver.

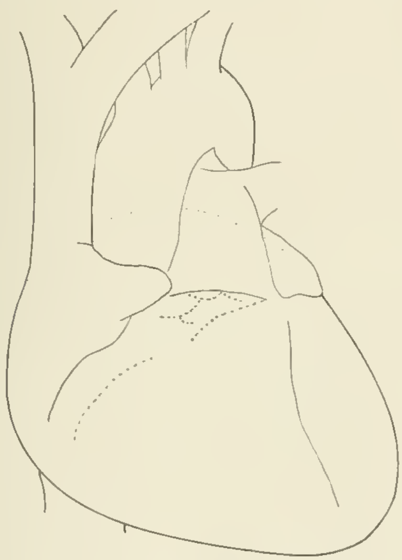

FIG. 1. Cadaver heart. The curved line in dashes at the base indicates the region through which passes the line used to demarcate the upper limit of the cardiac silhouette. The positions of the pulmonary and aortic valves are each marked by three short curved lines in dashes. Two longer curved lines in dashes indicate approximately the proximal origins of the mitral and tricuspid valves.

From the silhouette area, heart volume may be calculated with a fair degree of accuracy. In order to get a formula for doing this, I studied sunlight silhouettes of numerous anatomical specimens and models of the heart in various positions, and correlated these with the actual volumes of those specimens. I have described the method at length in the paper referred to above. That the calculated volume approximates the real volume I think is shown by the fact that cardiac output estimated from difference in silhouette area in systole and diastole corresponds closely with output estimated by other methods. This is true both in man and in dogs, as shown by the work of Eyster and Meek, as yet in part unpublished.

Having estimated the volume of the heart in a given individual, one naturally desires to compare this measurement with a standard of some kind. Such a standard may be the average of similar measurements made on individuals of similar sex, age, height or weight, or it may be based on a more generalized set of data. The standards which I proposed in the paper referred to

FIG. 2. Silhouette area of the heart and great vessels of a stocky man. Inside the silhouette area the ventral surface of the heart and the position of the valves have been schematically represented so as to correspond with the similar structures shown in Figure 1. The individual from whose roentgenogram the outline of this heart was traced was 27 years old; height 68 in.; weight 171.5 lbs.; chest girth inspiration, 41.2 in.; expiration 37 in.; thickness of chest, inspiration 9.1 in.; expiration 7.9 in.; pulse rate 82; systolic blood pressure 122; diastolic pressure 84; silhouette area 127.8 cm.; trans. width 13.8 cm.; cardiac volume 766 c.c. The individual was estimated to be 17.4 per cent above the average weight for stature. The volume of the heart was 9.5 per cent above the norm for stature, 7.1 per cent below the norm for weight. Individual taken seated. Moderate inspiration.

above and which were also published in the AMERICAN JOURNAL OF ROENTGENOLOGY for December, 1917, are of the latter type. They are based upon the following generalizations:

1. There is typically an approximately constant relation between size of heart and size of body. This may be expressed in terms of heart weight relative to body weight, of heart volume relative to body weight, heart volume relative to silhouette area, and of silhouette area relative to body weight. The following formulae are those which I have adopted to express these relations:

(1) $H = 5.5W$, (2) $V = \frac{5.5W}{.5187}$, (3) $V = 0.53A^{3/2}$, (4) $W = \frac{1}{20}A^{3/2}$. In these

Fig. 3. Silhouette area of the heart of a man of average proportions. Surface configuration and valves schematically represented as outlined above. The age was 22 years; stature 69.75 in.; weight 152 lbs.; inspiration 36.5 in.; expiration 32.9 in.; thickness of chest, inspiration 8.1 in.; expiration 7.5 in.; pulse rate 80; systolic blood pressure 108, diastolic 85; silhouette area 126 sq. cm.; trans. width 12.8 cm.; cardiac volume 750 cu. cm. The individual was estimated to be 1.5 per cent above average weight for stature. The volume of the heart was 3.7 per cent above norm for stature, 2.5 per cent above norm for weight. Individual seated. Moderate inspiration.

formulas H equals weight of heart in grams, W, weight of body in kilograms, V, volume of heart in cubic centimeters, A, area of silhouette in square centimeters. The above formulae express heart size in males. The female heart is about 5 per cent less in size for a given body weight.

2. For a given height and age there is an average or typical body weight. The typical heart size is correlated with this typical body weight and hence may be correlated with the stature corresponding with this weight at a given age. Typical statures for a given body weight at a given age are given in the tables referred to above. These typical heights are based on the height weight statistics available at the time the table was prepared. More recent data suggest inconsequential changes in these estimates. Individuals tall for weight and age may be expected to have somewhat

Fig. 4. Silhouette area of the heart of a relatively slender man. Surface configuration and valves schematically represented as outlined above. The age was 45 years; stature 71.5 in.; weight 146.3 lbs.; chest girth inspration 38 in.; expiration 34.4 in.; chest thickness inspiration 9.1 in.; expiration 7.6 in.; pulse rate 88; systolic pressure 112, diastolic, 75; silhouette area 118.4 sq. cm.; trans. width 12.2 cm.; cardiac volume 676 c.c. The individual was estimated to be 16.4 per cent below average weight for stature and age, the volume of the heart was 19.5 per cent below the norm for stature, 3.5 per cent below the norm for weight. Individual seated. Deep inspiration.

larger hearts than those of average build. Those short for weight and age may be expected to have somewhat smaller hearts than those of average build. By taking the mean between the silhouette area given in the table as typical for the weight of a given individual and that given as typical for his stature and age, we obtain the best standard with which to compare the silhouette area of that individual.

There are no obvious advantages in comparing silhouette area with cutaneous surface area estimated from height and weight. I believe that this merely introduces additional sources of possible error. Smith and Bloedorn, who introduced this method, found it but slightly superior to the method of comparing silhouette area with body weight. They do not compare it with my method of taking height at a given age and weight separately into consideration. Their data are not expressed in such a way as to make possible a comparison of the silhouette areas which they found with those called for in my table. Comparison can be made between the average silhouette area for a given weight and the silhouette area given in my table for that weight. Such a comparison shows silhouette areas smaller for a given weight than those called for in my table. In part, this difference may be due to a difference in completing the cardiac outline. In the example of completed outline which they give, the base of the heart is cut off more abruptly than I would cut it off. The difference in method would not probably, however, make a difference of more than 4 per cent in estimating area. To some extent the relatively small average silhouette areas which they found may be due to build. In this case the average build of the cadets would be a stocky build, relatively high weight for stature. It seems probable, however, that the average silhouette areas in the individuals studied by Smith and Bloedorn, if stature and age as well as weight were taken into consideration, would be at least 5 per cent and possibly 10 per cent smaller than those given as norms in my table. This may be ascribed in part to discarding those with large hearts at the physical examinations preceding entrance into service, in part to sitting upright instead of leaning forward when the radiographs were taken. There is also the possibility that the norms which I give are slightly large. This has not, however, appeared to be the case at the Wisconsin Clinic. LeWald and Turrell's data (*Am. J. Roentgenol.*, February, 1920, p. 67) show that in the aviators which they studied the silhouette areas average for a given weight and height about 4 per cent less than the norms given in my table. This may be due partly to selection at the time of the physical examination for extrance into service.

In Table I is shown the frequency of deviation from the norms given in my tables, in three series of individuals Series 1 comprises 200 clinically normal males of various ages studied at the Wisconsin Clinic, Series 2, a similar group of 50 females, and Series 3, 70 of the individuals studied by LeWald and Turrell, the data for whom were applicable to this study. The data given in this table show that the average deviation in volume from the median in the 200 males was 9.2 per cent. This is equivalent to a deviation of about 6.1 per cent in silhouette area. The median group shows a deviation of 2 per cent in volume above the norms in my table. Half the cases lie between 10 per cent above and 6 per cent below the norms. Three-quarters of the cases lie between 15 per cent above and 11 per cent below the norms. This is equivalent to 10 per cent above and 8 per cent below the norms for silhouette area. In Series 2 the norms are taken at 5 per cent below those given in the table. This correction is made on the assumption that for a given weight the female heart averages 5 per cent below the male heart in volume. The median is about one per cent below the corrected norms. For this series, therefore, the correction should have been 6 per cent instead of 5 per cent. Fifty-eight per cent of the cases came between 9 per cent above and 9 per cent below the norms for volume. The average deviation in volume from the median group is 6.32 per cent, which is equivalent to about 4.2 per cent in area. Seventy-six per cent of the cases lie between 11 per cent above and 11 per cent below the norms. In Series 3 the comparison is with norms for area. The median is 4 per cent below the norms. Fifty per cent of the cases lie between 2 per cent above and 10 per cent below the norms. Seventy per cent of the cases lie between 3 per cent above and 13 per cent below the norms. The average deviation from the median is 7.46 per cent. This is equivalent to a volume deviation of 11.19 per cent. In the three series the average deviation from the median is least in Series 2 (50 females), greatest in Series 3 (70 males studied by LeWald). In none of the series is the average deviation sufficiently large to throw doubt on the value of the method of using silhouette area in the estimation of heart volume. With increasing data, it will become possible to modify the norms in the direction in which these data point. From the data thus far at hand, I see no reason for altering those proposed. Furthermore, it does not seem to me, after making numerous attempts along similar lines, that the method proposed by Rohrer (*Fortschr.*, 1916, xxiv) of estimating heart volume from frontal and saggital views, or that of Köhler and Wechebach (referred to by Hammer, op. cit.) of estimating volume from stereoscopic pictures are either of them as likely to give approximately accurate results as that of estimating from the silhouette area of the frontal view.

Table I

Three series showing the number of cases with a given percentage of deviation from the norms in the Bardeen table. In each case the individual measurement is compared with the average of the norm for weight and that for stature and age. Series 1, 200 clinically normal males of various ages radiographed at the University of Wisconsin Clinic. Volume calculated from silhouette area compared with the norms. Series 2, similar series of 50 females, compared with the norms in the table reduced 5 per cent. Series 3, 70 of the aviators studied by LeWald and Turrell. Silhouette area compared with the norms. Median groups are underscored.

Per Cent of Deviation, Plus Dev.	Number of Individuals		
	Series 1	Series 2	Series 3
27.1–29	3		
25.1–27	1		
23.1–25	4		
21.1–23	5	1	
19.1–21	6		
17.1–19	2	1	
15.1–17	7		
13.1–15	11		2
11.1–13	4	4	1
9.1–11	10	5	5
7.1–9	14	3	1
5.1–7	16		2
3.1–5	9	3	3
1.1–3	13		6
0.0 1	5	4	2
Minus Dev.			
0.0–1	8	4	3
1.1–3	13	6	7
3.1–5	12	4	6
5.1–7	11	2	8
7.1–9	12	3	5
9.1–11	9	4	4
11.1–13	9	1	3
13.1–15	5	3	1
15.1–17	2	1	3
17.1–19	3	1	3
19.1–21	1		0
21.1–23	3		2
23.1–25	1		1
25.1–27	1		
33.1–39			2

DISCUSSION

Dr. Martin. I want to devote my time to a discussion of Dr. Bardeen's paper. He has, in the past, furnished us with much of value relative to roentgen-ray cardiac examination. One of his articles, published a short time ago in the *Journal of Anatomy*, represents an exhaustive study of this subject. However, I do not feel that his method of determining cardiac volume will prove to be of great value in studying the pathological heart. It is certainly true that any method which would give us an accurate estimation of the volume of the heart would be of great value clinically. But can we assume that a fixed formula will always give us such a value? You are all aware of the fact that the formula for the volume of a sphere is quite different from the formula for the volume of a cube. Therefore, I would hesitate to use the same formula in estimating the volume of the small spherical heart of early mitral stenosis and the long "beef tongue" shaped heart of senile myocarditis.

Dr. Bardeen's formula contains only one variable quantity; the silhouette area. He states that an error of 5 per cent in this area will become an error of 7½ per cent in the calculated volume. In a word, the volume is not as accurate a figure as the area. Since the area is the only variable quantity, his formula can give us no information that the area does not give. It would seem wiser, therefore, to use the area as an index of cardiac size rather than the calculated volume.

The shape of the heart is usually changed when it becomes diseased. This change involves the anterior posterior diameter as well as the transverse diameters, and it seems to me that any formula designed to represent the volume should contain one variable symbol representing the anterior posterior diameter. This point can be easily illustrated in early mitral stenosis. The area of the heart silhouette may be increased very little, or not at all, but a fluoroscopic examination in the oblique position may show the dilated auricles extending well back into the posterior mediastinal space.

Dr. Bardeen is an advocate of the cardiac area as a measure of cardiac size. He states that the transverse diameters which many of us use are inaccurate because they change with the shape and position of the heart. It is just such changes that we wish to record in the pathological heart. The transverse diameters are drawn from the only well-defined borders of the cardiac area. The errors made in outlining the cardiac area will not be made along the right or left borders, but along the indefinite upper and lower borders. I cannot feel, therefore, that the area offers any great advantage, so far as accuracy goes. I am inclined to believe that were a half-dozen of the men in this audience to outline the same heart on a teleroentgenogram and measure the area with a planimeter, we would find considerable variation in the results.

Personally, I have been inclined to accept the cardiothoracic ratio as a fairly reliable estimate of cardiac size. Dr. Bardeen feels that this ratio is only a rough estimate, and he may be right. However, it seems to me that his method of estimating enlargement on the basis of average normals is also a rough estimate, and the difficulty lies in determining which is the rougher. After determining the cardiac area he looks up the average area for the patient's weight and the average area for the patient's age and height and interpolates between these values to determine the correct area for the patient under consideration. Average values are always to be handled as rough estimates. In looking over the tables of normals for certain weights or certain ages one is struck with the number of individuals who show areas as high as 10 per cent above or below the average normal. In clinical work we deal with the individual rather than with averages.

Even though we assume these averages to be accurate for the classes of patients specified, it is not always possible to apply them in an accurate way. A patient just recovering from an attack of acute endocarditis will have lost considerable weight. A patient coming to the hospital after a break in compensation will have gained considerable weight. How are we going to look up the average cardiac area corresponding to this patient's weight? Shall we guess at what the weight should be under normal conditions? If so, we are getting into the field of rough estimations. The internal diameter of the chest does not change with emaciation or edema. It does change roughly in proportion to changes in age, weight and height. It changes with changes in position of the diaphragm. I am wondering which will prove to be the rougher estimate, the cardiothoracic ratio or the calculations compared with average normals.

Dr. Holmes. The value of any method of examination may be estimated, I think, by the test of time. In discussion of the *x*-ray examination of the heart one thing for us to remember is: Is it of any practical value?

Percussion of the heart outline is an old method and has been in use for a great many years. If it had not been of some value to clinicians, they would not still be using it. It has been demonstrated by men in this country and abroad, who have done this work for a considerable time, that the method of examination of the heart by the *x*-ray is distinctly more accurate as to size than any method of percussion; so that if percussion is of value, *x*-ray is of more value.

Dr. Martin has covered Dr. Bardeen's paper practically as I would like to have it done. I agree absolutely with what he says. I would like to add that we are dealing with the shadow of the heart and not with the heart itself. We cannot compare the roentgenogram with the actual heart; we must compare with shadows of normal hearts. We are always dealing with widely variable factors.

We have been doing this work at the Massachusetts General Hospital since 1914, and we have an average of between 5 and 10 patients a day. The patients are sent in by clinicians, and the work must be of some value or they would not send in the cases.

One other point in regard to the methods of measurement; I think the method which one adopts depends largely on what he is examining the heart for; what he is interested in. Bardeen was interested from a purely scientific point of view, getting at the most accurate method of determining slight changes in the size of the heart. One of the things we are asked to determine is whether the change is sufficiently great to be of any real damage to the patient. Another thing the practitioner wants us to do is to see how accurate he is in his percussion. One of the principal values in determining the size of the heart is to check up the percussion. Measurement by area would be of no value to them. They want to know how far to the right the heart is from the midsternum, etc.

Dr. Payne. In regard to Dr. Bardeen's paper: I have not had an opportunity to go over it, as I shall later. There are many here who have made a more real study of these methods, and have applied them, who are much better qualified to discuss the particular methods than I am; but to me, it has always been a question of the practical value of these methods, as compared to the amount of work done.

In the first place, we have observed the different types of patients, and have seen variations of the asthenic type, with small heart barely showing beyond the vertebral border, who live and show no heart symptoms; then there is the same asthenic type with the high diaphragm and apparently large heart, who live on.

It seems a great question, that in giving heart measurements, we really express to the clinician the value of that heart muscle. Personally, I believe the question must be: What are the results, and what is this man going to get out of the heart muscle? Is his heart muscle older than the rest of his system? How much longer is it going to last him? In view of that, I frankly confess that I have never been able to bring myself to the point of these accurate measurements, because of the many factors that are not subject to mechanical measurements; the matter of change of occupation, hardships, type of family, etc.—all these things that show the physical morale of the man and his chances of fighting infections.

Dr. LeWald. Dr. Bardeen's method is valuable for certain purposes. I would say it is the most accurate method of study of the normal individual, or a relatively normal individual, to determine in that individual the change in his particular heart.

Dr. Bardeen has referred to a series of cases examined by me, that were used in the study of the aviator's heart, in order to determine whether there was dilatation of the heart, as the aviator was put in a relatively low atmosphere to simulate high altitude. For a comparative study of that sort on normal individuals, I know of no method any more accurate.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor: H. M. Imboden, M.D.

Associate Editors: James T. Case, M.D. H. K. Pancoast, M.D. J. S. Shearer, Ph.D.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

FOURTH ANNUAL MEETING EASTERN SECTION AMERICAN ROENTGEN RAY SOCIETY

RITZ-CARLTON HOTEL, ATLANTIC CITY, N. J., JANUARY 25–27, 1923

MIDWINTER MEETING CENTRAL SECTION AMERICAN ROENTGEN RAY SOCIETY

SEELBACH HOTEL, LOUISVILLE, KY., FEBRUARY 24, 1923

CENTRAL SECTION OF THE AMERICAN ROENTGEN RAY SOCIETY

Midwinter Meeting

The Midwinter Meeting of the Central Section of the American Roentgen Ray Society will be held in Louisville, Ky., February 24, 1923, at the Seelbach Hotel. It is planned to have a full day's meeting, including morning, afternoon and evening sessions. A six o'clock dinner, followed by lantern slides, is planned for the evening program. We would be more than pleased to have members of the other sections meet with us.

Anyone having anything new to present at the meeting is advised to communicate with Dr. E. C. Ernst, president of the section. All information regarding the arrangement of the meeting can be obtained from the secretary, Dr. D. Y. Keith, 746 Francis Building, Louisville, Ky.

Terminology

The Executive Council has requested that the nomenclature which was adopted at the fourteenth annual meeting of the Society, held in Boston in 1913, and published in Volume 1, 1913, be again published. The reason for this is that since its publication many others have taken up this work, and it is deemed important that they be acquainted with the nomenclature which has become not only the standard of this society, but has also been adopted by other societies and many publications.

Roentgen: To be pronounced rent-gen.

Roentgen ray: A ray discovered and described by Wilhelm Konrad Roentgen.

Roentgenology: The study and practice of the roentgen ray as applied to medical science.

Roentgenologist: One skilled in roentgenology.

Roentgenogram: The shadow picture produced by the roentgen ray on a sensitized plate or film.

Roentgenograph (verb): To make a roentgenogram.

Roentgenoscope: An apparatus for examination with the fluorescent screen excited by the roentgen ray.

Roentgenoscopy: Examination by means of the roentgenoscope.

Roentgenography: The art of making roentgenograms.

Roentgenize: To apply the roentgen ray.

Roentgenization: Application of the roentgen ray.

Roentgenism: Untoward effect of the roentgen ray.

Roentgen diagnosis: roentgen therapy: roentgen dermatitis. These terms are self-explanatory.

Examinations of the National Board

The National Board of Medical Examiners announces the following dates for its next examinations:

Part I: February 12, 13 and 14, 1923.

Part II: February 15 and 16, 1923.

The fees for these examinations have been continued at the reduced rate for another year. Applications for these examinations must be forwarded not later than January 1, 1923. Application blanks and circulars of information may be obtained from the secretary of the National Board, Dr. J. S. Rodman, Medical Arts Building, Philadelphia, Pa.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page ix of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to Roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

BOOK REVIEWS

Contribucion al Estudio de los Tumores de la Hipofisis. By Wehrhahn R. Alejandro. 175 pages with illustrations. Santiago de Chile. Imp., Lit. y Enc. "La Illustracion," Calle Moneda, 873. 1922.

This is a splendid work on the clinical diagnosis and treatment of tumors of the hypophysis. Of special interest to the roentgenologist is the chapter by Dr. Kaplan, corresponding member of this society, on the roentgenographic sign. After a brief histological mention of the previous work done, the author gives a brief but complete summary of our present knowledge of this disease from the roentgenographic standpoint.

James T. Case.

Etude Anatomo-Radiologique des Vaisseaux de la Base du Coeur vus de face. By Dr. Robert Chaperon, Assistant de Radiologie des Hopitaux. 60 pages. Paris, France. 1922.

In reviewing the classical roentgenological publications relating to the heart, and especially relating to the blood-vessels of the base of the heart, one is astounded by the difference in the descriptions given by the various authors. In normal subjects the descriptions are similar, but the interpretations vary. In pathological cases the variations are accentuated, and if one consults the works which have recently appeared, he is astounded by the still greater variations in the descriptions. Recently, there have been published several works with the object of harmonizing the various interpretations and arriving at the truth. The author refers particularly to the work of Vaquez and Bordet. In spite of these efforts, there still exist disagreements in the descriptions of the border of the median cardiovascular shadow as seen in the frontal position of the normal subject. This and similar questions relating to the vessels of the base of the heart form the subject for this work.

James T. Case.

TRANSLATIONS & ABSTRACTS

Windrath. A Contribution to the Question of Roentgen Therapy in Pulmonary Tuberculosis. (*Med. Klin.*, 1921, No. 26.)

The author prefers the method proposed by Bacmeister, namely, the combined irradiation with roentgen rays and the quartz lamp. For twenty days, he irradiated every other day with the quartz sunlight lamp, the first treatment lasting three minutes, and increased the treatment by three minutes at each session. Then an interval of eight days. Then the first roentgen treatment, which consists in irradiating two fields in front and two behind, through 3 mm. of aluminum, one-third of the skin erythema dose, treating one field every other day. After an interval of eight days, the second roentgen treatment; this was followed by a second quartz-lamp-sunlight treatment. In progressive cases, the treatment had to be interrupted frequently. An examination of 14 cases after about two years demonstrated a favorable result. The author considers as especially favorable cases those which are either stationary, nodular, or inclined to induration.

Siegel. The Technique of Roentgen Irradiation in Malignant and Benign Hemorrhages. (*Strahlentherapie*, xii, No. 1.)

In order to eliminate the difficult physical measuring methods, which the author values highly, he advocates, in cases of menorrhagia, radiation at a distance over large portals of entry. He selects a portal of entry of 20 × 20 cm. and irradiates through a 0.5 mm. zinc filter at a focus skin distance of 50 cm. With a parallel spark-gap of 37 cm., at a depth of 10 cm., he obtains the ovary dose in one hour, the complete castration dose in two hours, the skin dose in three hours. In cases of carcinoma, he employs two fields, over the abdomen and sacrum, through a 1 mm. copper filter, the other conditions the same as above, with at least 150,000 volts, and obtains in a depth of 10 cm. over one area, the dose-quotient of more than one-half in eight to nine hours; and on the skin, four-fifths of the skin erythema dose. That is, with two fields, each rayed eight to nine hours, he obtains the full carcinoma dose in the depth. With this method, he lost only 10 per cent of the cases of metastatic carcinoma. In previous treatments, under similar conditions, he lost 25 per cent. The author calls this method a biologic self-measuring method, because he controls the measuring by the effect of the rays upon the function of the ovaries.

Levy, I. H. and Haft, H. H. The Incidence of Cecal Tuberculosis with Pulmonary Tuberculosis. (*Am. J. M. Sc.*, July, 1922, clxiv, No. 1.)

Tuberculous colitis is by no means an infrequent complication of pulmonary tuberculosis. From 70 to 90 per cent of all pulmonary cases show involvement of the gastrointestinal tract. Practically all cases with cavities show some involvement. Any portion of the intestinal tract may be involved, but the predominating site of involvement is in the ileocecal region, 51.4 per cent being in the ascending colon. Ileocecal tuberculosis, in the early stages, at least, is difficult to diagnose by ordinary means; neither the symptomatology, the physical examination nor the ordinary laboratory findings give the necessary information. Stierlin of Basle was the first to call attention to the roentgen diagnosis of ileocecal tuberculosis. In 1911, he reported 6 cases—4 of tuberculous colitis, 1 of cancer and 1 of ulcerative colitis—in which he was unable to fill the cecum and ascending colon with the opaque meal. These cases were all operated upon and verified. In 1912, Case, in a paper discussing tuberculosis of the ileocecal region says: "Ileocecal tuberculosis is a condition which, in a certain number of cases, can be almost surely diagnosed by the roentgen-ray examination." In 1917, Pirie of Montreal made *x*-ray studies of intestinal tuberculosis and said in part as follows: "We could not show the cecum filled by a barium meal because it never did fill when tuberculous ulceration was present. Setting out with this as a working hypothesis, we examined the cases at half-hour intervals from five to twelve hours after the barium meal. We found our theory correct in each case of tuberculous cecum, namely, the cecum never filled up with the meal. Each small squirt of barium which left the ileum was quickly passed on past the cecum and collected elsewhere in the colon." It was not until 1919, when Lawrasen Brown and Homer Sampson published their work on Early Diagnosis of Ulcerative Tuberculous Colitis, that this subject received the attention that it deserved. They substantiated the work of the former observers *in toto*, and gave their observations and conclusions in a large number of patients. They used a contrast enema and noted failure of the cecum to fill. Where a barium meal was given, they noted a pronounced hypomotility, barium remaining in the stomach for seven hours and even longer. W. R. Sante.

Watson, W. W. Human Actinomycosis. (*Surg., Gynec. & Obst.*, April, 1922.)

The writer discusses this subject under the headings: Biological Characteristics, Origin and Mode of Infection, Portal of Entry, Pathological Features, Clinical Course and Symptomatology, Differential Diagnosis, Prognosis, and Treatment.

Under the latter heading he states: "This seems to be one disease in which potassium iodide is specific." This should be given in heroic doses, beginning with not less than 75 drops of the saturated solution, thrice daily, well diluted. This may be increased one drop daily until 125 or 150 drops daily is reached.

Surgery was found valuable chiefly in jaw and neck cases, and only where the involved tissue can be widely excised. He does not believe surgery essential except where softening and abscess formation has taken place. He found no advantage in giving copper sulphate three times daily. The cases given potassium iodide alone did fully as well.

Although radium and *x*-rays have been widely advocated as of value in treatment of actinomycosis, the writer's experience indicates that they were of value only as adjuncts to the surgical and medical treatment. Radium hastens the softening of the actinomycotic tissues, but does not alone eradicate the parasite. Pulmonary and appendical cases were treated with radium and *x*-rays in addition to potassium iodide. It was possible to arrest the disease to a certain extent, but all proved fatal eventually.

In neck and jaw cases the prognosis is good. Skin cases eventually clear up under vigorous treatment.

A. C. C.

Kretschner, Herman L. Demonstration of Bladder Diverticula. (*Surg., Gynec. & Obst.*, April, 1922.)

Diverticula of the bladder are usually discovered during cystoscopic examination. The size and extent of the diverticula may be demonstrated by cystography, but this sometimes fails because of the position of the diverticulum. When this happens, an opaque catheter may be passed into the diverticulum and the latter filled with the opaque medium through the catheter. In addition to this, the writer has then injected the bladder with air in order to secure sharper definition of the diverticulum.

A. C. C.

Quick, Douglas A., and Johnson, F. M. Radium Treatment of Parotid Tumors. (*N. York State J. M.*, July, 1922, xxii, 7, 297.)

The problem of successfully combating parotid tumors has always been to the surgeon a difficult task. The limiting capsule of many parotid tumors is a snare, and if grossly injured, as it easily is, malignant cells which are restrained by nature's barrier are sown in the tissue, take root and grow. Sistrunk of the Mayo Clinic, in reporting 103 cases operated upon with twenty-eight recurrences, states that in practically every case of the series the operation was an excision of the encapsulated growth, thus forcing the reader to the conclusion that his cases were all distinctly favorable and early. He concludes that surgery is the only form of treatment, radium having little effect.

The authors declare that on the same type of tumor radium always performs its task in the same way. If efficiently used, its value is not disputed in skin lesions, in cancers of the mucous membranes of the mouth and in uterine growths. There are no anatomical or biochemical reasons for believing that parotid tumors behave differently from all others. In fact, they have generally been found highly susceptible to radium. At the Memorial Hospital, during the years 1918–1921, 59 cases of parotid gland tumors were treated. Twenty per cent of the cases were considered operable. No growth showing deep fixation, skin involvement, or metastatic nodal involvement, has been considered anything but inoperable. The cases were about equally divided between the sexes, occurring with slightly greater frequency in females (53.7 per cent). Half of the cases had been operated upon elsewhere with recurrences which appeared from six weeks to six years after operation; 51.0 per cent of the cases were primary. In reviewing the histories of the operated cases, it seemed evident that the malignant characters were increased by repeated attempts at removal. Only two of the operated cases were benefited.

The preliminary phase of the radiation treatment as carried out by the authors involved an external radiation of about 2,200 mc. hours, the emanation being 3 cm. from the skin surface; filter, 0.5 mm. of silver and 2 mm. of brass. Applicator 24 sq. cm. Such applicator gives skin erythema over an area of about 50 sq. cm. For very large tumors a dose of 9,000 mc. hours at a distance of 6 cm. may be used, the filter remaining the same, but the area of the applicator increasing to about 77 sq. cm. For most lesions the above dosage is not sufficient, especially for the firm mixed tumors which contain abundant fibrous tissue or cartilage. For these and for unresponsive carcinomas, the authors use unfiltered glass tubes of emanation, 3 mm. in length, about 0.3 mm. in diameter, containing usually 1 to 1.5 mc. The insertion of these glass tubes is preferably done through a skin incision. In two cases, the authors produced paralysis of the seventh cranial nerve. Successful irradiation is followed clinically at first by hyperemia of the overlying tissue, and swelling and softening of the tumor. As fibrous tissue is produced, the tumor becomes smaller and firmer, and if it originally was of a cellular type the anticipated result would be a very small fibrotic inert mass. These changes occur during many weeks after treatment, and it is therefore important not to repeat the dosage too soon. The authors firmly believe that fibrotic masses remaining after treatment should be observed frequently, but not removed.

Results for four years ending 1921 may be tabulated as follows:

	No. of Cases	*Clinically Free of Disease*	*Improved*	*Unimproved*
Primary Operable	8	7	1	0
Primary Inoperable	20	7	7	6
Recurrent Operable	3	3	0	0
Recurrent Inoperable	23	5	8	10

The authors conclude that in the case of mixed tumors, if the case is favorable for excision, it is likewise favorable for radium therapy, and the latter does not predispose to recurrence or the production of metastases. If the tumor is inoperable, radium offers an opportunity that may lead to improvement or clinical cure. In carcinomas, whereas surgical results are very disappointing, radium treatment affords a reasonable hope of disease control or clinical cure.

Pfahler, George E. Radiotherapy in Carcinoma of the Breast. (*Surg., Gynec. & Obst.*, Aug., 1922, xxxv, pp. 217–226.)

The author describes his roentgen technique for ante-operative treatment as follows: Three areas are defined by drawing a horizontal line across the front of the chest on a level with the lower border of the axillary fold and another horizontal line posteriorly at the level of the spine of the scapula. The area above these lines is the supraclavicular area to be treated. The area below the anterior line is the mammary area to be treated, and has the mid-axillary line for its posterior limit. The third area is below the posterior horizontal line. He treats over each of these areas through 6 mm. of aluminum at 40 cm. distance, using a 9 inch spark-gap, for forty minutes, all the areas being covered within a week. The three areas are again given the same dose during the second week, so that each area receives its two doses a week apart.

Dr. Pfahler draws the following conclusions:

1. It has been shown that thorough radiation treatment of cancer tissue will devitalize the cancer cells so as to interfere with their inoculation or further development. This justifies our recommendation of ante-operative treatment.
2. It has been shown that radiation effects are most evident on new growing tumor, and that such radiation will prevent the growth of inoculated tumors. Therefore, we recommend active postoperative treatment in cancer of the breast.
3. Visible and palpable recurrent metastatic cancer are probably only an index of similar disease elsewhere, and therefore, the treatment of these cases should not be confined simply to the palpable and visible disease. Such visible and palpable disease should receive the most active treatment, and a sufficient amount to cause its destruction and disappearance.
4. Thorough radiation treatment will cause the disappearance of tumor tissue in some cases and, therefore, can be recommended when there is any reason for avoiding an operation.
5. In every case of cancer of the breast, there should be an x-ray examination of the chest, and this should be repeated from time to time to detect any possible invasion of the mediastinum or lungs, sternum, or spine.

James T. Case.

Carman, Russell D. Limitations of Roentgenologic Diagnosis. (*N. York State J. M.*, July, 1922, xxii, 302.)

A scholarly presentation of the present value of the roentgen rays in diagnosis. This is another example of the fact that roentgenologists have pointed out their limitations quite as freely as other medical workers. The essayist especially refers to the limitations of the roentgen diagnostic method in pulmonary tuberculosis; in the pathological differentiation of thoracic tumors; in the differential diagnosis of osteomyelitis, tuberculosis, sarcoma, syphilis, metastatic malignancy, and Paget's disease; in the differentiation of gastric carcinoma from gastric syphilis; in the differentiation between a small cancer, gastric ulcer near the pylorus, duodenal ulcer with adhesions, and a syphilitic lesion near the pylorus; and especially in the diagnosis of adhesions, chronic appendicitis, gastroptosis, enteroptosis, stasis, gall-stones, and disease of the gall-bladder.

NUZUM, FRANKLIN R. The Pathology and Bacteriology of Excised Tonsils and the Effect of *X*-ray Therapy upon the Bacterial Flora of the Tonsils. (*Calif. State J. M.*, July, 1922, xx, 237.)

Seven per cent of 218 pairs of tonsils removed presented no microscopic evidence of disease. Ninety-six and one-tenth per cent of this group of 218 pairs of tonsils harbored hemolytic streptococci. Of the three groups of hemolytic streptococci, Alpha, Alpha prime and Beta, the last were found much more frequently. There seemed to be a relation between the pathology of the excised tonsil and the type of organism it harbored. Roentgenotherapy was effective in reducing the size of tonsils in but 16 per cent of this series. Hemolytic streptococci, the essential organism in chronically infected tonsils, were permanently removed in but 50 per cent of the patients treated.

NIELSEN, N. AAGE. About the Choice between Medical and Surgical Treatment of Ulcus Ventriculi S. Duodeni. (*Acta Chir. Scandinavica*, July 15, 1922, lv, No. 1.)

A review of the literature shows that it has never been possible to state the frequency of carcinoma ex ulcere; in fact, its existence has not even been demonstrated definitely.

The present material does not indicate that ulcus simplex ventriculi s. duodeni has any tendency to become cancerous. It could not be proved during a period of observation of two and one-half to nineteen years that 221 patients with ulcus symptoms which were clinically certain and of several years' duration, had any special tendency to gastric cancer.

The disease, which has formerly been considered as carcinoma ex ulcere, is a primary ulcus-simulating cancer. The symptoms appear almost always after the thirtieth year, and develop in the course of a relatively short time into a serious clinical "ulcus picture," on which the effect of a medical ulcus treatment is poor, or but of short duration; and have caused death in the cases here examined, in the course of one to five and one-fourth years after the first appearance of the symptoms.

This cancer may often be clinically distinguished from ulcus simplex with so great a probability that an operative removal of the ulcer is justified.

JAMES T. CASE.

KOLISCHER, G. Surgical Diathermy and Radiotherapy in Cancer of the Uterus. (*Surg., Gynec. & Obst.*, Aug., 1922, xxxv, pp. 227–229.)

The author's experience leads him to believe that the best method of treatment of uterine cancer is electrocoagulation, followed immediately by *x*-ray or radium therapy.

He offers arguments in support of the theory that the beneficial action of radiation on cancer is not due to a direct destructive effect on the cell, but to the production of certain materials which in time produce defensive ferments which act on the tumors.

The aim, then, should be the removal of the "decayed and decaying cancer cells," and the production of a real chemotherapy by stimulation of the virile cancer cells to the production of ferments.

JAMES T. CASE.

MÉRY, DÉTRÉ and DESMOULINS. Radiodiagnosis of Gangliopulmonary Tuberculosis in the Child. (*Presse Méd.*, March 19, 1921, xxix, 23.)

The clinical diagnosis of this affection should always be checked up by radiography, for the latter resource is suited for giving exact information about the lesions of the hilus which are not readily accessible to physical diagnosis. When one is a little self-hypnotized about the apices it is radioscopy which brings out the hilus lesions. From initial radioscopies followed by radiography with breath held, it is very often possible to obtain ramified shadows in the hilus which stand out in plain relief from the lung and are almost always reinforced by minute lenticular spots. These shadows formerly perplexed the roentgenologist: in 1904, De la Camp thought them to pertain to the normal bronchovascular pedicle. In 1907, Sturtz interpreted them as due to peribronchitic lymphatic infiltration with minute calcified ganglia. A year later, Rieder gave the correct interpretation. Today, we admit that the bronchovascular pedicles are normally visible as discrete shadows (at least on the screen); and that peribronchitis of whatever kind reinforces and extends the faint and circumscribed pedicular shadow; and that finally sclerosis or calcification gives a still better definition. It is natural to connect with these shadows the interbronchial ganglia which are seen on autopsy to be hypertrophic, tuberculous or calcified—satellites of the mediastinal glands—but the general result is the same, for in either case we are dealing with the same process and the differentiation adds nothing to our basic diagnosis.

In radiodiagnosis of ganglionopulmonary tuberculosis of the child, the authors isolate a first degree in which hilus shadows are seen with disconcerting frequency in routine examination. The children with such shadows may give a negative skin reaction. They are not necessarily indicative of tuberculosis, for they are seen after whooping cough and measles. Later, the shadows are ramified as in the first degree and may be no broader, but they are more entangled, and especially softer. The image shows great variability in the individual case, but common to all is the infiltrated character which indicates an active process, when there can be no doubt as to the tuberculous nature. The neighborhood reactions may or may not be extensive. But in this second degree the tendency is invariably to recovery, although in the individual case death may follow from lesions elsewhere (peritonitis). In the third degree the shadow loses its sof: character and becomes again clean and distinct. The ramifications are darker and show spots of calcification, which may be in fine groups or so large and distinct as to resemble foreign bodies. Calcifications are indelible traces of tuberculosis. The phenomenon of aberrant calcification outside the hilus area is occasionally visible as a single isolated spot which indicates a distinct inoculation of tuberculosis somewhere in the lung; this focus was the parent lesion of the tracheobronchial adenopathy.

Kohlmann. Clinical and Roentgen Diagnosis of Multiple Myelomata. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, Heft 1.)

The author cites 3 cases of multiple myeloma, and discusses the differential diagnosis. As a roentgenological point of distinction from osteomalacia, he enumerates the following: 1. Osteomalacia never attacks the cranial bones; myeloma very frequently. 2. In osteomalacia, the shape of the pelvis is usually that of the heart in playing cards; with myeloma there are no changes. 3. Osteomalacia presents diffuse absorption of the calcium salts in the bones; myeloma presents numerous circular areas of transparency of small size. 4. In osteomalacia, there is pliability of the long bones and consequent change in form; in myeloma, the contours are well preserved and there is tendency to spontaneous fracture. Difficult is the differential diagnosis between myeloma and osteoclastic carcinomatosis: in myeloma, the transparencies of the bone are more sharply circumscribed than in carcinoma, the process is more diffused, all ribs, the scapulae, the pelvic bones are affected; in carcinoma the lesion is rarely so extensive. In sarcoma, the corticalis is thinned out and expanded, which is not the case in myeloma. Early diagnosis by means of the *x*-ray is possible, and is of great value for its treatment.

Werner and Grode. The Present Status of Radiation of Malignant Tumors. (*Ergebn. d. Chir. u. Orthop.*, 1921, xiv.)

The fundamental requisites for radiation therapy of malignant tumors are apparatuses which will generate the hardest possible rays and the greatest intensity. To this type belongs the symmetry apparatus of Reiniger, Gebbert and Schall (Erlangen), the intensive reform apparatus of Veifa-Werke (Frankfort-on-the-Main), and the radio-silex apparatus of Koch and Sterzel (Dresden). These apparatuses are constructed on entirely new principles. The most important innovation in the methods of measuring is that of Glocker and Reusch. It consists in measuring the ionization with a mirror-galvanometer instead of an electroscope. By this means, the intensity of the radiation is determined during the entire period of treatment. Every change is at once apparent, and, by regulation, the same surface doses per second can be obtained.

The intensity of the biological effect of roentgen and radium rays, according to Krönig and Friedrich, is dependent only upon the absorbed radiant energy. It is, within very wide limits, entirely independent of the hardness of the rays. With the equal dosage, the effect is stronger if the radiation is given during a short time with higher intensity, than during a long time with lesser intensity. The effect of the gamma rays of radium or of mesathorium filtered through 1.5 mm. of brass and 5.0 mm. of celluloid is virtually the same as the effect of roentgen rays filtered through 1.0 mm. of copper. The authors recommend treatment with radium alone only in superficially situated small tumors, and, in the cases of the large ones, only in places where the concentric roentgen radiation is practically impossible.

Clinical experience would suggest more frequent experiments with irradiation in brain tumor cases, inasmuch as a large number of curative results have been reported. In early cases of carcinoma of the tongue, the best results are promised by operating, and then irradiating afterwards. In cases of carcinoma of the esophagus, irradiation with radium and roentgen rays resulted in improvement for only a short time, excepting in one case. Cases of gastric carcinoma reacted favorably in a very few instances. Carcinomata of the colon, operated on radically and then systematically irradiated, remained, in almost all instances, free from recurrence. Prevention of recurrences in carcinoma of the breast could not be achieved. The usefulness of roentgen therapy, however, is shown by its potency to cause the disappearance of recurrences and to produce cures which have lasted several years. The most rational method appears to be the following: First, a thorough extirpation of the carcinoma; then in the first year, irradiation five to six times, in the second year, three to four times, and then two or three times, according to circumstances. In cases of carcinoma of the uterus, the question is whether one should merely irradiate, or operate and then irradiate. According to the statistics of Warnekros, there were, during a period of observation extending from three to six years, 55 per cent of recurrences without postoperative irradiation, and 18 per cent of recurrences with postoperative irradiation. Seitz and Wintz found that after three years, only 25 per cent of the patients suffering from uterine carcinoma, who had not been operated upon, but who had been treated by combined radium and roentgen rays, were alive. From this the conclusion can be formed that surgical operation represents a momentary greater risk, but gives better chance for permanent cure. The carcinoma and sarcoma doses as advocated by Seitz and Wintz can be accepted only as the lower limit, because even 200 and 250 per cent of the skin unit dose were not sufficient, in some cases, to destroy the tumor tissue. For this reason, radiation therapy challenges surgery only in cases of skin epithelioma, carcinoma of the pharynx and of the larynx (above the vocal cords), carcinoma of the mucous membrane of the cheek, of the lips, and in lymphosarcoma. Very frequently the value of postoperative irradiation is quite evident, especially after incomplete operative procedure. The limits of irradiation are indicated by the patient's general condition, the drop of leukocytes to below 2,000, blood changes, and serious damage of the neighboring connective tissue. Inasmuch as sufficient radiosensibility occurs only in some of the malignant tumors, and histological appearances can give us no clue, every irradiation of a malignant tumor becomes more or less of an experiment.

Isaak. Multiple Myelomata. (*Ergebn. d. Chir. u. Orthop.*, 1921, xiv.)

The clinical picture frequently remains indefinite up to the patient's death, and the diagnosis is made only at autopsy. Roentgenograms, however, frequently give important diagnostic points: fractures and infractions, change in the structure of the bones, thinning of the corticalis, disappearance of the spongy portions. Instead of the spongiosa, there are found partly circumscribed, partly more diffuse, transparencies. The author believes it impossible to differentiate myelomata from secondary tumors of the bone-marrow. For treatment, he proposes roentgen radiation, intravenous injections of thorium X or benzol.

(Assmann also in his book on "Roentgen Diagnosis of Internal Diseases" points out that the defects in cases of multiple myeloma are apparently somewhat better circumscribed than carcinoma metastases, but that in many cases, a definite differentiation by *x*-rays alone is not possible. According to Assmann, it is not yet settled whether the multiple myeloma belongs to the general tumors or to the leukemic diseases. In the latter, especially in the lymphatic and myelogenous leukemias, Haenisch and Querner found transparencies in the bone shadows which had greatly resembled the appearance of metastatic bone tumors. Reviewer's Note.)

Schmidt. Results of the Radiation Therapy at the Gynecological Clinic of the University of Bonn. (*Strahlentherapie*, 1921, xii, Heft 1.)

The author had similar successful results with the irradiation of sarcoma of the uterus and ovaries, as with carcinomata of the ovaries. In contradistinction to Seitz and Wintz, he first operates upon carcinoma of the uterus, and then irradiates. For the castration dose, he recommends a single session, which gives 100 per cent lasting results, while serial irradiation gives only 98 per cent. The ill effects are not more severe after a single session than they are after a series of irradiations. It is interesting to note that he induced the desired temporary sterilization in a woman of thirty-one. Menstruation recurred, as intended, after six months, and was regular and normal.

Zweifel. Radiotherapy of Myomata and Metropathies of the Uterus. (*Strahlentherapie*, 1921, xii, Heft 1.)

At Doederlein's University Gynecological Clinic, the following conditions are accepted as contraindications:

1. Very large myomata extending above the navel.
2. In cases in which it is desirable to retain menstrual function in the uterus.
3. All myomata with malignant degeneration.
4. Purulent or gangrenous myomata.
5. Subperitoneal pedunculated myomata.
6. Completely or partially prolapsed submucous myomata.
7. Myomata with tumors of the adnexa.
8. Myomata which cause compression symptoms.

Notwithstanding this very careful selection, 64 per cent of the myomata were irradiated: 438 myomata, and 320 cases of metropathies and climacteric bleeding. It is best to irradiate during the first half of the intermenstrual period. In most instances, the tumor diminished in size, and in some, normal conditions were obtained. One patient who was treated during the fourth month of pregnancy for a myoma as large as a fist, gave birth to a normally developed, healthy child. Nurnberger estimates the frequency of deformities of irradiated foeti at 3 per cent.

SIEGEL. The Length of Life of Women Suffering from Carcinoma of the Uterus. (*Strahlentherapie*, 1921, xii, Heft 1.)

The author believes that the end result of radical operations, such as Wertheimer's total extirpation, is not better than that of the less radical procedures. He recommends that uterine carcinoma should be rayed in institutions only which are equipped to measure exactly the applied *x*-ray or radium dosage by means of the iontoquantimeter. Otherwise, he recommends operative procedure to be followed by radiation for the prevention of recurrences. Technique: distant large fields irradiation and 1 mm. copper filter.

WERTHEIMER, SELMA. Metastases from Irradiated and Non-irradiated Carcinomata of the Cervix. (*Strahlentherapie*, 1921, xii, Heft 1.)

Fifty-four irradiated and 50 non-irradiated cases, among which there were 32 postoperative cases of carcinoma of the cervix, were particularly carefully examined at autopsy for metastases. In cases that were not rayed there were metastases in 54 per cent. In those cases that were treated by *x*-rays, radium, or by both, there were metastases in 48 per cent. This shows that radiation therapy of carcinoma of the cervix does not increase metastases. The liver, however, is unique, in that carcinomatous metastases were found in 26 per cent of the irradiated cases, and in 14 per cent of the cases not rayed.

KLEWITZ. Roentgen Deep Therapy of Internal Diseases. (*Strahlentherapie*, 1921, xii, Heft 1.)

In myelogenous leukemias, the author found irradiation of the spleen sufficient. Occasionally, he also rays the liver and the bones, but avoids forced irradiation, and ceases treating when the number of leukocytes has dropped to 20,000 or 30,000. In lymphatic leukemias, his results are frequently less favorable. In acute cases, irradiation is often without effect. Polycythemia was treated successfully; at first the long bones, then the sternum, later the spleen. With mild irradiation of the spleen (1/4 of the skin unit dose over one field) he occasionally had good success when there were hemorrhages. Pulmonary tuberculosis was rayed with a 1/4 skin unit dose, size of field 10 by 15 cm., 4 mm. of aluminum, causing no ill effects. Fever was no contraindication. It was not possible to claim good results with any degree of certainty. In tuberculosis of the peritoneum, he used one skin unit dose and 4 large fields. Radiation over many fields has resulted in disastrously excessive dosage. Bronchial asthma reacted favorably to irradiation (7 fields, 10 × 15 cm., 1/3 skin unit dose each). In neuralgias, he had good results in only a few cases; in chronic articular rheumatism, there were frequently very brilliant results, and just as frequently poor ones, but the relief from pain was noted in almost every case.

JÜNGLING. Treatment of Sarcoma with Roentgen Rays. (*Strahlentherapie*, 1921, xii, Heft 1.)

According to extensive statistics, 20 to 25 per cent of sarcomata remained unaffected by radiation therapy. It is true that sarcomata which disappear as the result of radiation do not recur, but this method does not protect against metastases. Cachexia in sarcoma is not the contraindication to radiation that it is in carcinoma. In sarcomata of the skin, one can always at first try radiotherapy. On the other hand, sarcomata of the upper jaw are the poorest cases for radiation. For this reason, operable cases should be operated upon. Lymphosarcomata occasionally disappear after the application of 30 per cent of the skin unit dose. Even in sarcoma of the pelvis, very astonishing results have frequently been obtained. Sarcomata of the extremities must be very sharply divided into periosteal and *myelogenous;* the latter are relatively benign, consequently they can be resected. In periosteal sarcomsta, surgical means are powerless; consequently an attempt at irradiation should be made. This, however, must be of the homogeneous type.

BACMEISTER. The Roentgen Therapy of Pulmonary and Intestinal Tuberculosis. (*Strahlentherapie*, 1921, xii, Heft 1.)

The solid foundation for the roentgen treatment of pulmonary tuberculosis was created only through the experimental work of Küpferle and Bacmeister, who demonstrated that even in pulmonary tuberculosis, the tuberculosis granulation tissue can be transformed by radiation into scar tissue, while the tubercle bacilli are not affected. Where the granulation tissue recedes, roentgen therapy is powerless, so in all acutely progressive and acutely destructive processes it can only aid the natural process of healing, and stimulate and increase scar formation. For this reason, the type of the pulmonary tuberculosis must be determined before the irradiation treatment by exact clinical observations and by roentgen diagnosis; radiation of ambulatory cases must be avoided. Only the slowly progressive, the stationary, and those forms of the cerotic and nodular tuberculosis which have the tendency to become latent, are adapted for radiation. Not only the indication for treatment, but also the technique, is very important. The stimulating effect for the development of connective tissue is the result to be obtained. The author employs the 4 mm. aluminum filter, large areas, small doses (8 to 30 per cent of the skin unit doses) up to 5 fields from in front as well as from behind, and long intervals for the reaction. He warns against over-enthusiastic hopes, but he considers the roentgen treatment of pulmonary tuberculosis a very valuable aid in the treatment at sanatoria, which cannot be replaced by anything else. He has also had very good results in intestinal tuberculosis. His technique is 20 to 40 per cent of the skin unit dose, 4 large fields, 4 mm. of the aluminum filter.

Bryant, John, Visceral Adhesions and Bands; Normal Incidence. A Preliminary Report. (*Am. J. M. Sc.*, January, 1922, clxiii, 1, p. 75.)

The frequency of occurrence of adhesions or bands in the fetus of both sexes has been greatly underestimated. Of a group of 34 fetal cases of both sexes, only 5.9 per cent were free from demonstrable adhesions or bands: 100 per cent of the 18 male feti showed such variations from the normal.

The adhesions present in the fetus are less varied in number and of a definitely less complex type than those found to occur in later life.

The age of forty is critical in both sexes. There is practically no increase in frequency above the fetal rate of involvement for the different viscera by adhesions until the age of forty. Beyond the age of forty, there is a sudden increase of about 50 per cent in the involvement of the different viscera by adhesions in both sexes, the increase being somewhat more marked in the female than in the male.

The two actual adhesions or bands found to occur most often in both sexes at all ages are, in their order of frequency, as follows: (*a*) Gall-bladder to the duodenum and to the transverse colon in both sexes; (*b*) gall-bladder to the transverse colon in the male and the gall-bladder to the duodenum in the female. In both the male and the female fetus the two adhesions or bands most frequently found were: (*a*) Gall-bladder to the duodenum and to the transverse colon; (*b*) gall-bladder to the transverse colon. It would therefore appear that these two most frequently occurring adhesions or bands are of congenital or developmental origin.

The regions or quadrants of the abdomen most frequently involved by adhesions or bands in both sexes are, in their order of frequency, as follows: Right upper quadrant, right lower quardant, left upper quadrant, left lower quadrant.

Kumer, L. The Management of Roentgen and Radium Ulcers (Ein Beitrag zur Therapie des Rontgen und Radiumulcus), München. med. Wchnschr, Aug. 6, 1921, lxviii, p. 1084.

The radical treatment of roentgen and radium ulcers is excision with subsequent sliding skin flap or skin transplantation to cover the defect. This method, however, can only be used when the ulcer is favorably located, and in some cases it develops into a rather serious surgical intervention. In the clinic of Prog. Riehl, continuous water baths have been used for a long while. Sacken also reports good results with this method. The purpose of the treatment is to prevent diseased parts from contact with any irritating substance. The relief from pain is very marked. Continuous submersion in warm water hinders necrosis by permitting much better blood supply to the diseased parts. Wetterer has employed fomentations with water containing hot camomile. Bettmann reports favorable results from the use of physiological saline solution, both as a douche and as a fomentation.

Wetterer. Roentgen Treatment of a Few Complications of Gonorrhea. First Experiments with Acute and Chronic Gonorrhea. *Strahlentherapie*, 1921, xii, Heft 2.

Wetterer had for several years observed a favorable effect of the roentgen rays upon gonorrhoic processes in the vicinity of the urethra, and upon gonorrheal prostatitis, especially paraurethritis, and he consequently decided to irradiate the penis as well as the female genital organs in cases of acute as well as chronic gonorrhea.

For gonorrheal arthritis, roentgen therapy is of great value. All joints react similarly well; in cases of hydrarthrosis there must be several prophylactic radiations after the exudate has been formed. Prognosis is best in acute and subacute cases, but also the chronic and even protracted cases are likely to improve under the treatment. Periostitis blennorrhoica reacts favorably as long as the focus still retains a doughy feeling. In 75 cases of gonorrheal disease of the organs of locomotion, the author did not have a single failure. In most instances the result was astonishing. Adenitis blennorrhoica reacts favorably to radiation whenever it has to be radiated. Gonorrheal prostatitis is one of the best indications for roentgen therapy; the acute as well as the parenchymatous forms are generally very favorably influenced. The chronic form, of course, requires longer intermittent treatment, but is also favorably influenced. Potential coeundi can become normal again. In gonorrheal inflammation of the seminal vesicles there is a rapid resolution, but in gonorrheal epididymitis, the result seems doubtful to him. On the other hand, paraurethral infiltrations and abscesses are very favorable for radiation. Among the complications in women, gonorrheal salpingitis and oophoritis were strikingly improved. In one case the author could not yet make any definite statement as to the duration of the result. Acute gonorrheal urethritis and gonorrhea of the cervix were the more easily favorably affected, the earlier the case came for treatment. In the male, the end result appeared, as a general rule, more quickly than usual, although at first there was the marked reaction of irradiation. In the cases which are radiated early, the processes never extended to the posterior urethra or the prostate. Chronic gonorrheal urethritis with extensive infiltrations in the mucous membrane and with granulations in a very favorable object for experiments with roentgen rays. In cases of acute and chronic gonorrheal inflammations of the cervix, Wetterer saw several favorable cases as well as absolute failures. The provocation of gonococci by roentgen rays in the male as well as in the female, owing to the produced inflammatory reaction, was successful even in such cases where bougies, stretching, arthigon had failed. The irradiation was made with a filter of 1 mm. cu., 1 mm. Al. and a sheet of celluloid. Technique was practically the same as in gynecology. The dosage was not quite as high as in gynecology; it was a little below the erythema dose.

Rieder. Prevention of the General Disagreeable Symptoms after Deep Therapy (Roentgen Sickness). *Strahlentherapie*, 1921, xii, Heft 2.

The cases of roentgen sickness, according to the author, are not only due to toxemia by ozone, but also to changes in the deep tissues due to electric charges. If the patients were grounded, irradiation was borne considerably better. In order to avoid electric shock through the grounding, it is necessary to make a broad and safe contact between the patient and the earth. The elastic metal band was applied directly to the skin of the limb of the patient, but this was applied only if the focus skin distance was at least 40 cm.; otherwise the possibility of discharge from the tube to the patient could not be definitely avoided. The grounding cable must be at a distance of at least 70 cm. from the high-tension wiring. It is also unsafe for the patient if the axis of the tube cathode is parellel to the axis of the body. This is surely so at the focus skin distance of less than 60 cm. With this precaution (grounding) and by exposing to irradiation as small segments of the body as is possible, which can be accomplished by the Holfelder method, roentgen sickness was avoided in cases of prolonged irradiation. The exceptions to this were only cases of irradiation of the splanchnic area, but here very large doses of laudanum-scopolamin were of great assistance, because they stopped vomiting and roentgen sickness. Even for long radiation laudanum-scopolamin proved an excellent narcotic which has a soothing effect upon the center of vomiting.

Schröder. Regarding the Treatment of Pulmonary Tuberculosis with Roentgen Rays. *Deutsche med. Wchnschr.*, 1921, No. 45.

Early cases, principally, should be treated. Chronic cases, even though they may present evidence of slight destructive processes, should be treated, but only if scar formation has begun to appear. The effect desired is the biological increase in the activity of those cells which cause formation of connective tissue, but do not cause disintegration of the diseased tissue. This effect can be obtained by stimulating doses. Fraenkel rays, with stimulating doses, the foci in the lungs and the spleen simultaneously. According to him, the spleen is the more important organ because it forms antibodies and fat-splitting ferments, a process which may be accelerated by stimulating doses. The author has checked up animal experiments made by Küpferle and Bacmeister, but he chose for infecting the guinea-pigs the bovine type of the tubercle bacillus and not, as Bacmeister did, the less virulent human type. In very extensive experiments which were modified in various ways, the author infected the guinea-pigs, partly subcutaneously, partly intravenously, with .1 mg., and later, .05 mg. of the virus, and rayed the animals at varying intervals with 1/3 to 1 skin erythema dose. The comparison of the control animals which were infected but were not rayed showed no effect upon body weight or length of life of the animals. Autopsy findings showed no perceptible difference, but the favorable effect of the irradiation was distinctly recognizable in the cases of tuberculous adenitis produced experimentally. In the animals which had been rayed with large doses, there were at the site of the infection small hard nodules up to the size of a bean, and in the control animals there were caseous nodes varying in size from a plum up to a small apple.

For the clinical experiments, 11 patients with relatively benign chronic types were selected. Radiation: one field at intervals of two to three weeks, 0.6 to 1.0 skin erythema dose per field was given. Three patients were simultaneously treated with pneumothorax, 7 with careful vaccinations, 3 by irradiation with the quartz lamp. Although the author frequently obtained the impression that retraction of the tissue was stimulated, no really favorable effect was obtained by roentgen therapy. In a few cases he saw injurious effects, which should cause us to be very cautious. For this reason, he considers it more advisable to use the stimulating doses suggested by Baemeister, in order to work with less danger to the patient. In tracheobronchial tuberculosis, however, the author had undoubtedly good results.

Huldschinsky. The Treatment of Rachitis with Ultraviolet Rays. *Zeitsc. f. Orthop. Chir.*, 1920, xxxix.

In view of the very favorable results, the author is of the opinion that radiation with ultraviolet light is a specific in the therapy of rachitis. All children from one and a half to six and a half years, suffering from rachitis in varying degrees, who were treated with ultraviolet rays, were cured in two months. All told, there were 22 to 26 treatments. Huldschinsky considers this assertion proved by means of extensive *x*-ray examinations; the roentgen findings serve as a test of the process of healing; calcareous or osseous deposits and new-bone formation were demonstrated. The irradiated children showed a tendency to healing after one month, which became very marked at the end of two. One child had been in the hospital already ten months suffering from severe rickets which resisted all therapeutic methods; aside from the physical findings, the patient made the impression of a complete idiot, but in two months of irradiation rapid mental and physical improvement was shown. The author used a quartz mercury lamp (artificial alpine sun) without filter. In determining dosage, one must attempt to avoid that the patient becomes accustomed to the rays. As soon as the result is obtained, treatment should be interrupted, and should be begun again with small doses after eight to fourteen days. The author believes that intensive initial treatment promises better result. He believes that the effect of natural sun rays can be an obstructive one, owing to the formation of pigments. For orthopedic surgery this method is of especial importance, because in acute rickets surgery can be employed at any stage if there is postoperative radiation. The plaster cast is no obstruction to the rays; if it is removed four weeks after operation the fracture will be found healed and the bones sufficiently calcified to prevent renewed deformity. The author believes that the prevalence of rickets in Germany as a result of the war and post-war years can be made to disappear completely.

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Paul B. Hoeber, 67-69 East 59th Street, New York