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X-RAYS IN MILITARY SURGERY*

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IN addition to the humanitarian impulse that constitutes a deep activating force in the heart of every true physician and leads him to put forth his best efforts in the behalf of the human wreckage of war, there is another and harsher necessity laid upon him in wartime military service; namely, to keep the maximum number of men in the battle lines. Possibly this fact has been emphasized before, but it will bear repetition for it is properly a fundamental feature of military surgery. Happily, the humanitarian and military responsibilities usually go hand in hand, save when, in the heat of action, it becomes more important to return the slightly injured to battle than to attend to serious cases.

HISTORICAL DEVELOPMENT

Certain it is that, in dealing with the casualties of war and all the various kindred surgical problems of wartime, the *x*-ray is a prime essential. Its discovery and utilization was one of the most important milestones in surgical annals and its military importance was promptly recognized. In 1897 successful use of the *x*-ray was accomplished in the Graeco-Turkish war. The British used it on the Indian frontier in 1898 and, later, somewhat extensively in the Boer War. In this country, at the outbreak of the Spanish American war, the more important Army hospitals and three hospital ships were equipped with *x*-ray apparatus. Seventeen machines were provided in all.[1]

At that time construction was in an elementary stage. Induction coils and static machines were used to activate "gas" tubes

* The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

and thereby produce a feeble beam of "soft" roentgen rays. Batteries were commonly used, or occasionally direct current from a dynamo was available either to activate a coil or rotate the plates of a static machine. Radiographs were made on glass plates, and their production was something of an abstruse art worthy of the efforts of a crystal gazer, so variable and poorly controlled were the factors. Exposures were enormous: hands, one to two minutes, shoulders, ten minutes and head, pelvis and spine about twenty minutes. It is remarkable that only a few cases of burns are recorded, and also that creditable work, including localization, was done. Naturally, use of roentgen rays near the front lines was impossible and, in fact, decried, since it was earnestly felt that its employment there would tempt the more injudicious and overenthusiastic surgeons to attempt premature operations under bad circumstances. And in spite of our vastly improved facilities, or perhaps because of them, we can still lend an ear to these views with profit and apply our best judgment to this particular problem of how far forward to station roentgenologic units.

When, almost two decades later, we finally slipped into the vortex of the first World War, the military services were not any too well equipped with *x*-ray facilities, as was of course in keeping with the state of unpreparedness generally. Only the larger hospitals had roentgenologic units, and very few trained roentgenologists were in the active service or reserve corps. Thus, a weighty problem had to be dealt with without delay, and prodigious efforts were required for its successful solution as may be read in an account by Manges.[2] Suffice it to say that the radiator type of self-rectifying tube was developed, generators were improved, ambulance roentgenologic units provided, and schools for roentgenologists and technicians established. In all, 719 roentgenologic units were sent abroad—a most creditable record.

ROENTGENOLOGIC FACILITIES OF THE NAVY AND ARMY TODAY

As we now prepare ourselves for any eventuality, in these troubled days when the clash of arms again fills the world, we

find ourselves in a much better situation in regard to roentgenologic personnel and equipment.

In the Navy, for a number of years, medical officers have been encouraged to specialize in roentgenology and have been given courses in some of our great civilian medical centers. In addition, roentgenologists have been enrolled in the reserve corps and are available in case of necessity. Training of *technicians* likewise has not been neglected. It has been carried out in our major hospitals and, in Washington, a twenty weeks' course is given to men of proper aptitude. In regard to *equipment,* the larger hospitals have full diagnostic facilities and installations for therapy that include 200 kv. units. Various smaller hospitals and dispensaries have appropriate installations; hospital ships have facilities for all but deep roentgen therapy. Most other ships have either some type of mobile unit or a dental unit. In regard to the latter, it is surprising what it can accomplish in the way of roentgenography. Suitable equipment is also available for expeditionary units.

In the Army the story is much the same.[3] Its Medical Corps has studied the problem of field equipment with a special thoroughness. In general, apparatus for use in the field is now far advanced technically. It is shock and ray proof, of adequate capacity, portable, durable, and easy to assemble and disassemble. Processing installations are excellent. One is sorely tempted to dilate further on this matter but space forbids.

APPLICATION OF ROENTGENOLOGY TO SURGICAL CONDITIONS

It is only possible to summarize here the subject of the employment of *x*-rays in surgical conditions. In so doing, I have in mind more particularly those physicians who are relatively new to roentgenology or its military applications, or perhaps to both.

Fluoroscopy for the Localization and Removal of Foreign Bodies.—Pre-eminent among the surgical conditions incident to war is the presence of foreign bodies. Utilization of *x*-rays for diagnosis, localization and aid in actual removal of foreign bodies is inevitable. The exact procedure will depend on

a variety of factors, not the least of which will be limitations imposed by difficult circumstances. At times, optimal conditions will prevail, and careful roentgenologic studies of any nature desired will be possible. Again, circumstances and the urgent pressure of work will impose serious limitations on the roentgenologist. In general, a simple method will often suffice and may be all that is practicable.

Proper Accommodation of the Eyes.—In the performance of fluoroscopy, a first essential is proper accommodation of the eyes, and, regardless of length of experience the roentgenologist must not start work too soon, especially when he is confronted with urgent situations. Dark glasses or spectacles kept in readiness for use against sun glare for a preliminary half hour or more are a good investment, and will reduce the period in which heavier shielding will be a requisite. Needless to say, any tendency to night blindness would render the victim of it a poor fluoroscopist and so the usual dietetic precautions should not be forgotten. The diet may be deficient in vitamin A and this deficiency may be entirely unsuspected.[4]

Technic of Removal.—In employment of the simplest possible method, the operator uses a minimal fluoroscopic field, centers the object, extends forceps down to it, seizes it and removes it. This procedure sounds deceptively simple, but in actual practice trouble is frequently encountered. Important structures may be in the way or dangerously nearby. In this case, especially if the foreign body is jagged, it will be advisable to grasp or approximate the object with forceps, then dissect down to it, and so free it safely and expeditiously under good illumination. When such work is being performed, it may be an advantage if one member of the operating team keeps his eyes protected during this final stage. In general, division of labor will often be desirable. A method found practicable by the French calls for screening immediately prior to operation of patients with retained fragments. Fluoroscopic studies are carried out with the patient in the anteroposterior position. An "A" is marked on the skin over the fragment. Other studies are made with the patient in the lateral position, an "L" being

marked over the fragment. When the patient is on the operating table, the letters are scratched on the skin with a needle, the field prepared, and then removal carried out.[5]

Determination of Depth.—At times, more elaborate means of localization will be called for because of the impossibility of extending forceps directly to a foreign body. Accurate determination of depth will then be needed. The methods employed, in general, depend on the shift of the image of the object on the fluoroscopic screen or roentgenographic film as the *x*-ray tube is moved. Obviously, the closer a foreign body is to the tube, the greater will be the shift of its image. Shift of the tube and image, anode screen distance, and, when required, shift in terms of angle can be measured. Thus, by triangulation, the depth of the foreign body can be calculated. If the shift is standardized at a fixed distance or angle, depth tables can be prepared, or a fixed ratio determined for a convenient anode screen (or film) distance so that, on determination of the image shift, the depth can be read off or calculated immediately. For additional details of various methods, standard references and current literature are available.[3, 6, 7]

Nonopaque Objects.—Objects of poor radiopacity are dealt with much easier by roentgenography than by fluoroscopy, and careful technic as to roentgenographic density is needed. Stereoscopy is often of aid.

Foreign Bodies in the Eye.—With the eye, special technic and the use of apparatus such as the Sweet localizer or the contact lens localizer (Pfeiffer) will be needed. Difficult cases also bring to mind the fact that it will often be possible under modern conditions to carry out prompt evacuation of casualties by plane to a well-equipped base hospital at the rear.

Protection of Personnel.—It appears worthwhile to mention briefly the matter of protection from *x*-rays, even at the risk of seeming unduly elementary. Roentgenologic apparatus has been vastly improved and will stand enormous punishment, but there has been no improvement in the resistance of the human skin nor in systemic resistance to the deleterious effects of roentgen rays. Self-sacrifice is, of course, entailed in war, but by

care this can be minimized. Moreover, a technician, surgeon or roentgenologist who, himself, becomes a casualty loses his usefulness and constitutes a liability.

Precautions are essential. The use of diaphragms to obtain the minimal field practicable gives sharper definition and reduces exposure. The hands should be protected by gloves; when the conventional heavy gloves are impracticable, even light gloves will afford some protection. The hands should be kept out of the direct beam—the patient's body should always intervene. Other factors are strictest economy in the time the roentgenologic unit is in operation; aluminum filtration; tests as to degree of exposure by the wearing of dental films; checks on the blood count; good ventilation of the fluoroscopic room, and good personal hygiene. In this way, much painful and often unnecessary damage can be avoided. Unwary individuals still are falling victims to roentgen rays.[8]

X-RAYS IN FRACTURES AND DISLOCATIONS

A second huge class of surgical conditions in which roentgenology is a prime essential is comprised of fractures and dislocations. Both roentgenography and fluoroscopy are needed, but, in diagnosis it should never be forgotten that the roentgenogram will reveal more than the fluoroscopic screen, and, moreover, provide a permanent record which can be given meticulous scrutiny. In diagnosis of bone conditions, fluoroscopy is a deceptive short-cut fraught with peril and likely to entail more trouble than it will save. Also, it will occasion more personal exposure to roentgen rays, which is an important consideration.

Reduction under Fluoroscopic Control.—Reduction of fractures under fluoroscopic control is often favored and, at times, necessary. The ever-increasing use of such appliances as the Roger Anderson apparatus to obtain and maintain reduction will tend to increase the amount of fluoroscopy. It is not at all necessary, however, no matter what the volume of work, to receive excessive exposure. Several millimeters of aluminum filtration can be used, and, by intelligent planning and use of good judgment, a very small amount of fluoroscopic exposure will

accomplish all that is necessary. On the other hand, with carelessness and a heavy foot on the switch, damage can result from only a few exposures. When reduction is accomplished, the end-result should, by all means, be checked roentgenographically.

Obscure Fractures in Extremities.—A complete summary of fractures is, of course, impossible, and it appears best to touch on some aspects which, though apparently minor, cause much trouble. Injuries to the extremities are of great frequency, and all too frequently are attended with undetected fractures which, through neglect, occasion heavy disability and loss of time. Notable in the group is *fracture of the carpal navicular* which, as often as not, fails to be promptly recognized either through failure to make roentgenograms or failure to employ adequate technic. The results are deplorable, particularly in military service. The wrist, weakened and painful due to nonunion of this bone, distinctly limits usefulness of the patient and may keep him on the sick list for months no less surely than a formidable injury that compels attention, such as a fractured femur.[9] Because of the peculiar curvature of the navicular, some modification of conventional technic, such as turning the wrist laterally toward the ulnar aspect, or turning the central ray upward at an angle toward the elbow, or taking an additional view with the wrist in a slightly oblique position, usually will be desirable.

Other injuries likely to be missed are damage to other carpals, fractures of the various tarsal and metatarsal bones, fractures of the intercondylar eminence of the tibia, fractures of the condyloid and coronoid processes of the mandible, fractures of the facial bones, particularly the zygomatic, and compression fractures of the vertebral bodies. On the other side of the picture, care must be taken in diagnosing as fractures such conditions as bifid sesamoids, accessory ossicles or growth centers, ununited epiphyses or apophyses, lines due to overlapping bony or even soft tissue margins, and various artefacts and anomalies.

Fractures of Skull.—Skull injuries are grave, but there is

practically never any occasion to rush a patient who is in a state of shock, or possibly threshing about in delirium, into the *x*-ray room to determine the matter of possible skull fracture. Fortunately, this overpreoccupation with damage to the cranial vault is passing away, and less and less of this particular manifestation of poor judgment is encountered. None the less, it is worth mentioning because it is most important, because many of us still worry too much about the skull itself and, finally, because we have to withstand pressure from lay people who do not understand the situation in the slightest way and, almost invariably, believe that it is a matter of life or death to determine at once if fracture is present.

Other Conditions in Bones and Joints.—In the natural concern with foreign bodies and fractures, we must not lose sight of other conditions of the bones and joints. They continually obtrude themselves on us and occasion numerous vexatious problems. Among these problems, complaints referable to the spinal column and extremities are well to the fore. Serious disabilities must be detected from the minor, the exaggerated and, now and then, the simulated. In making these distinctions, roentgen rays are of course, indispensable; only thus will we sift out conditions such as Pott's disease, osteochondrosis, osteochondritis dissecans, the para-arthritides such as peritendinitis or bursitis, serious sacro-iliac trouble, spondylolisthesis, retrodisplacement of the fifth lumbar vertebra, various anomalies, arthritis and bone tumors from the innumerable cases of mere strains, sprains and the like, with which we are likely to deal summarily. It is, of course, impossible to examine roentgenologically every minor case of trauma, but common sense dictates that, when pain and disability persist unduly, *x*-rays should be called for. Otherwise, grave and humiliating results may be forthcoming.

ROENTGEN THERAPY

Roentgen therapy is an important adjunct to surgery. In wartime service, *furuncles, carbuncles* and *cellulitis* occur at least as frequently as in civil life, and roentgen rays usually are of great benefit, particularly if used early.[10] When these infec-

tions involve the face, roentgen rays may be life-saving. *Gas gangrene* also is greatly benefited. Large dosage and heavy filtration are not essential to good results and, accordingly, the lightest type of apparatus, such as a dental unit, can be utilized in emergencies. A word of caution is necessary about its use, however. Although it is surely permissible to use such a unit for severe infections, it would be folly to use it for the innumerable cases of fungoid infections, acne and others; such abuse would soon ruin the unit. Treatment of numerous cases calls for fairly sturdy apparatus.

Another group of frequently encountered infections that is greatly benefited by roentgen rays is comprised of *infections of the middle ear and mastoid process*. My experience at the Naval Hospital in Washington, extending over some years, indicates extremely good results and a marked drop in cases that require operations. Inasmuch as low or moderate dosage will nearly always suffice, the use of roentgen rays is not completely interdicted if one of the sulfonamide drugs is being given. Heavy dosage should of course be avoided, and those physicians referring such cases for treatment should inform the roentgenologist of the use of these medications and the dosages employed.

As a final word on treatment, it might be mentioned that splendid results are obtained by the use of roentgen therapy in many cases of so-called *subdeltoid bursitis* and kindred conditions that so often prove resistant to usual measures. Also, good results are occasionally obtained in cases of severe *strains* and *sprains* that have likewise proved unduly resistant to treatment.

PHOTOFLUOROGRAPHY

Units for photofluorography (photoroentgenography) have been developed in the Navy, following the lead of Dr. De Abreu of Brazil,[11, 12, 13] chiefly for chest surveys. Improvements and refinements as to technic and material have made possible excellent results; thoracic examinations of all recruits are made by means of this method. In addition, experiments indicate that further expansion of its field of usefulness may be ex-

pected. Excellent views of bony structures can be made, and such things as surveys of hands and feet may become practical at a minor cost in addition to a certain amount of routine work.

Another innovation, still in the experimental stage, is the application of *lenticulated film* to photoroentgenography. By this method, it is possible to obtain stereoscopic depth perception on a single film, and it is hoped accurate depth measurements as well. If the method should prove practicable, its value to military surgery is obvious. We expect to acquire an experimental unit for this type of work in the near future.

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