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A COMPLETE SYSTEM OF THE SCIENCE AND
ART OF SURGERY, BY REPRESENTATIVE SUR-
GEONS OF THE UNITED STATES AND CANADA

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By JAMES FARQUHARSON LEYS, M.D., Surgeon, U. S. Navy.

LEPROSY.

Synonyms.—*Lat.* Lepra; Lepra vera; Elephantiasis Græcorum. *Fr.* La lèpre; le mal de Saint-Lazare. *Sp.* La lepra. *It.* La lebbra. *Ger.* Der Aussatz. *Norw.* Spedalskhed.

Definition.—The disease caused by an invasion of *Bacillus lepræ;* characterized by granulomatous infiltration of the skin, mucous membranes, nerves, and viscera, resulting in anæsthesia, trophic lesions, paralysis, and deformity, and usually fatal.

History.—Allusions are made to a loathsome and fatal disease, characterized by lesions of the skin, in the oldest Chinese, Indian, and Egyptian writings, which leave no doubt that leprosy was as well known in those countries thousands of years ago as it is to-day. It appears to have been introduced into Greece in the early part of the fourth century B.C.; into Italy, about the beginning of the Christian era. Thence it was carried by the Roman conquests all over western Europe by the close of the seventh, and to England by the middle of the tenth century A.D. Its European prevalence was increased by the Crusaders, both by their carrying the disease from the East and by the destitution among the masses resulting from the wars. It reached its height in the fourteenth century. From that time severe measures of isolation enforced by rulers and clergy, together with improving conditions of living, brought about its diminution and almost complete disappearance. Norway is at present the only country in western Europe in which lepers are found in any considerable numbers.

As no mention of leprosy is made in the history of the Spanish conquest of America, it appears probable that the disease was brought to the West Indies and later to the mainland by the negroes, it having been endemic in most parts of Africa from very early times. On the mainland of North America a limited endemic focus of leprosy has existed at Tracadie, New Brunswick, since the close of the eighteenth century, when the disease was brought from Normandy.

Leprosy still exists extensively in Mexico. Scattered cases are found here and there among the Gulf States, and it is seen on the Pacific coast in the persons of Chinese and Hawaiian immigrants. Isolated cases are encountered from time to time in all the seaboard cities. Many Norwegian lepers settled in our North-western States, but the disease has never shown a tendency to spread there and is rapidly dying out. Leprosy in Louisiana appears to have been introduced either by Acadian immigration in 1758 or, as in the case of Tracadie, directly from northern France, where the disease has not yet entirely died out.

The first clear differentiation and systematic clinical study of leprosy was presented to the world in 1848, in Danielssen and Boeck's "Traité de la Spedals-khed," the publication of which marked the beginning of our modern knowledge of the disease. Macroscopic and microscopic pathological studies by Virchow and many others followed. In 1874 Armauer Hansen, of Bergen, reported to the Medical Society of Christiania the discovery of minute, rod-like bodies in leprous tissues, and in 1879 he described the bacilli which he had differentiated with osmic acid and stained with methyl violet in sections of lepromata. His discovery was promptly confirmed by Neisser and others.

Geographical Distribution.—Leprosy exists in all latitudes and climates, from the North Cape of Norway to the equator, and throughout the southern hemisphere. In its prevalence, however, it may be regarded at the present day as essentially a disease of tropical and sub-tropical climates. In northern China it is comparatively rare; in southern China it is probably as prevalent as in India, where the census of 1891 gave 105,000 lepers in a population of 210,000,-000, or 1 leper in every 2,000 persons. The disease has disappeared from Great Britain. It has almost disappeared from western Europe. It is decreasing at a satisfactory rate in Norway, which had, according to Hansen,* more than 2,500 lepers in 1870, and fewer than 600 in 1900. It is dying out at Tracadie and in Minnesota and Wisconsin. On the other hand, there are places where the disease is increasing. Its implantation on a new soil is usually followed by a comparatively rapid spread, which demonstrates its contagious character. Thus, after its introduction into Hawaii, according to Hildebrand in 1848, there were 230 known cases in 1865 and 1,500 in 1891. A Chinese first brought the disease to New Caledonia in 1865, and in 1888 the lepers numbered 4,000. Numa Rat states that, within twenty years, in two of the British West India islands, Trinidad and St. Kitts, the disease has doubled in the actual number of cases as well as increased in the percentage of population affected.

According to the report of the Marine Hospital Commission in 1902, there were at that time, in 21 of the continental United States and Territories, 278 known cases of leprosy, of which number there were in Louisiana 155, in Florida 24, in California 24, in Minnesota 20, in North Dakota 16, the remaining 39 being scattered over 16 other States. Of this total of 278 cases, 72 were isolated

* Scot. Med. and Surg. Jour., Edin., Jan., 1905.

and 206 at large. Leprosy appears to be on the increase in Louisiana. Its existence is reported in the Aleutian Peninsula of Alaska. Turning to the recently acquired insular possessions of the United States, we find that there were, in 1900, about 1,100 lepers in the Hawaiian Islands, or nearly 1 to every 30 of the native population, which furnishes nearly all the cases. There are 24 lepers in Guam in a population of 10,300. These have been isolated since 1902 in an asylum. The disease exists throughout the Philippines, where 200 deaths are charged to leprosy in the official mortality reports for 1902, and the number of lepers in the archipelago, partly segregated in some forty leprosaria, is estimated to exceed 3,500. Samoa alone of our recently acquired colonies is happily free from the disease.* In Puerto Rico there are only 17 lepers, all isolated in an asylum.

Etiology.—*Bacillus lepræ* is a small, straight rod, with rounded, sometimes attenuated ends. It is shorter than B. tuberculosis, which it closely resembles (see Fig. 1). Its rods are, however, always straight. It stains with the aniline dyes and by Gram's method. It exhibits the same staining reactions as B. tuberculosis and B. smegmæ, belonging to the acid-fast group. It stains more readily than B. tuberculosis with cold carbol fuchsin. It resists decolorization by mineral acids, as does B. tuberculosis, but while B. tuberculosis is resistant to acid alcohol, B. lepræ is almost instantly decolorized by it. The bacillus exists in denser clusters and greater numbers in the affected tissues than is the case with B. tuberculosis. It
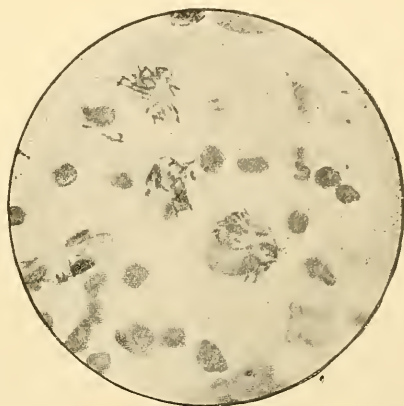
Fig. 1.—*Bacillus lepræ* in Skin. × 1500.
(*Hewlett.*)

is found free both in the fluids and inside the cells of the affected parts, and can be demonstrated by staining sections of tissue, or smears of "leper juice" expressed from a leproma, or the discharge from ulcerating leprous lesions. Up to the present time it has been impossible to satisfy the requirements of Koch's postulates in establishing the relation of the bacillus to the disease. But leprosy is not the only disease whose specific bacterial cause has been fully accepted without such a demonstration. Many unsuccessful attempts have been made to cultivate the bacillus outside the body.

The theory that leprosy is hereditary was long held, precisely as such a theory was held concerning tuberculosis, and on similar grounds. It was based simply on the frequent occurrence of the disease in different generations of the same family. Hansen has followed up the family histories of one hundred and sixty-one Scandinavian lepers who emigrated and settled in our Northwestern

* Spear, in Rep. Surg. Gen. Navy, 1903.

States. He says: "Many of those who brought the disease with them have had numerous progeny there, none of whom were affected by the parental malady. I have never found lepra among those born in America. Of one hundred and fifty-six lepers settled there (in America), none were there attacked by the malady and none left it as an inheritance to their descendants. There has never occurred a single case of lepra in America that can be adduced as inherited. If that could have taken place among the numerous persons I have seen related nearly or distantly with lepers, we should have had one at least. Heredity is so tenacious a thing that it could not have been excluded in the stream of humanity flowing from Norway to America." Dr. J. T. Reeve, secretary of the State Board of Health of Wisconsin, writing in 1883, states, from an inquiry into the subject of imported cases and their descendants, that "in the cases in which it has been imported into the Northwest by immigrants, its tendency has been to die with the patient, that its reputed hereditary character has been rarely if at all manifested, and that . . . there are now living in Wisconsin, Minnesota, and Iowa the perfectly healthy widows, children, and grandchildren of those who were lepers." The British Leprosy Commission, in 1893, after careful investigation in two thousand cases of leprosy in India, reported "that leprosy in India cannot be considered an hereditary disease, and . . . the evidence which exists is hardly sufficient to establish an inherited predisposition to the disease." Leprosy has not been seen in the fœtus. It has been reported once or twice in the newly born, but is extremely rare before the fifth or sixth year. The disease is sometimes seen in the first and third generations of a family, the second being exempt, and many instances are observed in which children develop the disease first, their parents afterward. The old theory of heredity received little notice at the hands of the Berlin Lepra Conference in 1897, and it may now be properly regarded as of historic interest only, as in the case of tuberculosis. In the absence of any evidence that leprosy is ever hereditary in the scientific sense, and in the light of modern pathological and clinical knowledge of bacillary diseases, heredity in leprosy must be definitely rejected.

Inoculability.—Several cases have been reported in which infection of a wound appeared to have been the starting-point in the invasion of leprosy. In one instance the wound was made by the bone of a fish freshly caught in tropical waters and being cleaned by the steward of a steamer plying regularly in the tropics. In a case reported by Strain, the wound of operation for mammary cancer, in a Brazilian woman whose son had been a leper for three years, failed to heal promptly, the sternal end of the incision remaining somewhat inflamed and indurated, and the patient developing leprosy six months later. Vandyke Carter has reported the case of a medical student in India who received an accidental cut in the course of a necropsy on a leper, and who subsequently developed the disease. As all such cases have occurred in persons who have been otherwise exposed to the disease, some other mode of infection cannot be ex-

cluded. In no case has the suspected wound been demonstrated to be the seat of bacilli early in its inflamed condition and before the disease became general and gave constitutional manifestations.

Danielssen was the first to attempt the transferrence of the disease by inoculation. Between 1844 and 1858 he made fourteen attempts to inoculate himself and other healthy individuals, all without result. In a second attempt to inoculate himself he caused fresh tissue, cut from a leprous nodule in an active stage, to be inserted under the skin through an incision which was closed over it by sutures. Only a trifling local inflammation ensued. He made, besides, several attempts to inoculate syphilitics with leprosy. All failed. Many similar attempts have since been made by other experimenters in different parts of the world, but no inoculation was ever followed by the development of the disease until, in 1884, Dr. Arning, while in Hawaii, inoculated a Kanaka criminal named Keanu, who escaped capital punishment on condition of submitting to the experiment. Not only was this man's own son already a confirmed leper, but in his family two other near relatives, his sister's son and his mother-in-law, were victims of the disease. A leprous nodule was excised from the arm of a leper and transplanted to the arm of Keanu in September, 1884. The bacilli were demonstrated in the resulting sore every month for six months, and they were demonstrable in the scab fourteen months after the experiment. After two years and a half the patient developed leprosy and was shortly afterward sent to the leper settlement at Molokai, where his son had preceded him, and died there. It is, of course, quite possible, and we might say not unlikely, that this man contracted his leprosy through the experimental inoculation; but, in view of the facts that all antecedent and subsequent inoculation experiments, by Danielssen and others, on both man and the lower animals, have met with nothing but failure, and that the only case in which the disease has developed after inoculation is one in which a member of an already leprous family was the subject of the experiment, we must regard the transmissibility of leprosy by direct inoculation of the healthy as not proved.

It has been asserted that leprosy has been conveyed in vaccination of the healthy with virus taken from lepers, and this appears probable in at least one reported case. No one, of course, would now think of using vaccine from lepers. Even in the face of failure of experimental inoculation, the many cases of suspected accidental inoculation, and, above all, our knowledge that the disease is a specific bacillary infection and that it is certainly communicable or transmissible, even if not *directly* contagious, justify the suspicion that the disease is inoculable, and that experiments have failed for lack of certain unknown necessary conditions. These conditions might have to do with a peculiar susceptibility in the subject, or with the site of inoculation, or with impaired virulence of *Bacillus leprœ* under certain circumstances. Direct inoculability, though not proved, is by no means disproved, and must be regarded as probable.

Contagion.—We know that leprosy is an infectious disease, and that it is communicable in some way from person to person. Whether it is directly or indirectly communicable we do not know. Dr. Alvarez, of Honolulu, has demonstrated the bacilli in mosquitoes which have been allowed to feed on leprous ulcers. Commenting upon reports of the supposed transmission of leprosy by clothing, and especially by occupying the same bed with lepers, T. A. Palm has suggested *Pediculus vestimenti*, or some other insect, as a possible carrier of the disease;* and Mugliston, of Penang, has argued for *Acarus scabiei*.† In view of the rôle believed to be played by certain fleas in plague and by flies in the dissemination of typhoid, the suggestion is in no way an unreasonable one. It does not involve the assumption, however, that any insect is an indispensable intermediate host for the bacillus of leprosy. Insects have not, thus far, been demonstrated to have such relation to other than animal parasitic diseases, or to play, as hosts, any necessary part in the simple life cycle of a bacterium. It is difficult to imagine that a temporary residence in the body of an insect could confer upon B. lepræ a virulence in inoculation which it did not possess in the human tissue from which the insect took it.

A most striking and conclusive illustration of the contagiousness of leprosy was furnished to the Medical Society of Dublin and published in 1877 by Dr. Hawtrey Benson. Dr. Benson had shown to the society in 1872 a man who had contracted leprosy in the West Indies, where he had lived twenty-two years. The man returned to his home, where he died a year and a half later. During this period his brother slept in the same bed with him and wore his clothes. This brother, who had never been out of Ireland except to visit England, forty-six years before, developed leprosy and was shown to the same society in 1877.

Leprosy has never appeared in any country until lepers have entered and settled in that country.

Leprosy, though unquestionably contagious, is only feebly or mildly so, or its communication is possible only under certain necessary conditions, which occur rarely and which are not yet understood. The word *contagious*, as applied to leprosy, is therefore accepted and used in the sense of directly or indirectly communicable, and not in any more limited sense.

Owing to the immunity enjoyed by many members of the immediate families of lepers, by wives with leprous husbands and husbands with leprous wives, and by the physicians and nurses in leper hospitals, the idea was long entertained that leprosy was not contagious. Basing its conclusion entirely upon such negative evidence, the Royal College of Physicians, as a result of its inquiry into leprosy in the British Empire, reported in 1867 its belief that the disease was not contagious. The belief in contagion has, however, been so strengthened by Hansen's discovery of the bacillus and the infectious nature of the

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* Brit. Med. Journ., Aug. 18th, 1900.

† Journ. Trop. Med., London, 1905, viii., 209.

disease, by more careful and intelligent historical and clinical study, and by the failure of the theory of heredity to account for its rapid extension in some places and its decline in others, that it is now quite universally accepted. Hansen, who continues to be foremost among leprologists, and who has preserved a judicial attitude toward all questions connected with the disease, announced to the Berlin Lepra Conference, in 1897, his belief both in direct contagion and in contagion by infected clothing. That conference, whose conclusions are to be regarded as the last authoritative deliverances on this subject, based its recommendations for prophylaxis on the accepted contagiousness of the disease. The belief is now practically universal that "leprosy is propagated by contagion, and only by contagion." *

Predisposing Causes.—The disease exists in all *climates*, but, as already noted, its present prevalence is chiefly tropical and sub-tropical. The nodular form of the disease appears to be commoner in cold climates, and nerve leprosy commoner in warm climates. A similar difference in the prevalence of one or the other form has been noted within the limits of a single country, as in Norway, nodular leprosy being commoner in the northern, and nerve leprosy in the southern districts. All *races* are susceptible. As regards *age*, the disease is rarely seen before the fifth year, and the majority of cases begin in early life, between the ages of ten and thirty. It is rarely developed after forty. As to *sex*, the statistics of leprosy in most countries include more males than females. *Habits* and *hygienic conditions* are unquestionably important factors in predisposition. Hansen attributes the failure of the disease to spread among the Norwegian settlers in America to larger, cleaner houses, separate beds, and improved habits of personal cleanliness, all reducing the liability to family contagion. More and better food and less hardship were doubtless also important factors. Bad nutrition, bad hygiene, chronic disease, or anything which lowers the vitality and resistance of the individual increases his susceptibility to the infection of leprosy. Among special contributing conditions enumerated by Dyer are "syphilis, malaria, tuberculosis, scurvy, alcoholism, and sexual immorality." †

A theory that the eating of fish, and particularly of fish badly cured or insufficiently cooked, is responsible in some way for the existence and spread of leprosy has been advanced by Jonathan Hutchinson; but, in spite of able advocacy at such distinguished hands and the pointing out of much apparent coincidence, such a theory does not appear to be tenable and is rejected by leprologists. Mr. Hutchinson concedes that B. lepræ is the cause of leprosy. Hansen‡ says it rests, then, on Hutchinson to demonstrate the bacillus in improperly cured fish, and he thinks the attempt would be a useless task, since, if the bacilli were found, they could not be identified as the bacilli of leprosy, because inocu-

* Manson: "Tropical Diseases," 1903.
† "Amer. Syst. Pract. Med." (Loomis-Thompson), New York and Philadelphia, 1897, vol. i.
‡ Scot. Med. and Surg. Journ., Edinburgh, Jan., 1905.

lation experiments on animals could not be carried out. And, moreover, if B. lepræ could survive as a saprophyte, there would be no difficulty in cultivating it. Badly cured or uncooked fish would appear to have the same relation to leprosy as other forms of insufficient or innutritous diet, in being responsible for a lowered vitality, and therefore an increased susceptibility when exposed to infection.

Symptoms.—We do not know the condition in which the germ enters the body, whether as bacillus or as spore, nor the site at which it enters, nor if a solution in the continuity of skin or mucous membrane be necessary for its entrance. We do not know if it is conveyed by air, water, food, the bites of insects, or in some other manner. No primary lesion has been demonstrated. Morrow, of New York, in 1894, expressed himself as to the primary seat and the conveyance of the disease as follows: "I believe that the first manifestations of leprosy are, in the majority of cases, determined toward the pharynx and upper air passages. According to my observation, alteration of the voice, betrayed by a slight husky or rough phonation, rhinitis with an abnormally free nasal secretion, sometimes epistaxis, and an increase in the salivary secretion are among the earliest signs of leprosy. I believe that the vehicles of the virus through which contagion is effected are the secretions of the mouth and nose, and that the port of entrance is the mucous membrane of the respiratory and intestinal tract, with secondary infection through the blood or lymphatic system." * Sticker made a comprehensive investigation of this point in India, reporting his results to the Berlin Lepra Conference. Of 153 cases examined he found leprous changes in the mucous membranes of the nose in 140, and demonstrated the bacillus in the nasal mucus in 128. He believes the primary lesion to be in the nasal septum, and notes epistaxis as an early symptom in many cases.

Whatever the mode of invasion, the period of *incubation* which elapses before constitutional invasion is manifested is a long one. It is stated to have been but a few weeks in some cases, and in others as much as forty years. It is seldom less than several months, and is generally between the limits of two and twenty years. There is usually a history of prodromal symptoms preceding the recognized development of the disease—fever, weakness, sense of heaviness, drowsiness, dyspepsia, headache, vertigo, pain, hyperæsthesia, paræsthesia—all due probably to invasion of the nerves by the bacillus or to poisoning by its toxin. Epistaxis has been recognized as one of the most frequent of the early symptoms by Boeck, Leloir, Hillis, Morrow, Sticker, Manson, and others. Localized anidrosis may be noted in some spot, which subsequently becomes anæsthetic. Leloir, Manson, and many other observers have noted attacks of general and excessive sweating among the prodromes. Prodromes may be absent, or be so slight as not to be noted by the patient.

The first tangible and pathognomonic sign of the *invasion* of leprosy is the

* Morrow's "System," vol. iii., "Dermatology," 1894, p. 572.
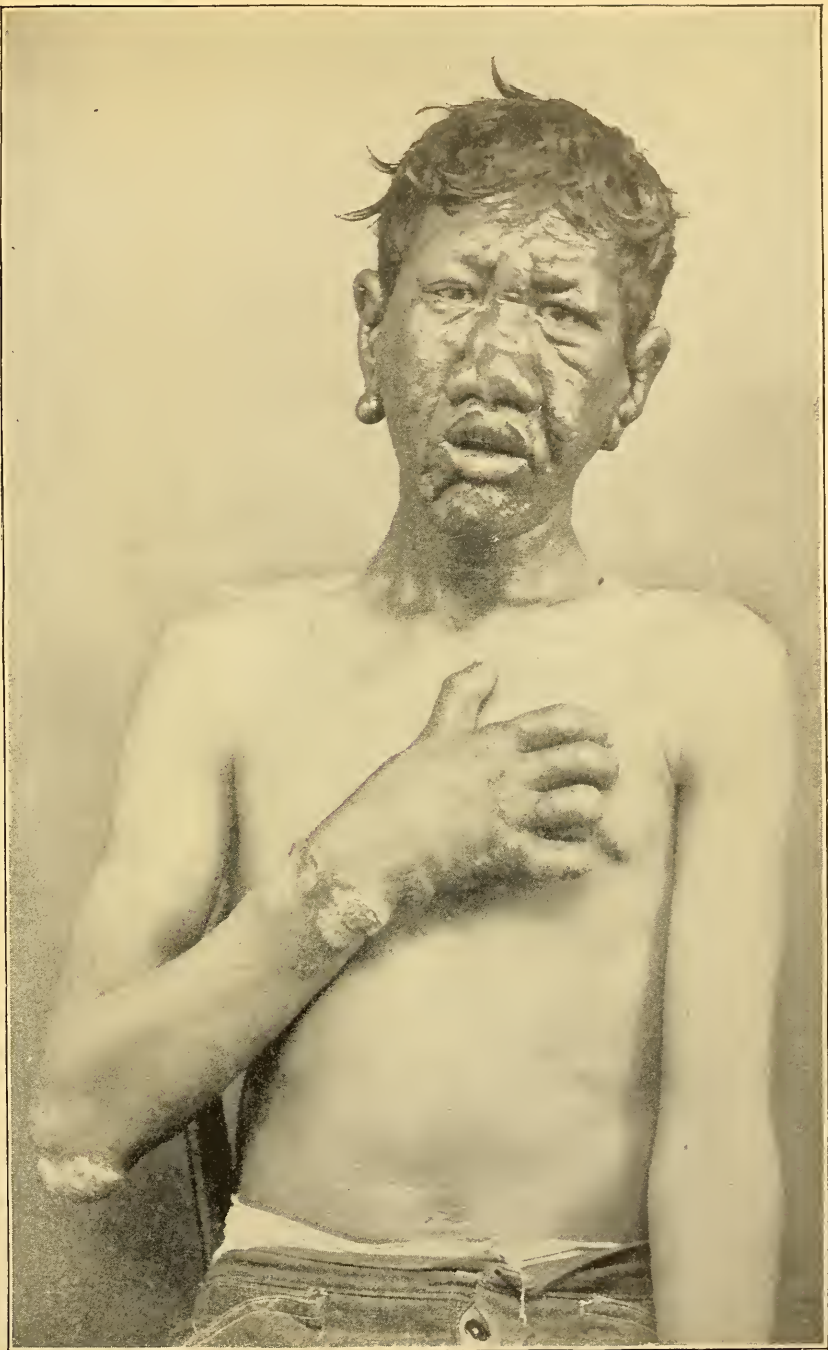
NODULAR LEPROSY.

(From an official report by L. E. Cofer.)

Note the diffuse infiltration of face, thickened ears, loss of eyebrows and lashes, elephantoid hand, and numerous ulcerating lepromata.

appearance of a macular eruption. This is often preceded by a pronounced attack of fever, and accompanied or followed by a temporary improvement in the general health. The spots are so variable in number, size, shape, color, and location that no concise description of their character is possible. They may be erythematous or inflammatory, pigmented or vitiliginous, darker in the centre or at the periphery, evanescent or comparatively permanent. Though they are usually irregular, there is often a noticeable symmetry in their distribution. Their most striking and constant characteristics are the sensory changes associated with them. They are usually anæsthetic or paræsthetic. Their most frequent seats are the face, trunk, and extensor surfaces of the limbs. They are rarely observed on the palms and soles, and never on the scalp. The hair is lost from the affected areas, and this is particularly noticeable in the eyebrows and beard.

As the disease advances, a specific infiltration takes place in affected tissues. It has long been customary to divide cases of leprosy into three classes or types, for purposes of description: (1) *Nodular leprosy;* (2) *nerve leprosy;* and (3) *mixed leprosy,* in which the features of the first two types are combined.

Nodular Leprosy (*Lepra nodosa*).

In this form of the disease the specific deposit is seen chiefly in the integuments, the skin and mucous membranes, where the formation of the new morbid tissue produces either discrete lumps or nodes or a confluent, irregular, more or less diffused thickening. To the characteristic nodule of this deposit Leloir gave the name *leproma.* The deposit is a rather hard and inelastic mass, occupying the deeper layers of the skin and freely movable over subjacent structures. It is of a yellowish, reddish, or dusky color, smooth, and often of a greasy appearance. It is usually partly or completely anæsthetic. It is found on the limbs, particularly on the extensor surfaces, and on any part of the trunk; but its commonest site, and the one in which it produces the most characteristic appearance, is the face. Here it affects conspicuously the forehead and superciliary regions, the cheeks, alæ of the nose, chin, and lobes of the ears. Either a large number of nodules, distinct lepromata, exist in these situations and become more or less confluent, or the infiltration is diffuse and the thickened skin is thrown into massive folds. The overhanging skin of the forehead and eyebrows, the pendulous ears, broadened and thickened nose, exaggerated creases marking off the jowls, and the general heaviness of the countenance produce the peculiar facial expression called "leontiasis," which is so characteristic of the disease (see Plate VI.). In the course of the disease individual nodules soften and become absorbed, or ulcerate and cicatrize. The specific leprous infiltration may invade any of the soft tissues and the viscera, especially the liver, spleen, and lungs. In either a diffuse form or in distinct nodules it is particularly prone

to invade the conjunctiva and cornea, and the larynx and its adnexa, demanding surgical interference for the relief of pain, the prevention of asphyxia or blindness, and, if possible, the local arrest of the disease process. These ocular and laryngeal complications of leprosy are among the most important that demand the attention of the surgeon. The infiltration of mucous membranes in cases of advanced nodular leprosy gives rise to dyspnœa, aphonia, loss of the senses of taste and smell, and blindness; hearing alone of all the special senses being left to the miserable victim. Death usually results from diarrhœa, septicæmia, or pneumonia, or from inanition and exhaustion.

Nerve Leprosy (*Lepra nervosa*).

In this form of leprosy the nerve trunks are the seat of the specific infiltration, and this type of the disease is often called *anæsthetic* or *trophoneurotic* leprosy. A distinct and prolonged macular stage usually marks the onset of this form. The macular stage is often accompanied or followed by the appearance of bullæ (pémphigus leprosus), which burst, forming shallow ulcers and leaving scars (see Plate VII.). The whole series of nervous symptoms is more pronounced in this than in the nodular form. Lesions are not confined to the integuments. Infiltrated and thickened trunks can often be palpated in the ulnar, median, peroneal, tibial, auricular, and supraorbital nerves. Hyperæsthesia, paræsthesia, and neuralgia are followed by anæsthesia and trophic changes. Muscular atrophy and contraction follow, as seen in the claw-hand of lepers (main-en-griffe), and in general weakness and impaired gait. The gait is usually characterized mainly by feebleness, though in one of the writer's cases it was markedly ataxic, owing to the extensive and profound anæsthesia in feet and legs. The patient, on attempting to stand still with closed eyes, swayed like any case of tabes, but his patellar reflex was normal (see Plate VIII.).

Facial paralysis, affecting the eyelids, often results in ectropion and in corneal leucoma from inflammation of the unprotected conjunctiva. The lips are involved, the mouth cannot be closed, the saliva dribbles, deglutition is difficult. Aphonia results from laryngeal paralysis. Trophic ulceration attacks the nasal septum and cartilages, the gums, the palate; and the teeth are loosened and fall out. A peculiar and characteristic lesion is the trophic ulcer of the sole of the foot. It is situated most commonly on the ball of the foot, sometimes at the heel. Its exciting cause is the pressure on a part of lowered vitality. As it spreads and penetrates it assumes a deep conical shape, and frequently becomes a perforating ulcer. Trophic ulceration also occurs extensively and irregularly on the legs. The hands and fingers are involved, a favorite seat being at the base of the nails and on the back of the terminal phalanges. The palms of the hands are apt to be affected if subjected to pressure by the use of tools. Deep ulceration of fingers and toes is often observed, going on to spontaneous amputation
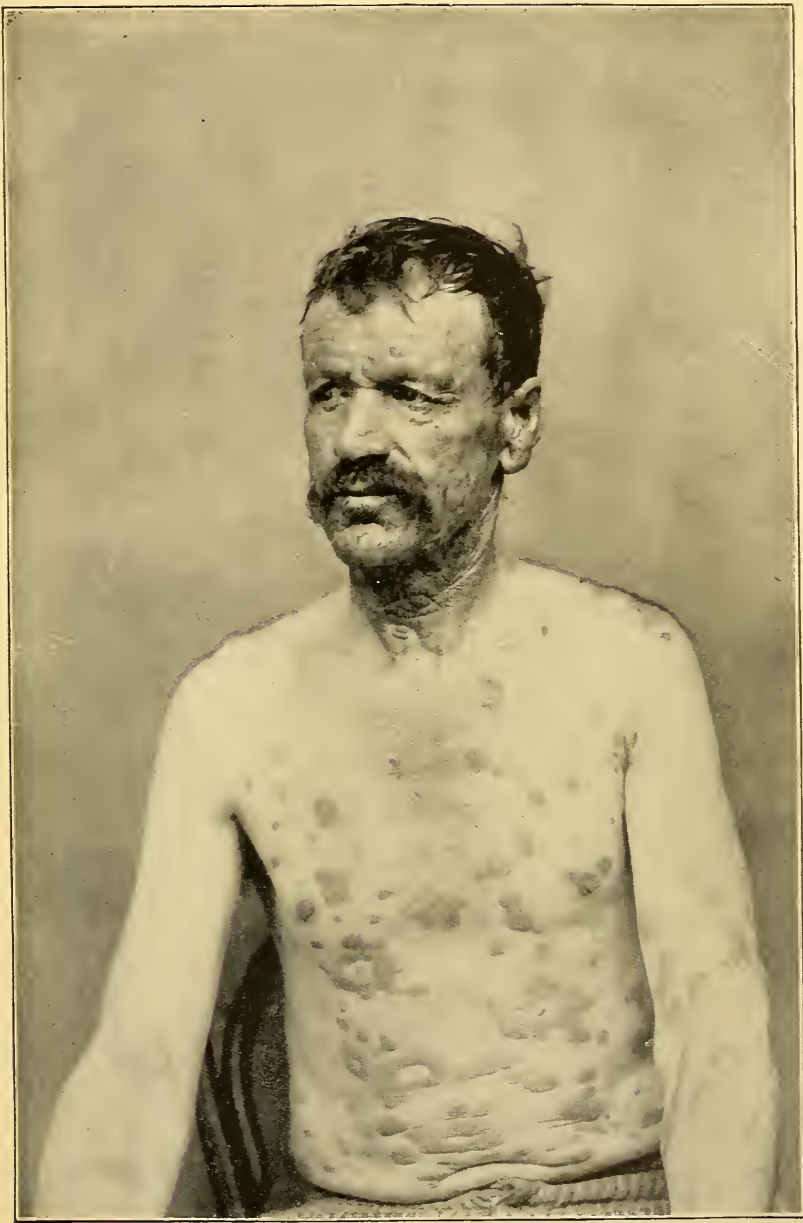
NERVE LEPROSY, MACULAR STAGE.

(From an official report by L. E. Cofer.)

Note the partial loss of eyebrows and dry, cracking skin.

(lepra mutilans). A dry gangrene sometimes effects the same result. Another, and perhaps the most characteristic, trophic change of advanced nerve leprosy is to be seen in the absorption of bones in the fingers and toes. Not only does inflammation of the joints or articular surfaces of the bones often produce anky- losis and deformity in fingers, but frequently in lepers one or several phalanges will undergo a gradual interstitial absorption, of the shaft only or of the entire bone, producing a kind of deformity seen in no other disease. Fingers and toes which have been shortened in this characteristic way, their bones partly or en- tirely absorbed and gone, the soft parts intact, often without a scar, and a more or less distorted nail crowning the stump, are pathognomonic of advanced nerve leprosy.

Nerve leprosy runs a longer course than the nodular form. The average duration of the active disease is stated by Impey to be eleven years, and the average duration of life about eighteen years. If the patient survive fifteen years and the disease has not assumed the mixed form, it is often arrested and life is likely to be terminated by some intercurrent affection, as phthisis, nephri- tis, or diarrhœa.

MIXED LEPROSY (*Lepra mixta*).

From the outset of the disease there is often a coexistence of nodular and nerve leprosy, and the case is one of so-called mixed leprosy. In the course of nodular leprosy involvement of nerve trunks takes place, and sooner or later, if he live long enough, almost every case of nodular leprosy becomes mixed. On the other hand, the nodular form is seldom engrafted on nerve leprosy (see Plate IX.).

Impey, in his valuable monograph,* has called attention to the importance of recognizing antecedent or coexistent syphilis as a complicating factor in lep- rosy. He places a large class of cases, for purposes of description, under the heading "syphilitic leprosy." There is objection to such a terminology, which tends to create or perpetuate confusion in the minds of students; but while we cannot have a syphilitic leprosy, we do undoubtedly have many *syphilitic lepers* to deal with, and the fact is important for both diagnosis and therapeutics. A failure to realize its importance probably accounts for conflicting reports as to the value of mercury and iodides, some writers having found them beneficial in some cases, while others declare them to be always injurious in leprosy. For the recognition of the syphilitic complication in leprosy in the absence of a definite history, the following points are put forth by Impey: Secondary syphilis co- existing with lepra is apt to produce a papular syphilide, which ulcerates at an early stage of the disease, covering the face with "ugly, shallow ulcers, which, when they heal, leave the skin much deformed. A very ragged face is the result. In these syphilitic leprosy cases the mouth and throat become much affected,

* "Handbook on Leprosy," London, 1896.

the hair is removed from the scalp in large patches, the bones in various parts of the body become necrosed, the lymph nodes are enlarged and often suppurate, indolent abscesses are formed in various parts of the body, the bones of the nose are soon lost, and the nose itself is removed by ulceration, these symptoms being due almost entirely to the syphilitic poison. Add to these disfigurements the deformities of any form of leprosy, and symptoms are produced almost too terrible to behold: the head bald in patches; the eyes shrunken, and in most cases disorganized, and almost hidden by a swollen face; the face swollen, scarred, puckered, and covered with ragged wounds and scabs; the mouth with retracted lips and prominent teeth; foul discharges pouring from the mouth and nose; abscesses about the neck and body; hands reduced to mere suppurating stumps; and feet a shapeless mass of corruption—and you have syphilitic leprosy in its last stage."

Pathology.—All the lesions of leprosy in the active stage of the disease are caused by the invasion and proliferation of *Bacillus lepræ*. The bacilli are abundant in all the tissues which are the seat of the specific infiltration, in the skin spots of the macular stage, in the typical leproma or the more diffuse deposit in the thickened skin, in the trunks of the affected nerves, and in the liver, spleen, lungs, and testicles when the disease has extended to those viscera. They are found in the ulcers which result from the breaking down of leprous nodules, but not necessarily in the trophic ulcers of nerve leprosy. They have been observed in the endothelial cells of the intima, in the leucocytes, and occasionally free in the plasma. According to Gerlach, the bacillary invasion in nerve leprosy begins around the nerve terminals in the skin, attacks and destroys them, and then extends up the nerve trunks.

The neoplastic tissue of leprous infiltration, seen especially well in the typical leproma, is a granulomatous tissue consisting of cells of various kinds in a connective-tissue matrix, with abundant bacilli within and without the cells. There are, besides, in old lepromata, brown granular bodies called "globi," which are, according to Hansen, cells in which the bacilli have died and undergone a granular degeneration. It is these globi that give the brown color to old lepromata. Giant cells, or bodies resembling them and containing the bacilli, are frequently seen in the granulomatous tissue. Unna maintains that these are cross-sections of lymph spaces, containing the bacilli massed in a "glœa" form.

The leprous infiltration of *nerves* causes them to undergo an irregular thickening, often nodular or fusiform, and, finally, a destruction of the nerve substance proper and the degeneration of the nerve trunk into a fibrous cord, incapable of function.

In nodular leprosy there eventuates in a large proportion of cases albuminoid disease of the *liver, spleen,* and *kidney*. In advanced cases of nodular leprosy the epididymis and *testicle* are usually involved in the infiltration. Nodular and ulcerative lesions in the *nose* are common, and congestion and catarrh of the mu-

NERVE LEPROSY, ADVANCED STAGE.

(From an official report by L. E. Cofer.)

Note the comparatively slight facial change, left main-en-griffe, spontaneous amputations of right fingers, interstitial absorption of bone and trophic ulceration in right foot, and old scars on left leg.

cous membrane, with discharge of bacilli in the secretion, are among the early manifestations of the disease. Nodular infiltration and destructive ulceration of the *pharynx* and of the *larynx and its adnexa* are important lesions demanding surgical attention. Laryngitis and suffocation cause about five per cent of the deaths among lepers. The nose being frequently stopped up with scabs and crusts, mouth-breathing predisposes to and aggravates this dangerous complication.

The *eye* is the seat of infiltration in a very large proportion of cases. This, either by giving rise to corneal opacities or by primary or secondary inflammation of deeper structures in the eyeball, causes the large percentage of blindness in advanced lepra. In 111 cases of nodular leprosy in which the eyes were examined by Boeck, he found 49, or 44 per cent, with eye affections. The structures affected were as follows: Nodules in cornea, 23; opacities, 5; ulcers, 5; iris affected, 9; staphyloma, 2; atrophy of eyeball, 2; rupture of eyeball, 1; cataract, 2; lachrymation with ectropion, 2; sclerotic sallow, 2. In 42 cases of nerve leprosy he found ectropion in 20, iritis and distorted pupil in 9. Pollock * examined 463 lepers in the hospitals of Norway, and found 41, or nearly 9 per cent, blind. Corneal infiltration was the commonest cause of the blindness. Infiltration, ulceration, or nodule formation invades the cornea from the corneo-scleral junction. Leprosy produces ectropion oftener than any other cause of that condition, and this leads to blindness as a result of inflammation in the unprotected conjunctiva.

Otitis media is, fortunately for the unhappy victims, a rare complication, and lepers generally retain their hearing unimpaired when all the other special senses have been lost.

In all the localized inflammations incident to the disease the corresponding *lymph nodes* are involved and show a chronic enlargement and induration which rarely ends in suppuration.

Diagnosis.—The diagnosis of lepra rests upon the symptoms and signs already described in the clinical history and pathology of the disease. Diagnosis is easy in advanced cases, but in the early stages it is by no means so, particularly for those unfamiliar with the disease and in cases far removed from any of its endemic areas. Leprosy is a protean disease of slow development, and in the vast majority of cases the early lesions are trifling. A patient may fail to observe the early lesions or to suspect their nature, or very often he conceals them to avoid the social or legal isolation that would follow a diagnosis.

Where the habitat of the patient or any history of contact or exposure justifies suspicion in a case of skin disease, some of the peculiar manifestations of leprosy should be sought for, such as loss of eyebrows, thickened ears, infiltrated face with tendency to leonine expression, thickened nerve trunks (ulnar, peroneal, great auricular), localized anæsthesia (especially in feet and legs), paraly-

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* "Leprosy as a Cause of Blindness," 12mo, London, 1889.

sis, contracture or atrophy (claw hand, ectropion), trophic ulceration (especially plantar and digital), phalangeal deformities (blunted, misshapen nails; interstitial absorption of bone). Dr. Dyer, of New Orleans, lays special stress on the importance of thickening of the ulnar nerve and anæsthesia in the little finger as a diagnostic sign almost constantly present in nerve leprosy. He notes also a "hunted," anxious look in lepers that have come under his observation in Louisiana. The writer has not observed this as a characteristic of the disease in other parts of the world.

Leprosy has been mistaken for erythema, lupus, keloid, eczema, and psoriasis, and even for pityriasis and ringworm, but such mistakes must be chargeable to carelessness. The anæsthesia, difference in color, and absence of areola should serve to distinguish leprosy from *morphœa* (Addison's keloid). From *sarcoma* ulcerative leprosy may be distinguished by the anæsthesia and the number and distribution of the lesions. Early leprosy has been mistaken for *beriberi*.* The differential diagnosis between lepra and *syphilis* is most important. Leprosy has been very frequently mistaken for syphilis by physicians unfamiliar with the former and accustomed to relegate, by exclusion, all chronic skin disease, refractory ulcers, and a great variety of lesions which resist treatment to the domain of the latter. Dr. D. T. Smith, writing of leprosy in Louisiana,† says: "In nearly every case I have met, a diagnosis of syphilis had been made and the patient subjected to a course of treatment for that disease." It would be useless to attempt to enumerate here all the differential points between these two diseases. Lepra in young adults is not infrequently complicated by syphilis—a point to which attention has been drawn. It is important for purposes of treatment to recognize the existence of syphilis in a leper. But the syphilis would in no case mask a leprosy sufficiently advanced to establish a diagnosis, and a well-developed case of lepra could be mistaken for syphilis only by one who does not have leprosy in mind. In nerve leprosy with an ulcerous laryngitis suspected of being syphilitic, the therapeutic test may be employed. Mercury and iodides in lepra uncomplicated by syphilis aggravate the disease.

Many observers have called attention to the close clinical analogies sometimes presented by lepra and *syringomyelia*. Syringomyelia is characterized anatomically by cavities in the cord, and clinically by analgesia, thermo-anæsthesia and paræsthesia, and muscular atrophy. The atrophy is often localized, more especially in the muscles of the hand and forearm, with slight wasting of the deltoid, degeneration of the interossei, flattening of the thenar and hypothenar eminences, and permanent flexion of the fingers. Dejerine says the error of confounding the two diseases has frequently been made in the absence of the prior manifestations and etiological history of leprosy. In syringomyelia, while

* Pernet: Quart. Rev., London and New York, 1903, cxcvii., 384 *et seq.*
† Louisville Med. News, 1885, xx., 257.

MIXED LEPROSY.

(From an official report by L. E. Cofer.)

Note the striking leonine face, entire loss of eyebrows, leucodermatous mottling of left arm and elephantoid wrist and hand.

there is loss of the pain- and temperature-senses, the tactile sense is preserved—a sign which usually serves to distinguish it from leprosy.

In connection with the differential diagnosis of lepra, the views of Zambaco, expressed in an address before the Lepra Conference of 1897, are of great interest. This eminent leprologist believes some of the diseases having a curious pathology, an unknown or unestablished etiology, and a peculiar distribution, to be attenuated or abortive forms of leprosy or the hereditary effects of ancestral leprosy. Among such diseases he enumerates syringomyelia, Morvan's disease, scleroderma, morphœa, Raynaud's disease, aïnhum, and the progressive muscular atrophy of Aran-Duchenne. He has made good his case against Morvan's disease, and shown it to be surviving leprosy in a region well known a century ago to be a focus of the disease, but supposed recently to be so no longer. Yet the so-called Morvan's disease had deceived no less an authority than Charcot. In several cases diagnosed at first by others as syringomyelia, Zambaco has subsequently, with the concurrence of able colleagues, diagnosed lepra; and in a remarkable case of Souza Martin's, lepra bacilli were demonstrated post mortem in a large cavity in the cervical portion of the cord. Ashley-Emile, observing aïnhum in East Africa, is inclined to accept Zambaco's theory as applied to that disease.*

McDonald,† analyzing 150 cases of lepra among suspects examined in Hawaii, states that from two to six or more of the following signs and symptoms "will be found, in some slight degree at least, in every leprous subject":

1. Maculæ, chiefly leucodermic spots, are found in 89 per cent of all cases.
2. Lepra nodules, the chief distinguishing skin lesion, in 74 per cent.
3. Thinning or complete loss of eyebrows and eyelashes in 63 per cent.
4. Atrophic changes in hand and forearm, with retraction and contraction of fingers and enlarged ulnar nerve, in 32 per cent.
5. Plantar ulcer, usually on ball of foot, in 26 per cent.
6. Absorption of phalanges, with occasional spontaneous amputation, in 16 per cent.
7. Elephantoid hands and feet in 16 per cent.
8. Facial paralysis in 11 per cent.
9. The entire body should be carefully tested for anæsthetic areas.

Finally, especially where legal sequestration follows upon the diagnosis, it should be confirmed, if possible, by the demonstration of the bacillus. In cases of nerve leprosy this will often be difficult, and at times impossible, but in the great majority of cases the demonstration will be easy. If final diagnosis and sequestration be suspended in the absence of such demonstration, the case would be little of a menace to the community.

The bacilli can be demonstrated in a section of leproma, in the so-called

* Journ. Trop. Med., London, Feb. 1st, 1905.
† Journ. Amer. Med. Assoc., 1903, xl., 1567.

"leper juice" expressed from a leproma by squeezing and puncturing it, in bits of macular skin snipped out with scissors, in scrapings from active leprous ulcers, but not from purely trophic ones, or in portions of a thickened, diseased nerve. When examined fresh they are seen in active motion, which is stated by some authorities to be molecular and not vital. Spread on a cover glass or slide, dried, and fixed by passing through the flame, smears can be stained with cold carbol-fuchsin, decolorized in a few seconds with nitric acid twenty-five per cent, and counter-stained with methyl blue. The bacilli appear as red rods in a blue ground, similar to but shorter than B. tuberculosis. Acid alcohol (acid. hydrochlor., 3 parts; ninety-five-per-cent ethyl alcohol, 100 parts), under which B. tuberculosis will retain the fuchsin color, decolorizes B. lepræ very quickly. Moreover, it will often be found impossible to stain the bacillus in specimens of leprous tissue which have been kept long in alcohol prior to examination. When the bacilli are not sufficiently abundant to be easily demonstrable, the method of Alvarez will be found useful. He subjects the piece of skin or other tissue to be examined to prolonged trituration in a mortar with a little normal salt solution, and spreads and dries the resultant fluid on a cover glass or slide for staining.

Because of the dread inspired by the disease (leprophobia), a diagnosis of leprosy should be given only in cases where it is established beyond doubt; and such a diagnosis should not be suggested to any suspect under examination while the nature of his disease is *sub judice*.

Leprous laryngitis must be distinguished if possible from an intercurrent syphilitic or tuberculous or alcoholic laryngitis. In the laryngitis of leprosy, as observed with the laryngoscope, there is at first vascular injection with dilatation of the veins, followed either by a shallow ulceration or by deep infiltration with formation of nodules (lepromata) on the epiglottis, arytenoids, or false cords. The true cords are frequently the seats of injection, sometimes of ulceration, rarely of persisting nodular lesions. A peculiar dirty-grayish or yellowish discoloration of the parts is characteristic; and if there is ulceration it is apt to be covered with a yellowish pellicle. In alcoholic and syphilitic laryngitis nodules are not present. In tuberculous laryngitis the congestion is rarely so intense as in the leprous affection.

Leprous orchitis begins in the testicle proper, or with a simultaneous infiltration of testicle and epididymis; there is neither pain nor tenderness on pressure, there is no involvement of the spermatic cord, and no prostatic tenderness. There is a rapid swelling, which subsides slowly in two or three weeks and leaves the testicle filled with hard nodules in its parenchyma; these can be discerned by a firm pressure which causes no pain, the sensitiveness of the organ not being restored after the attack. Attacks are apt to be recurrent (Hallopeau *).

Leprous otitis media is, as has been said, a rare condition, and presents no

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* Bull. soc. franç. de dermat. et syph., Paris, 1893, iv., 146.

special features to distinguish it from the commoner pyogenic inflammations of the middle ear.

Prognosis.—Leprosy, as has been stated, is usually fatal, either directly or by predisposition to tuberculosis, sepsis, or some other intercurrent affection. There was a time in the past when, on recognition of this dreaded disease, hope was abandoned by both doctor and patient, and, with it, all effort to help the sufferer. In general, the prognosis, as compared with that in most other diseases, is undeniably bad. But, as a result of our present exact knowledge of leprosy as a specific bacillary infection and our more attentive and intelligent study of individual cases, we now know that the prognosis in certain types of the disease is not hopeless, and that in individual cases, far from being absolutely bad, it may be relatively good.

Though it runs a very slow course, during which death may occur, lepra appears, like other bacillary diseases, to be a self-limited disease, and, if the patient survive the attack, the disease process is arrested. The structural damage wrought is never repaired, but the active disease is recovered from and does not longer exist as such. The bacilli cannot be demonstrated, and are either no longer present or, if present, they are quiescent and neither injurious to the patient nor dangerous to others. Such spontaneous cure or arrest of the disease is rare in nodular and mixed leprosy. It is by no means uncommon in unmixed nerve leprosy. Though it had been previously recognized that leprosy is seen in rare instances in imperfectly developed, mild, benign, or abortive forms from which recovery is complete, Impey was the first able and persistent advocate * of the view that well-developed nerve leprosy frequently ends in recovery from the disease as such, that the disease is arrested and therefore cured in precisely the same sense that tuberculosis is cured. He reported, from the Robben Island Leper Asylum, seven per cent of cures with no lesions remaining, and fifteen per cent of cures if the trophic ulcer be considered as not a sign of active leprosy. The same view is now accepted by the majority of leprologists. Hansen † says: "In my opinion nearly all the maculo-anæsthetic cases are cured before they die. This view is in full accord with Dr. Lie's researches, who found no bacilli in some cases after death."

The statistics of leper hospitals and asylums show that, under favorable hygienic conditions and proper medical and surgical treatment, the average duration of nodular and mixed leprosy is from seven to eight years. It is very rarely arrested, being in the overwhelming majority of cases directly or indirectly fatal within that time. The average duration of anæsthetic leprosy is about eleven years (Impey). Tonkin believes the disease to be quiescent in all persons who have survived the attack fifteen years, and that after twenty years lepra can never be recognized or demonstrated as such. In 220 cases examined by him in

* Prize Essay, London, 1894.
† St. Thos. Hosp. Gaz., London, June, 1905.

the Soudan, he found that 24 per cent had survived the fifteen-year limit, and 8 per cent had lived twenty to twenty-five years from the time of attack.* Acting upon this view of the matter, many were discharged after being from three to ten years on Robben Island as cases of arrest or cure, and the example has been followed at Kingston, Jamaica, and in other leprosaria. Dyer reports ten cases cured during the past ten years.† That a comparatively favorable prognosis is occasionally justified in nerve leprosy is shown in the case mentioned by Osler, who says: "One of the most prominent clergymen on this continent had anæsthetic leprosy for more than thirty years, which did not seriously interfere with his usefulness, and not in the slightest with his career."

Prophylaxis.—As lepra is an infectious disease, communicated in some way from person to person, and cases never arise where such communication has not taken place, all cases of the disease in an active stage should be either segregated in a suitable public asylum or as far as possible isolated in their own houses under systematic public supervision. Where the latter plan is the best that can be followed, the leper should be separated as far as possible from other persons in a clean and well-ventilated room. Attention should be paid to the cleanness of his person, clothing, and bedding; he should not use the dishes and utensils used by others, nor eat or sleep with others. Measures should be taken to disinfect his sputum and nasal discharges, and if he have any open lesions they should be washed with antiseptics and protected by proper dressings—materials to be furnished at the public expense if necessary, and burned after use. The better plan by far, however, in this country at least, would be the establishment of a national leprosarium, as recommended by the Marine Hospital Commission in 1902, with first-class hospital equipment and a domain large enough to afford every sort of recreation and to remove any sense of confinement, offering altogether such benefits and attractions that the patients would gladly avail themselves of the privilege of entering it.

Except in the cases of married couples entering them, the organization of leper asylums should provide for an effective separation of the sexes. Too often the separation is only nominal and ineffective, and many illegitimate births result. The children of leprous parents are born clean; and under every system of segregation legitimate as well as illegitimate children born within an asylum should be removed promptly to safety. Segregation has two objects: (1) to protect all clean individuals and (2) to stamp out the disease in the community. Both these objects are defeated by permitting clean infants to remain with leprous parents. Under no circumstances should leprous mothers be permitted to suckle their infants. If clean relatives or foster parents willing to take them cannot be found, a refuge should be provided for them by the state. Humanity will often suggest and public policy may justify the volun-

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* Journ. Trop. Med., London, 1904, vii., 263.
† Med. News, New York, July 29th, 1905.

tary segregation of clean adult members of families with their leprous relatives. But nothing can justify permitting a helpless infant, which is as clean as any other infant, but which has had the misfortune to enter the world through a leper asylum, to remain exposed to the contagion of this dreadful disease. Remaining in the asylum, it will in all probability become a leper. Removed, it will in all probability never become a leper.

The prophylactic value of segregation and supervision has been admirably illustrated in Norway, the only country in which it has been systematically enforced for a long time. There were, in 1870, over 2,500 lepers in Norway; in 1900 there were fewer than 600; and Hansen predicts, from the steady decrease in recent years, that there will be none in 1920.*

Treatment.—*Hygienic.*—All leprologists bear testimony to the favorable effects of a good dietary, regular bathing, sufficient clothing, and avoidance of dampness, exposure, and fatigue. Hutchinson, Besnier, and others recommend removal to a non-leprous country when practicable. Of the importance of hygienic treatment, Manson says: "It has been found that most lepers, on being placed in favorable hygienic conditions, improve for a time, and that in a small proportion of cases the disease by these means may sometimes be actually arrested. . . . The methods of treatment now coming into vogue for tuberculosis are equally applicable to leprosy." †

Medicinal.—In attempts to combat this once hopeless and still always dreadful disease, many drugs have been tried in the hope that some one might be found to have a specific effect. One after another experienced observer has believed that cure was effected or distinct benefit obtained by the use of some one of these either internally or locally. Among constitutional remedies which have been more or less extensively tried and to which such effects have been attributed may be mentioned gurjun oil; ichthyol (Unna); potassium chlorate (Chisolm, Carreau, Dyer); sodium salicylate (Danielssen); salol; Koch's tuberculin; Calmette's antivenene (Dyer); thyroidin (Manson); hoang-nan; arsenious acid; the bite of a venomous snake (Carreau). Local remedies which have been alleged to be of special value are europhen in oil (Goldschmidt); ichthyol, pyrogallic acid, resorcin (Unna); nitrous acid (Chisolm); arsenious acid (Colles); carbolic acid (Lalor); creolin (Rake). There is no reason to believe that coincident improvement was attributable to any of these substances. Among the constitutional remedies mentioned, hoang-nan is of some value as a tonic, but is in no way superior to nux or strychnine. Improvement under the local remedies could be reasonably attributed to their antiseptic and stimulating effects and to the effect of the cleaning and dressing involved in their use.

The one drug which has for many years stood the test of time and use is *chaulmoogra oil.* The natives of India had long used it locally on leprous ulcers,

* *Loc. cit.*
† "Tropical Diseases," London, 1903.

when it was brought to the attention of the profession in Calcutta by Dr. Mouat in 1854. There seems no room for doubt that it has a specific value in leprosy. Besnier * says: "From long experience we can state that if an oil of good quality in sufficient doses is regularly and perseveringly taken by a patient and tolerated, the result is always successful." He insists upon large doses, regarding 200 drops as a good average daily dosage, and gives it on bread. The ordinarily accepted dosage is less than this, beginning with 10 to 15, and seldom exceeding 100 drops. The small dose may be given in capsule at the beginning, or in milk. If well tolerated the pure oil may be taken floated in a little peppermint water or with a dash of tincture of ginger. Or it may be given in a flavored emulsion, alone or with cod-liver oil. Locally, to nodules, ulcers, and crusts, well rubbed in, chaulmoogra oil is valuable not only for its special properties, but as an emollient and by the massage employed in its application. The writer is convinced that specific benefit results from the internal administration of this drug, and believes it should have a routine part in the treatment of leprosy. Strychnine and other tonics are beneficial and should be used as indicated. Anodynes are seldom required, but if they are indicated in advanced and hopeless cases their free use is certainly justified.

Attempts have been made to develop a serum therapy for leprosy, but the sera put forward by Carrasquilla, Laverde, Herman, and others have been found useless. It has been noted repeatedly that attacks of erysipelas, measles, and smallpox have a favorable effect upon nodular leprosy in the affected part, causing a softening and absorption of the leprous infiltrate.

Radiotherapy in nodular leprosy has been tried by Oudin, who believed that benefit resulted in two cases so treated. He used exposures of from two to five minutes every two days, with the anti-cathode at a distance of 15 cm.† Dr. H. B. Wilkinson ‡ states that he has had rather promising results in the treatment of leprosy by the use of the x-ray. He is inclined to believe that the cure takes place by the lepra bacilli in the lesion being "killed and their bodies absorbed by the system, thereby producing an immunity against the living organism." In support of his theory he states:

"1. The treatment of one leprous spot on a patient produces improvement in spots at a distance from the one actually treated.

"2. The cure in the distant spots seems to progress parallel to and to be just as complete as that in the one treated.

"3. The best results seem to be obtained only when treatment is pushed to the point of killing or beginning to kill the tissues, which would also probably be to the point of killing the organisms.

"4. Cases in which there are massive localized leprous deposits are most rapidly improved, as in these cases we have an abundant culture on which to operate and thereby produce immunity more rapidly.

* "Pict. Atlas Skin Dis. and Syph." (transl.), London and Philadelphia, 1896.
† Bull. off. soc. franç. d'électrothérap., Paris, 1902, ix., 138.
‡ "Observations on Leprosy in the Phillipines." H. B. Wilkinson.

"5. In diffuse general involvement of slight degree or atrophic character where there are only a few scattered organisms we have had little success.

"6. In two well-advanced cases where the amount of new leprous tissue was excessively great, the improvement was marked and rapid, but followed by loss of general health and rapid physical decline. This may be an overdosage, so to speak."

Surgical.—In the history of recent study and advancing knowledge of this disease, nothing is more striking than the entrance of surgery into the treatment of leprosy. We have recognized the essential nature of the disease as a slowly advancing infection, and we have learned that it is not altogether uncontrollable in its course and is occasionally curable. Something can usually be done to relieve or arrest its local manifestations, with relief to the patient and often with marked influence on the general course of the disease.

An impulse to surgery in lepra was given by Danielssen and Boeck, who observed that the blood of lepers coagulates more quickly than normal blood, owing to an excess of fibrin; and that, because of this increased plasticity, clean wounds in lepers, contrary to preconceived ideas on the subject, healed more promptly than is the case in other wasting diseases, such as tuberculosis. Not only, then, is the existence of lepra no contraindication to operation for some independent affection, but the surgeon observing in the development of leprosy any condition amenable to surgical relief should not stay his hand.

The knowledge that their disease is in most cases ultimately hopeless and the attitude of society toward them are apt to produce in lepers a despondent stolidity. They complain little and often fail, in their shifting and changing sufferings, to call attention to conditions for which some surgical relief could be given. It is the surgeon's duty, therefore, to be on the alert for such conditions. He should frequently inspect the patients and be freely guided by general surgical principles in their treatment. If the disease is complicated by a painful tumor amenable to operation, it should be removed and the patient's life made more tolerable. Dental caries and odontalgia should be discovered and relieved. If advancing ulceration leads to alveolar abscess or infection of the antrum, pus should be evacuated. Sinuses or abscesses in any part of the body should be attended to. Crusting discharges should be removed, dryness of the skin with tendency to cracking and fissuring relieved by emollient applications, protection given to open lesions of all kinds, and healing promoted by antiseptic and stimulating dressings. Nothing is more important and generally more neglected in the care of lepers than frequent and thorough bathing. Fortunately, the importance of this is being more realized, and balneotherapy now constitutes the chief feature of treatment in some asylums, with the happiest results.

Concerning the value of operative treatment, Beavan Rake* said, in 1893: "I have for some time been of opinion that surgery can do far more than medicine in the palliative treatment of leprosy." During the years 1887–1892, in the

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* St. Louis Med. and Surg. Journ., April, 1893.

asylum at Trinidad, he performed on lepers 13 major and 105 minor amputations, 113 nerve stretchings, 630 removals of necrosed bone or cartilage, 60 excisions of nodular lesions, 4 abdominal paracenteses, 1 tracheotomy, 1 herniotomy, 16 circumcisions, 23 operations on the eye, 2 operations for hemorrhoids, and 1,016 incisions for abscess, ulcer, sinus, or tension—a total of nearly two thousand operations of various sorts to improve the condition of lepers. Among miscellaneous operations he reports scrotal incision for extravasation of urine, the resulting urinary fistula being subsequently cured.

Concerning the excision of leprous tissue, though no distinctive primary lesion is recognized in leprosy, when a single macule or a few nodules are the only lesions to be found and the symptoms and history of exposure warrant a diagnosis or a strong suspicion of leprosy, a bit of the skin should be examined for the bacilli, and, if they be found, the affected spot should be freely excised, in the hope that the disease has gone no farther. Such an attempt is justifiable and reasonable in view of Gerlach's demonstration that the bacilli start from the terminals in such skin spots to invade the nerve trunks. Marcano and Wurtz report the case of a child of four whose brother was a leper, and who presented a single macular lesion on the right temple in which the bacilli were demonstrated. When observed eight months after free excision of the macule, no further signs of disease had developed.*

Recurring attacks of *orchitis*, not uncommon in nodular leprosy, require no treatment beyond rest until the subsidence of the acute swelling, which is usually painless. *Otitis media*, occurring rarely, presents no special features. It may be set up by discharge and crusting at the external auditory meatus or in the canal. It will respond favorably to the usual methods of treatment.

Laryngitis is one of the gravest complications in lepra. Attention was first called to the changes characteristic of leprous laryngitis by Dr. Gibb, who was the first to use the laryngoscope in the examination of a leper and who described the peculiar nodular infiltration in 1863.† The laryngeal manifestations of lepra have been more recently studied by Hillis and others. The characteristic appearances and diagnosis have already been given. When recognized the condition should be treated locally with a cleansing spray and soothing emollient inhalations, chaulmoogra oil and tonics being given internally at the same time. Besnier recommends that nodules in the pharynx or other visible mucous surfaces be destroyed by the electro-cautery. Both Taylor and Rake have reported successful tracheotomy, relieving distress and prolonging life. ‡

Serious *eye complications* are brought about in leprosy in three ways: (1) Paralysis of the orbicularis palpebrarum, causing ectropion and constant exposure of the eye, which is deprived of its normal protection and moisture. The

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* Arch. de méd. expér. et d'anat. path., Paris, 1895, vii., 1–16.
† Transac. Lond. Path. Soc., 1863, xiv., 273.
‡ Lancet, London, July 27th, 1899.

dryness and the irritation of dust set up chronic conjunctivitis and keratitis, resulting in leucoma and blindness. (2) Granulomatous infiltration of the sclerotic and cornea or of deeper structures, either diffuse or in distinct nodules. (3) Secondary inflammation following upon one of the first two causes, with panophthalmitis, followed by destruction or atrophy. In conjunctivitis temporary relief may be given by a soothing collyrium, such as ac. carbol. 0.1, glycerin. 0.5, sod. chlor. 0.8, aquæ dest. 100.0; but lasting benefit can be secured only by a blepharoplasty, which should be performed for the cure of the ectropion. Granulomatous infiltration, nodular or diffuse, generally begins at the corneo-scleral junction, and afterward invades the cornea. Its advance may be checked by thorough excision of the nodule, as practised by Panas with good results;* or, better, by linear keratotomy on the pupillary side of the lesion, the growth being arrested at the line of scar tissue, as pointed out by Broeckmann. Iridectomy may be done for an isolated nodule in the iris or to make an artificial pupil in a favorable situation when there is corneal opacity. Operations for cataract in lepers have usually been only transiently successful, as the cataract is generally an incident in a diffuse irido-cyclitis, which shortly eventuates in destruction of the eyeball. Following all the operations mentioned, atropine should be used to guard against the formation of synechiæ. Staphyloma and panophthalmitis are to be treated by excision of the eyeball.

As regards the *trophic lesions* of leprosy, the perforating ulcer of the foot, which is so common, should be treated like any other sinus by laying it open and packing it, causing it to heal by granulation from the bottom. When encountered in its commonest site, the ball of the foot, a bistoury may be run from below through the dorsum and brought out by slitting forward between the toes. Or, if near enough to the inner or outer edge of the foot, it may be slit out on that side. Of eight cases so treated by Rake, all did well and healed. One required a re-slitting before it was cured. Any sloughing tissue or dead bone encountered should be removed by curette or forceps before packing and dressing the wound. Coates has reported several successful subcutaneous tenotomies for contracture of fingers, with good results.

Nerve stretching in anæsthetic leprosy was suggested by McLeod, of Calcutta, in 1877, and was first practised by Lawrie, at Lahore, who reported in 1878 that he had done the operation thirty times, with marked benefit in most cases. Other surgeons in India adopted the practice, and it has now been employed hundreds of times, resulting in the relief of pain, the restoration of feeling, and the arrest of the morbid process in the nerve trunk in many instances. In Neve's series of 90 patients in whom 190 neurectasies were done, 84 improved, 2 did not, and 4 died. In the last 32 of these cases with 75 nerve stretchings, all but 1 case improved. The 75 stretchings were done on 61 sciatic, 7 ulnar, 5

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* Bull. de l'Acad. de méd. de Paris, 1887, 2 s., xviii., 757.

median, 2 musculo-spiral nerves.* The procedure recommended is a rapid in-
cision, an inch and a half long, just below the gluteal fold, midway between the
tuber ischii and the trochanter femoris, passing at once through the deep fascia;
then, introducing the finger under the edge of the biceps and recognizing the nerve,
separate it with the finger, draw it out, and stretch it by jerking the leg off the
table with a force of twenty-five to thirty pounds. Improvement follows in from
three to six days, and is usually complete or nearly so in three weeks. More
improvement may follow after the third week. Recurrence of the symptoms for
which the operation was done is noted rarely. Nutrition improves and trophic
ulcers in the distribution of the nerve heal. For the ulnar or median a force of
from four to eight pounds is sufficient. Failures may be attributed to insufficient
stretching. Neve has accidentally broken the ulnar and immediately sutured it,
and no bad result followed. In a case of Bomford's, the left ulnar, extensively
infiltrated, nodulated, tumefied, and adherent to surrounding structures, when
separated broke under light stretching and was immediately sutured. A prac-
tically complete recovery from the palsy and anæsthesia in its distribution fol-
lowed, and the patient, a laborer forty years old, resumed hard work.†

The ulnar, median, and sciatic nerves oftenest require stretching. The sen-
sory distribution of the musculo-spiral is unimportant. The ulnar is the selec-
tive seat of leprous neuritis. Slitting, in addition to stretching the nerve, has
been tried, but adds nothing to the results of the operation. Observers are
agreed as to the beneficial effects of neurectasy in at least fifty per cent of cases.
The relief of pains and paræsthesias and the healing of the trophic ulcers would
appear to be fairly constant and the results permanent even where anæsthesia
recurs. Rake attributes the benefit that follows sciatic stretching to dragging on
the spinal cord and stirring up its trophic centres. Where only one sciatic has
been stretched, he has observed improvement to follow on the opposite side also.
Downes, of Cashmere, has cured supraorbital neuralgia by stretching the nerve.

Where trophic or other ulcerative lesions have become extensive, sloughing,
and septic, or where gangrene has set in, *amputation* may be called for to re-
move a source of sepsis which is seriously affecting the health and strength. Or
a leg may be the site of a leprous or a true filarial elephantiasis, and be so en-
larged as to be a burden to the patient. Amputation is justified in all such cases,
and often results in the greatest relief to the patient and a vast improvement in
his general health. Manson has removed an enormous elephantiasis of the scro-
tum from a leper, with a good result. In amputations for gangrene there should
be no waiting for a line of demarcation. In one of Rake's cases, where amputa-
tion was done through the thigh for gangrene of foot and leg, the patient was
almost moribund when put on the table, but recovered and lived nearly six
years longer.

* Edin. Med. Journ., 1884, xxx., 433.
† Lancet, London, 1881, i., 329.

Advantage has been taken of the anæsthesia incident to the disease to amputate in some cases without ether or chloroform. Barnes has thus successfully amputated both forearms at one sitting without an anæsthetic, the patient feeling only slight pain when the deeper structures were divided. It would seem to be generally advisable, however, unless the patient's condition offer some contraindication, to employ an anæsthetic; as otherwise it may be necessary to begin it in the midst of the operation, as happened in a case of Pirigoff's amputation performed by Gibson * for necrosis in the anterior part of the foot.

PLAGUE.

Synonyms.—Bubonic plague; pest; black death. *L.* Pestis bubonica. *Fr.* La peste; peste bubonique. *It.* La peste bubbonica. *Sp.* La peste bubonica. *Ger.* Die Pest; Beulenpest.

Definition.—The disease caused by an invasion of *Bacillus pestis;* characterized by sudden onset, lymphadenitis, high fever, great prostration, rapid course, and high mortality.

History and Geographical Distribution.—There are clear descriptions of the disease antedating the Christian era, and referring to its existence in the Levant and neighboring parts of Asia and Africa. Its first invasion of Europe, known as the "plague of Justinian," started from Egypt in A.D. 542. The next great historic European pandemic began in 1348, and within three years caused 100,000 deaths in Venice, 100,000 in London, and wiped out one-fourth of the population of Europe. It raged with fluctuating virulence in London again during most of the seventeenth century, causing in the years 1665–66 70,000 deaths in that city. It was endemic in Paris from 1619 to 1668, since which time it has never reappeared there. Constantinople had an epidemic in 1841, since which date plague has not established a foothold in southern or western Europe. Certain places are believed to be more or less permanent endemic centres of the disease. Among such are Garhwal and Kumaon in upper India, and Yunnan in southwest China. The recent and still continuing pandemic started from the last-named district and reached Canton in 1894, causing 60,000 deaths there in that year. It reached Hongkong in the same year, and has continued endemic there. In 1896 it appeared in Bombay and Calcutta and spread over British India, in which empire the official returns show that it caused 1,040,429 deaths in the single year 1904. In 1899 it reached Egypt, which had been free of plague since 1844, and it continues epidemic in many provinces of that country. Sydney had in 1900 and the two succeeding years 444 cases. Plague had never been seen in America until it appeared in San Francisco in March, 1900; an epidemic continuing there, with a total of 119 cases, to February, 1904, when it was stamped out. The present pandemic reached Cape Town in 1901. The disease

* Annals of Surg., Philadelphia, 1898, xxviii., 256.

has also reached Naples, Marseilles, Oporto, and Glasgow, and set up limited epidemics, but has been successfully controlled and stamped out at all these European ports. Since 1901 it has appeared and gained some foothold in ports of Mexico, Brazil, Chile, and Peru. For more than a half century plague has been essentially and almost exclusively a disease of warm climates.

Etiology.—*Bacillus pestis* was discovered by Kitasato at Hongkong in 1894, in the blood, affected lymph nodes, or internal organs of all cases examined. This discovery was confirmed by the independent investigations of Yersin later in the same year. It is a short, broad rod, measuring 0.8 to 2 μ in length and 0.4 to 0.8 μ in breadth. It varies somewhat in morphology, the same specimen containing long and slender rods, dumb-bells, and forms resembling diplococci (see Fig. 2). This pleomorphism makes certainty of diagnosis difficult in the first
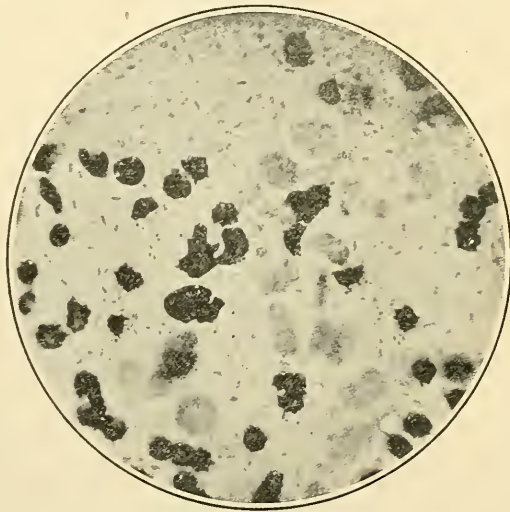

FIG. 2.—Scraping from Spleen, showing *Bacillus pestis* with spleen cells and leucocytes.　(*Jennings.*)

case seen in an epidemic. Though one or two terminal flagella have been demonstrated, it is non-motile, except that Brownian movement may be observed sometimes. It is aërobic and non-sporing. It grows on all ordinary culture media, does not liquefy gelatin or blood serum, nor produce gas. It does not stain by Gram's method, but stains readily in watery solutions of basic aniline dyes. The characteristic appearance is a bipolar staining with a clear space in the middle. It is found in practically all the tissues, diseased and healthy, and in all the excretions (see Fig. 3). Though usually abundant in smears from the contents of a bubo, the bacilli may occasionally be scarce and demonstrable only by culture. They are numerous in the sputum in pneumonic cases, and in the blood in the septicæmic type. It is obvious from the bacterio-pathology of the disease that an antitoxic serum, to be of value, must possess bactericidal properties, and this is the case with the serum of Yersin. The bacilli grow easily

in gelatin or agar, or in broth, blood serum, or milk. The cultures are best kept at a temperature below body heat, 25° to 30° C. The most characteristic growth, seen with no other bacterium, is obtained by Haffkine's method. A few drops of melted clarified butter or of cocoanut oil are added to bouillon, which, after being sterilized in a flask, is inoculated. After two to three days minute colonies are seen attached to the under surface of the oil drops floating on the medium. The flask must be kept absolutely quiet. In from one to three days more, long "stalactites" of growth hang from the surface oil down into the medium (see Fig. 4). The toxins produced by the bacillus are but slightly soluble in the
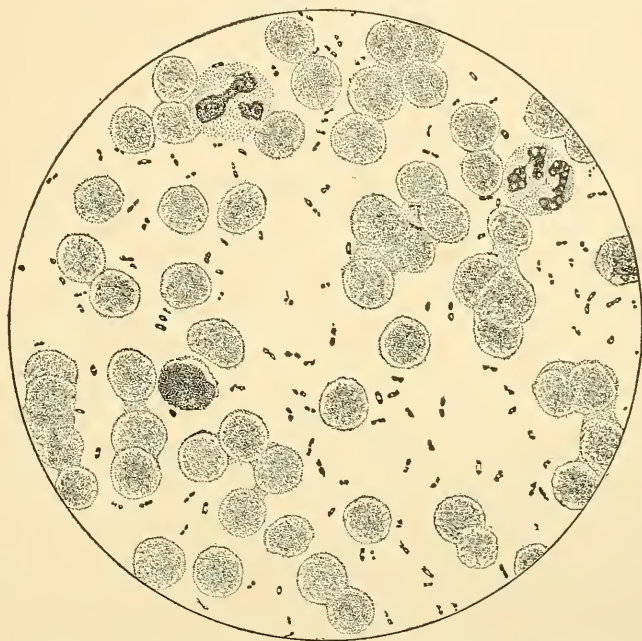

Fig. 3.—*Bacillus pestis* in Blood, stained with methylene blue.   (*Mueller and Poch.*)

culture media or in water, and the Haffkine prophylactic consists, therefore, of the dead bacilli themselves in a broth culture killed by heat at 65° C. The virulence of *B. pestis* is modified by varying natural conditions, and it can be modified artificially. It can be artificially increased by successive inoculations into guinea-pigs. It is diminished by cold, but the organism retains its vitality when exposed for months to a temperature of −30° C. Dried on glass, it dies in four days; exposed to sunlight, in from one to four hours. It is killed at once by steam at 100° C., and succumbs readily to antiseptic solutions of ordinary strength.

It is interesting to note, in the case of plague and its specific bacillus, that not only have all four of Koch's postulates been abundantly satisfied by experiment with many different animals, but that the disease has been produced in man himself by accidental infections in the laboratories of Berlin and Vienna,

from cultures representing many generations of removes, and at a time when there was no plague in Europe.

Pathology.—The most characteristic and constant lesion found post mortem is the adenitis. The lymph nodes are found in all stages of inflammation, from cellular hyperplasia to suppurative softening; and not only the buboes evident during life, but further and deeper nodes in the same chain are involved. If death has occurred early in cases not of the bubonic form, the adenitis is less conspicuous but is still demonstrable. The viscera are congested, the liver swollen, the spleen usually greatly enlarged. The serous membranes present punctate hemorrhages or ecchymoses, and are filled with bloody fluid. There are often hemorrhagic points or larger extravasations in the brain (Manson).
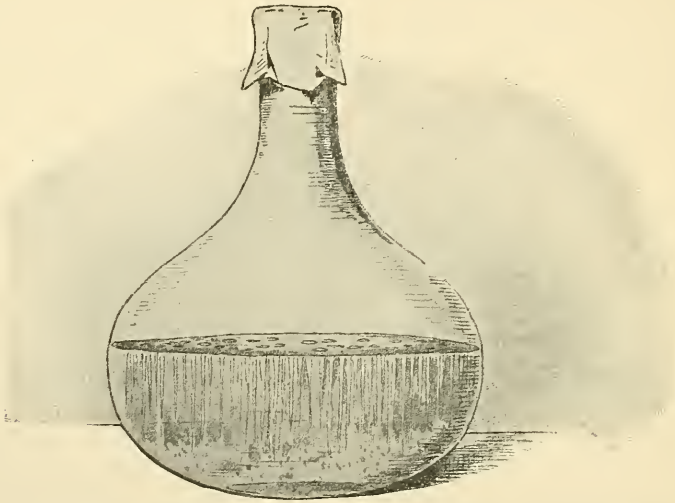

FIG. 4.—Haffkine's Stalactites in Bouillon Culture of *Bacillus pestis*.

As already stated, the bacilli can be discovered in all of the diseased and most of the healthy tissues. Petechiæ, larger ecchymoses, or areas of necrosis (often erroneously called "carbuncles"), are often met with in the skin.

Communication and Infection.—Plague is primarily and essentially a disease of rats, frequently communicated to other animals and to man. The mouse, cat, dog, hog, chicken, duck, goose, goat, cow, sheep, deer, bandicoot, and tarbagan (a species of marmot in Siberia and north China, hunted for its fur) are all naturally susceptible to it, and it has been artificially inoculated into the guinea-pig, mongoose, squirrel, horse, monkey, jackal, hyena, pigeon, and other animals.

The rat of the East, *Mus rattus*, appears to be more susceptible to the disease than the European rat, *Mus decumanus*. Wherever plague has appeared, it has always been noticed that rats first die in great numbers, the incidence of the disease among them preceding its outbreak in the population. The rat and the

tarbagan have both been shown to suffer from a chronic form of plague, which fact quite probably accounts for the endemicity of the disease in certain regions.

Plague is communicable in three ways: (1) By *inoculation,* either intentional or accidental; (2) by *ingestion* of infected food; and (3) in the pneumonic type by dissemination in the air and *inhalation,* the lungs being the primary site of infection.

(1) Infection by *inoculation.* The inoculability of plague has been shown not only in countless experiments on a great variety of animals, but by a number of unfortunate accidents. Instances occur in nearly every epidemic of physicians being infected through scratches or wounds of the hands incurred in making necropsies. This happened to Aoyama at Hongkong in 1894, Sticker at Bombay in 1898, and Pestana at Oporto in 1900. In the bubonic form, in which the disease oftenest occurs, there is only a slight danger of contagion to physicians and nurses, or to members of the patient's family, provided that the surroundings of the case are hygienic and the proper prophylactic precautions are observed. Bubonic plague does not spread in hygienic surroundings when introduced. If a case of the disease be removed from the rat-infested house in which it appeared, it brings little or no danger to the rat-free house, hospital, camp or neighborhood into which it may be taken; providing always that the excretions and discharges of the patient and the hands of the attendants are disinfected. But after the patient's removal and the disinfection of his rooms and belongings in the rat-infested house, though members of his own family may escape it and the incubation period of the disease may be long passed over, other cases appear in other families of the same tenement or in other tenements, dwellings, or shops which are structurally parts of the same building or which are in the same city block and inhabited by the same colony of infected rats. That is to say, the rats continue to be for other human cases, as they were for the first case, the source of infection.

As the result of his investigations in India in 1898, Simond was the first to assert a belief that the fleas of rats, becoming infected with plague, attacked and inoculated man. Following this suggestion, observations and experiments have been made by many investigators, and the following facts have been indisputably established. On rats, cats, dogs, and men various sorts of fleas are found in various parts of the world. Each species of flea prefers to live upon a certain animal as a host of election, but will occasionally, especially in the absence of a host of election and when driven by hunger, attack another kind of animal. Man is a host of election for *Pulex irritans;* the dog and cat for *P. serraticeps;* the rat for *P. fasciatus, P. pallidus,* and *Typhlopsylla musculi.* The dog flea attacks man frequently and is found on rats exceptionally. The various rat fleas are normally not found among fleas collected from man, but both *P. pallidus* and *P. fasciatus* will bite man when hungry. The bodies of rat fleas which have bitten plague rats have been shown to contain the bacilli. Fleas

have been allowed first to bite plague rats and become infected, and then to bite clean rats which were cut off from all other communication, direct or indirect, with the diseased rats. The clean rats developed plague from the flea bites, and died of it.* It has been shown, then, that in plague epidemics rat fleas infest man, that rat fleas when hungry will bite man, that the bodies of rat fleas which have bitten plague rats contain the bacillus, and that when such fleas bite healthy rats they give them plague. Every link has been supplied. It remains only to make one single chain of these links in a human experiment, which is not yet forthcoming. It would be necessary, for a complete demonstration, that infected rat fleas be carried to and allowed to bite a person at a distance from the epidemic area, who had not been otherwise exposed to possible infection. The length of time that the bacillus retains life and virulence within the flea's body has not yet been established.

The doctrine of flea transference as the ordinary mode of infection from rat to man, based upon observations and experiments in Europe, India, and Australia, has the support of Simond, Calmette, Tidswell, Raymond and Gauthier, Elkington, and Liston. Dr. J. Ashburton Thompson regards it as the only hypothesis which will explain the observed facts in the Sydney epidemic. A perusal of his most able and interesting argument is recommended to all interested in this subject.† Captain Liston,‡ I.M.S., explaining the operation of flea diffusion, says that it depends upon the migration of rats in the presence of an unusual mortality among themselves. They leave their fleas behind to a large extent, and these in sheer hunger attack man and other animals. In a plague tenement in Bombay, of 30 fleas caught on man, no fewer than 14 were rat fleas, and while normally rat fleas are never found on guinea-pigs, 18 were found on one sick guinea-pig in the same tenement. He thinks it reasonable to believe that the bacilli may live a long time in the flea's stomach, as they are there protected from the destructive effects of desiccation and sunlight and supplied with the very nourishment they require, namely, animal blood. It is quite probable that bedbugs and lice occasionally play a similar part in conveying plague from man to man.

(2) Infection by *ingestion*. The experiments of Simpson, Hunter, and Matsuda, in Hongkong in 1902, proved that animals are infected with plague as easily by feeding as by inoculation, that plague material from man or monkeys will give plague to rats, and plague material from rats will give it to monkeys (and presumably to man). Such feeding experiments result usually in the septicæmic form of the disease, with sudden death and abundant bacilli in the blood. Infection of food is a danger which may be incurred through soiled hands, through access to food stores by rats and mice who leave their excrement be-

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* Australasian Med. Gaz., Sydney, xxii., 348.
† Report Bd. Health Second Outbreak Plague, Sydney (1902), 1903.
‡ Ind. Med. Gaz., Calcutta, 1905, xl., 43.

hind them, and through roaches and flies. Yersin noted at Hongkong, in 1894, that great numbers of flies died in his laboratory, and he found the bacilli abundant and virulent in their bodies.

(3) Infection by *inhalation*. What primarily determines the infection of plague in some cases to the lungs is not known, but when it occurs and a case of the pneumonic form of the disease is developed, we have plague in its most virulent form—a form directly contagious, apparently by inhalation, as it gives rise usually to the same pulmonary form of the disease in those to whom it is conveyed; and attendants who are much in the sick-room, and who lean over the patient and handle his bedding, are very apt to take it in the same form in spite of all the ordinary precautions as to disinfection, cleanliness, and ventilation. This was the case with Dr. Manser, at Bombay, and the nurse who attended him, and with the equally sad cases at Vienna, where a servant in the Pathological Institute, one of his nurses, and the physician who attended them, Dr. Mueller, died of pneumonic plague.

Neither age, sex, nor occupation, nor variations of soil, temperature, nor elevation have any influence in the incidence of plague. Individual immunity and susceptibility must be recognized, and there is a certain degree of racial immunity in favor of Europeans, even in warm countries, as compared with the natives of those countries. Their higher intelligence as regards precautions and their better sanitary environment reduce the incidence of the disease among them, and their superior average physique and better nourishment and shelter reduce their case mortality as compared with natives. Thus, in Hongkong, the case mortality among the Chinese was ninety-three per cent; among the Europeans, only eighteen per cent.

It has been pointed out that many epidemic outbreaks of plague have been preceded by abnormal climatic conditions in the locality. War and famine, with poverty and crowding as natural consequences, favor the spread of plague. This was the case in some of the outbreaks of the Middle Ages, and it has been illustrated again recently in Cape Town, where plague extended rapidly at a time when the town contained many refugees on account of the Transvaal war, and a large number of natives, Indians, Arabs, and whites of various nationalities crowded its slums. Under the contrary conditions in hygienic communities, as at Glasgow and San Francisco, the disease when introduced gained no foothold except in the crowded quarters of Chinatown, to which, in the latter city, it was confined. Plague, like cholera, follows trade routes by both sea and land in its spread. Though sometimes introduced into a locality by diseased persons, infected merchandise or clothing, and body vermin, it is far oftener carried by rats, and this is especially true of its spread by sea in ships. Tidswell states that in the recent Australian epidemic the mode of introduction of the disease was never traced to any human source, and in its continuance it was plainly rat-borne.

Symptoms.—(1) Bubonic plague (*Pestis buboniea*).—The period of incubation is usually from two to eight days, the extremes noted being from a few hours to fifteen days. The disease sets in usually without prodromes; the invasion is sudden, with chilliness, fever, weakness, and extreme lassitude, aching of head and limbs, vertigo, drowsiness, with troubled dreams. The face is drawn and haggard, with an expression of fear or horror; the eyes are bloodshot and staring. There may be nausea, vomiting, or diarrhœa. This stage of invasion may last a day or two, but is generally short, sometimes altogether wanting, the disease being fully developed within a few hours, with high temperature, 103° to 104°, sometimes 106° or 107° F : rapid pulse and respiration, dry and burning skin,
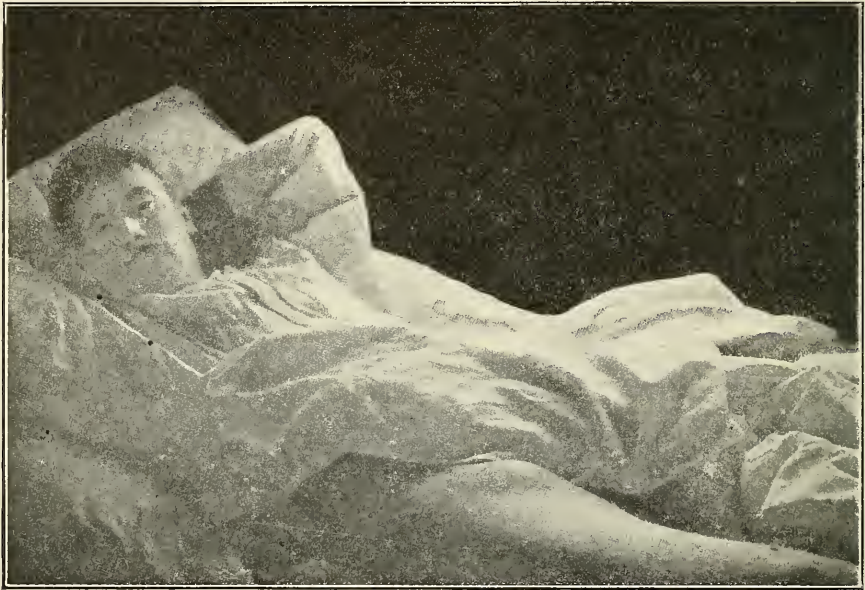

FIG. 5.—Inguinal Bubo in Plague. (*Simpson.*)

face deeply flushed, eyes injected and fixed, hearing dulled, tongue swollen and furred. The coat on the tongue turns brown or black, sordes form, thirst is intense. The typhoid state is rapidly developed, prostration is extreme, the voice is scarcely audible, and delirium, stupor, carphology, subsultus, and convulsions appear. There may be persistent vomiting or diarrhœa, scant urine with retention, usually with a trace of albumin. The pulse, at first full and bounding, becomes small, fluttering, dicrotic, or intermittent. Cyanosis may precede death.

Generally within twenty-four hours the characteristic adenitis appears. Its most frequent site is in the groin, and this gives the appellation *bubonic* to the disease (see Figs. 5 and 6). This fact, in turn (etymology being disregarded), has led to the application of the name *bubo* to the characteristic adenitis when it occurs in other situations, as the axilla (Fig. 7), angle of jaw, popliteal space,
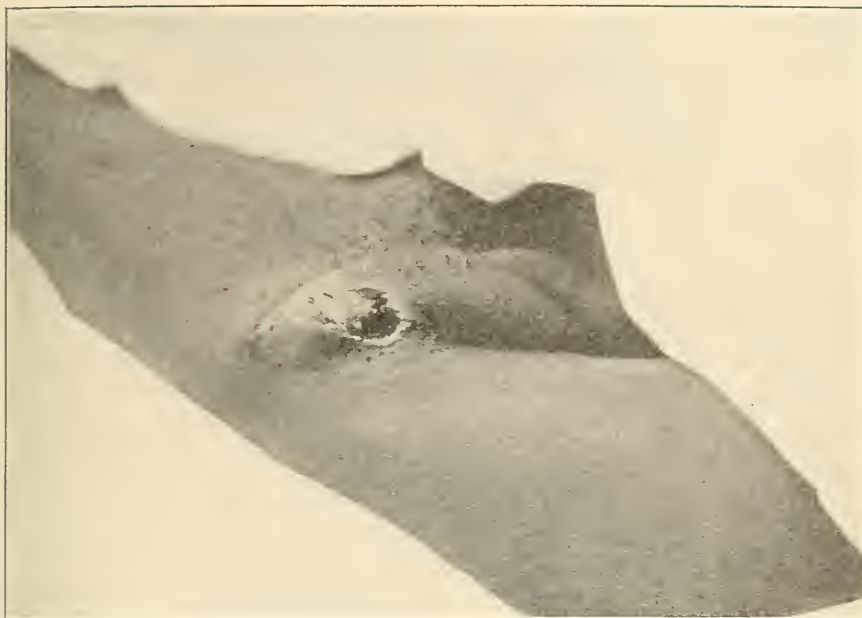
Fig. 6.—Another Instance of Iuguinal Bubo in Plague. (*Simpson*.)

Fig. 7.—Axillary Bubo in Plague. (*Simpson*.)

etc. The bubo is usually single, more than one occurring in only about one-eighth of the cases (Manson). In seventy per cent of the cases it is in the groin, in twenty per cent in the axilla, and in rarer cases it is post-maxillary, cervical, epitrochlear, or popliteal. The bubo, whether quite small or as large as a goose egg, is generally painful, tender to touch, and shows infiltration of the surrounding connective tissue. Skin sloughs appear (the so-called "carbuncles") in a small proportion of cases. The liver and spleen are usually perceptibly enlarged.

Improvement in symptoms sets in with profuse sweating. The tongue moistens, the fever falls, the pulse improves. The bubo continues to enlarge, and, after days or weeks, suppurates, and if not incised bursts and discharges its pus,

Fig. 8.—Sloughing Cervical Bubo in Plague.   (*Simpson.*)

leaving an indolent sore extremely slow in healing (see Figs. 8 and 9). Resolution, instead of suppuration, occasionally, though rarely, occurs in the buboes. Pyæmia, with boils, cellulitis, secondary lymphadenitis, or suppurative parotitis may supervene on the suppuration of the bubo. As a result of blood dyscrasia, petechiæ and ecchymoses in the skin occur, or hemorrhages from the nose, lungs, stomach, bowel, or kidneys. Such hemorrhages are evidence that the disease is of a malignant type. Death occurs from adynamia, external or internal hemorrhages, coma, and convulsions, or, later, from exhaustion. Convalescence, when it sets in, is apt to be tedious, delayed by sloughing and indolent healing in the buboes, and by the exhausted state of the patient.

(2) Pneumonic plague (*Pestis pneumonica*).—This is a most dangerous form of the disease. It is almost invariably fatal to the patient, and, through his ex-

pectoration, easily communicable in the same virulent form to others. The primary seat of infection is the lungs, and the sputum is loaded with the bacilli, sometimes in nearly pure culture, though more commonly associated with the pneumococcus and other organisms. The onset of the disease is sharper than in the bubonic form, often with pronounced rigor, vomiting, high fever, intense headache, and prostration. Cough sets in, with rapid respiration, soon followed by dyspnœa, moist râles, and profuse bloody expectoration. Unlike the scant, rusty, and viscid expectoration of croupous pneumonia, the sputum is copious,
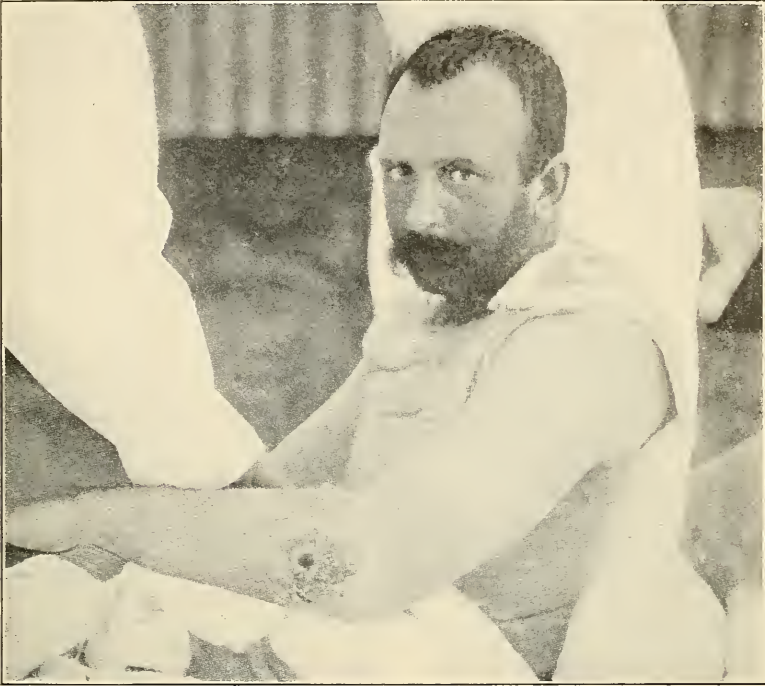

Fig. 9.—Necrosis of Tissues in Plague. (*Simpson.*)

watery, and tinged a bright red. Exhaustion soon supervenes and death occurs usually by the fourth or fifth day.

(3) Septicæmic plague (*Pestis siderans*).—In this type of plague cases adenitis is not discoverable during life, but can be demonstrated post mortem. The bacillus invades the blood directly, multiplies rapidly in it, and is demonstrable during life. The invasion is sudden, the course rapid, the result invariably fatal. The febrile movement is slight, the prostration extreme from the outset, and death occurs usually in from one to three days. Hemorrhages in the skin, deeper tissues, and organs are common. Atkinson has reported a case in which hemorrhage into the walls of the cæcum produced complete intestinal obstruction, which was the immediate cause of death.

(4) Ambulant plague (*Pestis minor*).—This is the mildest clinical form of plague. It has been called *abortive, larval,* or *walking plague.* Preceding a recognized outbreak, or early in an epidemic, cases are seen with mild fever, slight constitutional disturbance, and lymphatic swelling, which may or may not go on later to suppuration. Often the patient is able to attend to his daily affairs throughout the attack, and recovery is the rule, though death occasionally occurs suddenly from collapse. Such mild cases are not uncommon, too, toward the end of epidemics, when the disease is manifesting a generally diminished virulence. It is particularly important to recognize such ambulant cases at the beginning of an epidemic, on the patient's account that his strength may be conserved, and that he may be prevented from being a source of infection for others.

Diagnosis.—Plague has been mistaken for influenza, pneumonia, bronchitis, and pleurisy; for typhus, typhoid, malarial, relapsing, and yellow fevers; for rheumatism and for septicæmia; for pericarditis, endocarditis, gastroenteritis, appendicitis, and peritonitis; for dysentery, beriberi, syphilis, venereal bubo, and mumps. The diagnosis of a pneumonic case in the first stages is not easy. The râles are moist from the first, and the expectoration of a character different from that of *pneumonia,* as already described. From *typhoid fever* plague is to be diagnosed by the rapid and weak pulse very early in the case and out of all proportion to the severity of the general symptoms and the duration of the disease. A characteristic of the plague bubo is that the lymphadenitis is usually without any evident associated lymphangitis. In every case of fever of an adynamic character occurring during a plague epidemic, especially if it be associated with adenitis, plague should be suspected.

The only conclusive diagnostic test is, of course, the discovery of the bacillus in the lymph nodes, blood, sputum, or discharges. The following routine will usually be found satisfactory:

1. Draw a little fluid from the bubo with a syringe, or take the sputum of a pneumonic case, spread, fix, stain with Loeffler's blue, mount; search for short, plump bacilli, often in pairs, with polar staining and transparent centres. There may be a mixture of organisms in the bubonic fluid; and in the sputum *Diplococcus pneumoniæ* will very probably be present. The latter stains by Gram, which *B. pestis* does not.

2. Agar and broth cultures should be made and incubated at 25° to 30° C. for twenty-four hours, and then used to inoculate a mouse, rat, or guinea-pig. If the animal dies, investigate for *B. pestis.*

3. Make Haffkine butter-fat-broth culture for stalactite growth. No other bacterium behaves in this way.

Prognosis.—The average death rate among plague-stricken Europeans in various parts of the world during the present pandemic since 1894 has been about thirty per cent. Among colored and Asiatic populations it ranges from

sixty to ninety-five per cent. It varies according to the virulence of the epidemic prevailing at the time, and the type of the disease in the individual cases. The results of bacteriological examination are seldom of any assistance in prognosis, as in septicæmic cases the bacilli are not abundant in the blood until the case is advanced and near to death; and in the pneumonic cases, owing to mixed infection, they are hard to determine by direct examination, and they grow so slowly in cultivation that the patient is dead before the demonstration by culture has been made. Death in the ordinary bubonic type of cases usually occurs from the third to the fifth day. If the patient survive this period, convalescence sets in from the sixth to the tenth day. Prognosis in a particular individual depends on race and age, degree of reaction exhibited by the patient, virulence of the existing epidemic, and whether it is on the increase or declining; above all, on the type of the disease—bubonic, pneumonic, septic, or ambulant. Two-thirds of whites recover; two-thirds of other races die. In children from five to ten years of age there is a lower mortality than in adults. Great caution is necessary in prognosis, but encouragement may be given by a good pulse, absence of grave cerebral symptoms or of albuminuria, and early development of the bubo. Gravely unfavorable signs are frequent and weak pulse, rapid respiration, hyperpyrexia, violent delirium, continuous diarrhœa, hemorrhages, cyanosis, urinary suppression, or the discovery of the bacilli in large numbers in the blood.

Public Prophylaxis.—The Paris Plague Convention of 1903 recommended five days as the period for the enforcement of marine quarantine. This is too short a period. An incubation of six days is not excessively rare. The United States Quarantine Regulations require seven days, Manson insists upon eight days for safety, and Simpson considers that surveillance should extend to ten days if the suspect or contact be sooner discharged. As Kitasato has shown that the bacillus persists in the patient's body three weeks after the cessation of active disease, convalescents should be quarantined one month. Ships at infected ports should anchor out in the stream, or have rat-guards on all mooring lines if going up to the wharves be unavoidable. Methods of disinfection should be chosen which are especially effective against vermin. By far the best of such is the use of concentrated sulphur polyoxide by Clayton's apparatus. It should be used for both ships and buildings wherever possible. Small objects may be disinfected in solutions of corrosive sublimate, 1 to 1,000, carbolic acid 3 per cent, or chlorinated lime.

Communities which are peculiarly exposed to the introduction of plague should strive for the extermination of rats and their permanent exclusion from inhabited buildings. When, in such a community, rats are observed to be dying in great numbers, a public force of catchers and collectors should be got to work; rats taken should be tagged with the address where caught, and sent to a public laboratory for plague examination. When plague is found in a rat, the house

from which it came is a "plague house" and is to be treated accordingly, precisely as though it had already contained a human case. When human cases appear the measures to be enforced are: (1) Case notification to the authorities; (2) isolation of the infected; (3) segregation of suspects and contacts for eight days' observation (best in separate camps); (4) evacuation and disinfection of houses and destruction of huts; (5) disinfection of persons and clothes; (6) cremation of the dead or burial in graves not less than three meters deep (Kitasato); (7) systematic and continued destruction of rats; and (8) preventive inoculation of persons. The war against rats should be carried on by a well-organized public force. Exclusion should be aimed at by stopping holes, laying cement floors in cellars, and screening doors. Rats should be caught in spring-traps (they soon learn to avoid cage-traps), or poisoned with arsenic, or baited with bread inoculated with the Danysz bacillus. Their bodies should be collected and destroyed. The dogs, cats, and swine of infected households should also be destroyed.

The population may be, and suspects and contacts should be, treated with Haffkine's prophylactic, if it be obtainable. It must be prepared by competent hands and at not too great a distance. Its protective effect lasts several months. It reduces incidence among the inoculated about 80 per cent, and mortality among those afterward attacked about 80 per cent. The dose, hypodermically injected, is 2 to 5 c.c. for an adult, 0.5 to 1 c.c. for a child. Yersin's serum in hypodermic adult dose of 10 to 20 c.c. should be given at the same time as the Haffkine prophylactic (as advised by Calmette), as its protective effect is sooner established, though it does not last so long.

Personal Prophylaxis.—Attendants on the sick, members of municipal working forces, and other specially exposed persons, besides undergoing protective inoculation, should use disinfectant hand-washes and mouth-washes before eating, should wear boots, leggins, or puttees, or tie the trousers round the ankles, should keep accidental wounds sealed or dressed, should not eat or sleep in a ward. Doctors should avoid unnecessary visits to the sick, and nurses should avoid unnecessary leaning over patients or handling or shaking their bedding, and should go often into the open air. The ward or sick-room must contain a sufficient air space and be well ventilated. Pneumonic cases especially must not be crowded into a single ward. The excretions and discharges of patients must be scrupulously disinfected, and the dressings removed must be burned.

Treatment.—*Medicinal.*—At the outset of a case calomel catharsis should be employed. For headache, pain, or delirium, morphine is the best analgesic and hypnotic. Cold may be applied to the head. Sedative or antipyretic drugs which are depressant must be avoided. Strychnine, $\frac{1}{40}$ grain hypodermically every four hours, and alcohol judiciously administered are valuable stimulants. For the anæmia and enfeebled vitality of convalescence, iron, quinine, and strychnine are indicated, with nourishing and easily digested food. In all cases

of other than the ambulant or minor type, if it be accessible, an injection of Yersin's serum, 20 to 40 c.c. for an adult, should be given intravenously as soon as the diagnosis is even provisionally made.

Surgical.—Surgery plays but a small part in the treatment of plague. As Simpson says: "The only occasions on which the knife is found to be useful are when pus has formed in the bubo, and when masses of necrosed glands are lying in suppurating buboes." *   In the case of a woman with plague, who had had sarcomatous glands in the axilla and neck for some months, plague suppuration having occurred in them, Leumann excised the affected glands and the patient made a good recovery from both diseases.†   All authorities are agreed that incision or excision of a plague bubo prior to suppuration never does any good. And, as pointed out by Jennings, the pyogenic cocci associated with *B. pestis* in the bubo tend to destroy the bacillus by the time suppuration is complete.‡ The discharge is then less plague-infectious, and danger of the bacilli, through a premature incision, entering the patient's blood current and setting up the septicæmic form of the disease is obviated.   The rule is therefore established and imperative, *never to incise or excise a plague bubo before suppuration has occurred.* Buboes and secondary abscesses which have been opened, as well as skin necroses and other accessible lesions, should be treated on general surgical principles and dressed antiseptically.

GLANDERS.

Synonyms.—Farcy.   *Lat.* Malleus: Equinia.   *Fr.* La morve; le farcin.   *Sp.* El muermo.   *It.* Il moccio.   *Ger.* Der Rotz.

Definition.—The disease caused by an invasion of *Bacillus mallei;* characterized by nodular, pustular, and ulcerative lesions in the lungs, nasal mucous membrane, or skin, with secondary lymphatic involvement, deep abscesses, fever, grave constitutional disturbances, and a high mortality.

History.—Glanders is primarily a disease of the solipeds, the horse, ass, and mule. As such it was known to the ancients, having been described by Aristotle in the fourth century B.C.   Hippocrates prescribed for it.   Vegetius, in the fourteenth century A.D., gave the first systematic description of the disease, calling it "farcinium."   Schilling in 1821 and Rayer in 1837 made the first valuable modern studies of the disease in man.   Its existence in man was denied by many until the appearance of Rayer's monograph.§   The inoculability of the disease was established in 1840.   Our knowledge of glanders was put on its present sure foundation by Loeffler and Schuetz, who in 1882 identified and described the bacillus and isolated it in pure cultures, from which they made successful inoculations. Weichselbaum, in 1885, made the first cultures of *B. mallei* from a human subject.

* "A Treatise on Plague," Cambridge, 1905.
† Ind. Med. Rec., Calcutta, 1898, xiv., 57.
‡ "A Manual of Plague," London, 1903.
§ Mem. d'Acad. de méd., Paris, 1837, vi., 625 *et seq.*

Etiology.—*Bacillus mallei* is a rod with rounded ends, shorter and thicker than B. tuberculosis and B. lepræ (see Fig. 10). It is an obligatory parasite, aërobic, facultatively anaërobic, non-sporing, and occurring usually singly, sometimes in pairs or short threads. It is non-motile. Brownian movement is sometimes observed in hanging drops. I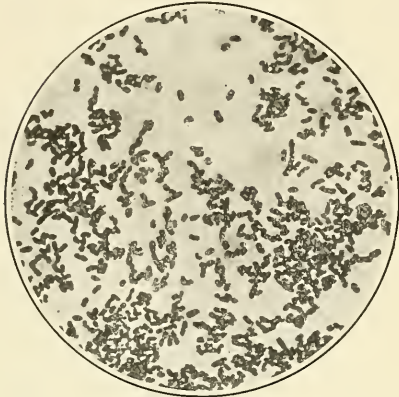t is easily stained with basic aniline dyes, but very easily decolorized. It does not stain by Gram. It grows on the ordinary media; most characteristically on potato at 37° C., on which, in forty-eight hours, the growth forms a delicate, transparent, yellowish, sticky layer, looking like honey spread on the surface. In a week it loses its transparency, becoming reddish, and later brownish, a faint greenish hue appearing on the potato surface around the growth. Glanderous discharges or ordinary cultures, when injected subcutaneously into guinea-pigs, cause death in from ten to twenty days. When virulence has

FIG. 10.—*Bacillus mallei.* × 1000. (*Sternberg.*)

been increased by repeated passage through susceptible animals, it will produce death in from four to five days. The bacilli usually die quickly when dried, though Loeffler has found them virulent after being dry for three months.

Communication and Infection.—Many animals other than horses are susceptible to the disease. Horned cattle are exempt. Glanders in man is a vocation disease. It occurs practically only in those who have to do with horses. The virus sprayed into the air by the snorting of a diseased animal may be inhaled by a neighboring one. Through the manure the dust of a stable may be loaded with dried virus, and the infection thus inhaled. It has been conveyed once to a passing infant in arms by a horse snorting its nasal discharge directly into the infant's eye. The infant infected its mother, and both died of the disease. Inunction experiments have proven the possibility of infection through the follicles of an unbroken skin. Lions in menageries, fed with the flesh of glandered horses, have developed the disease. Flawless experiments by Mc-Fadyean have proven beyond question that glanders can be conveyed *by ingestion.** But the usual mode of infection, obtaining in the vast majority of cases, is *by inoculation* of an abrasion or wound. Experiments on animals by Cadéac and Malet indicate that maternal glanders is sometimes, though rarely, transmitted to the fœtus in utero or to the nursing infant.† Galtier and Nocard believe that an attack of glanders does not confer immunity.‡

* Journ. State Medicine, London, 1905, xiii., 65.
† Comptes rend. d'Acad. des Sci., Paris, 1886, cii., 133.
‡ Bull. Soc. cent. de méd. vét., Paris, 1899, n. s., xvii., 502.

Pathology.—The glanderous lesion, whether in skin, mucous membrane, or deeper tissues, is primarily a cell infiltration of the kind called granulomatous. The neoplastic tissue of the nodule consists mainly of lymphoid and epithelioid cells, among and in which are seen the bacilli. The disease process is most constantly localized in the lungs, nares, and skin. The name *glanders*, derived from the neighboring lymphatic glandular involvement, is popularly given to the nasal manifestations of the disease, and the name *farcy* to those cases in which cutaneous, subcutaneous, and lymphangitic lesions are the most prominent. It would be desirable to bring the name *malleus* into general use as applying to the whole disease, regardless of its local variations. Deeper structures, as muscle, tendon, and bone, and all the viscera, are involved as the disease advances, by
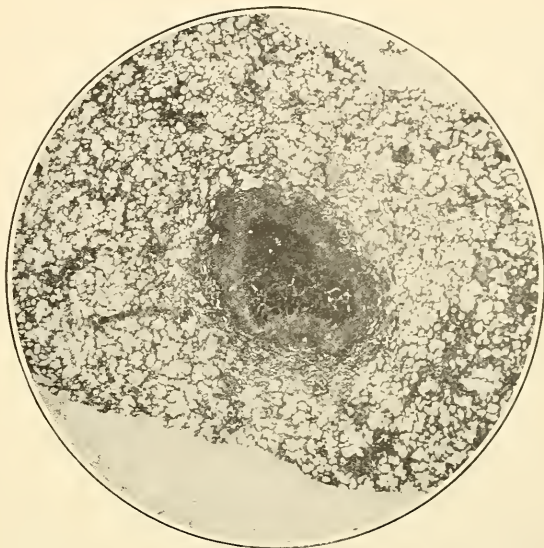

Fig. 11.—Glanders Nodule in Lung of Horse. (*McFadyean.*)

contiguity or by metastasis. Nodules and abscesses are thus found post mortem not only in the lungs (Fig. 11), but usually in the spleen and liver, and sometimes even in the brain. The purulent foci in muscles are usually without any distinct abscess wall, being surrounded by an area of irregularly extending necrosis. Inoculated guinea-pigs are peculiarly prone to an early infiltration and suppuration in the testicles. Concerning horses, McFadyean states that "no case of glanders with lesions elsewhere than in the lungs, and with these organs healthy, has ever been recorded." Lung lesions are probably less constant in man.

Symptoms and Course.—The course may be either acute or chronic. In *acute* cases, after a short incubation of from three to six days, the disease is ushered in with lassitude, headache, and chills. Fever may be absent. Generally, however, it is considerable, ranging for several days from 101° to 105° F.

If the point of entrance is a skin wound, there are at first local pain at the site and lymphatic inflammation extending from it. It is at this stage that the rise of temperature occurs. Inflammation of lymphatic vessels in their continuity produces the so-called "farcy pipes," and any distinct nodules in their course the "farcy buds or buttons." These nodular lesions undergo a liquefaction necrosis, rupture, and discharge a reddish or brownish, at first gummy, and later grumous, fluid having a vile odor. The fever fluctuates and the constitutional symptoms vary in proportion to the local infiltration and inflammation, superficial or internal. Very superficial pustules, bullæ, often develop and give the case a certain resemblance to smallpox. Deep tumefactions and necroses develop, either early in the case or in the course of three or four weeks, and may increase in extent and depth till tendons, bones, or joints are involved. When nasal infiltration has taken place and been followed by pustulation and ulceration, the characteristic nasal discharge appears. This feature of the disease is absent in a certain proportion of advanced cases in the horse, and is still oftener a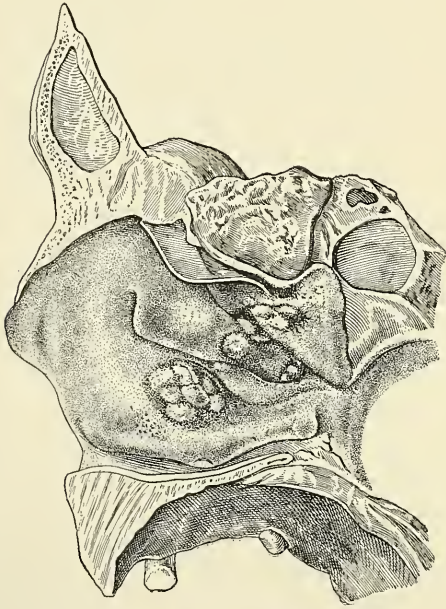bsent in man. The nasal discharge is at first a transparent, viscid, nearly colorless material. The nose and surrounding tissues are hyperæmic, swollen, hot, and painful, somewhat as in facial erysipelas. The discharge becomes thicker, purulent, sometimes hemorrhagic, and has a peculiarly offensive smell. Involvement of the septum and vomer may go on to perforation. Further involvement of the mucous membranes becomes evident in the mouth, pharynx, larynx, and bronchi; the corresponding cervical lymph vessels and nodes become involved, and may develop abscesses which rupture or require opening externally. Crusts and plugs of inspissated pus and mucus block up the nares; the nasal discharge becomes indescribably foul (see Fig. 12). Ecchymoses in the conjunctiva may be seen. The tongue is darkly coated, the mouth and throat are dry, and grave disturbances in the alimentary tract, albuminuria, delirium, and other alarming symptoms appear. Glanders in this acute form is invariably fatal, generally within two weeks. A subacute form of the disease is observed with an incubation period of from ten to fifteen days and a course of from three to six weeks.

Chronic glanders presents essentially the same pathology and symptoms as

Fig. 12.—Glanders in the Nares. (*Rayer.*)

the acute. It is often preceded by a prolonged period of incubation or latency, and runs an indefinite course of months or years. It is perhaps to be accounted for by a lowered virulence in the infecting bacillus, or an unusual individual resistance to the disease in the patient. When the chronic form is once established, fever is generally absent or very slight. The lesions are less numerous and less generalized than in the acute form. They are sometimes limited to the nose and adjacent parts of the face, a chronic serpiginous ulceration (*farcin*

Fig. 13.—Lesions in Chronic Glanders. (*After Baracz.*)

chronique térébrant—Besnier) progressing in this situation, which may be and has been mistaken for epithelioma, for lupus, or for tertiary syphilis (see Fig. 13). In less severe cases the processes of infiltration, ulceration, and healing go on simultaneously, white linear scars being formed, which contract and pucker the surrounding membrane and give an appearance which has been compared to that of frost on window panes. Somewhat more than fifty per cent of cases recover. While nasal involvement is very common in both horse and man, especially in advanced cases, lung farcy is the most constant lesion in horses, and skin farcy is commonest in man. The frequency of lung involvement in man is indicated by the number of acute cases in which pneumonia

has either been diagnosed at first or mentioned as a complication in the course of the disease.

Diagnosis.—The first essential point is the occupation history. Clinically, the tendency of the painful muscle nodules and abscesses to form near the joints may suggest *articular rheumatism*. This same peculiar location should put the surgeon on his guard against a diagnosis of ordinary *pyæmia*. Acute nasal glanders, with its associated facial swelling, has been mistaken for *erysipelas*. Where numerous bullæ are present, especially on the face, the disease has been several times mistaken for *variola*. The bullæ in glanders are never umbilicated, and the presence of characteristic nasal involvement will further point the diagnosis from smallpox. The chronic serpiginous ulceration of nose and face may be distinguished from other diseases by a careful inquiry into occupation and history, "the existence of former disease of old standing, the cicatrices of farcy buds in the skin, the penetrating character of the lesions, their form, color, livid base, mode of evolution and copious purulent secretion, and the coexistence of cicatrization at one point and extension at another" (Besnier).

An effort to discover the bacilli by staining smears of the discharges, especially at first when they are of a viscid, glairy, semi-transparent character, is apt to meet with failure. This very fact, however, in connection with the absence of staphylococci in the smears, is characteristic and suggestive. To establish the diagnosis of glanders in man bacteriologically, the following steps should be taken:

1. Stain smears of pus or discharge in the usual way. Search for the bacilli will probably be without result.

2. Inoculate potato and incubate at 37° C. Characteristic growth in from forty-eight to seventy-two hours. Examine stained specimen for growth.

3. Strauss' test.—Inoculate a male guinea-pig intraperitoneally with a little of the discharge diluted with sterile bouillon or normal salt solution. Characteristic testicular lesions in from three to five days. Verify presence of bacillus in the guinea-pig by potato culture and microscopic examination.

4. Sections of fresh nodules, if obtainable, before they have broken down, may be stained by Abbott's method. Rinse section in distilled water, stain on slide with dilute carbol-fuchsin (1 : 10 water) for half an hour. Wash for ten seconds three times with 0.3-per-cent acetic acid, wash with distilled water, blot, dry by very gentle heat, clear in xylol, mount.

The mallein test is not available for man, but is most valuable for establishing the diagnosis in horses. Mallein is prepared by growing virulent glanders bacilli for a month or six weeks in glycerin veal broth, in flat flasks, giving free access to oxygen. The culture is then put in the autoclave at 115° C. for fifteen minutes, filtered through a Berkefeld filter, concentrated to one-fourth volume, and mixed with an equal volume of 0.5-per-cent carbolic acid. It is active in a dose of 1 c.c. In a normal horse it produces little or no reaction. In a glan-

dered animal the injection is followed within twelve hours by a rise of temperature of 1.5° to 3° C., with local swelling at the site of injection and in neighboring lymph nodes and farcy buds.

The *agglutination test* has never been satisfactory for either man or horse, but recent experiments by Heanley * encourage the hope that a satisfactory *sedimentation test* with human glanders serum may yet be established.

Prognosis.—Acute glanders runs its course in from one to three weeks, and terminates fatally. The early appearance of a bullous eruption on the skin is a grave sign, as it indicates a virulent form not likely to become chronic. A subacute form may last six weeks. When a period of six weeks has been survived the case may be considered chronic, and if not growing worse at that time a hope of recovery may be indulged, as somewhat more than fifty per cent of chronic cases do ultimately recover. Lesions few and in situations accessible to surgical relief constitute a favorable condition.

Prophylaxis.—The disease in man never becomes epidemic, and public prophylaxis should be directed entirely to methods of dealing with glandered horses. When glanders is discovered or suspected in a stable, the mallëin test should be applied to all the horses. Of the horses that react, those with clinically evident signs of the disease and those that are seriously "out of condition" should be slaughtered. Those in which the disease is not clinically evident and which are valuable and capable of working should be segregated as fast as discovered, should thereafter receive the mallëin test once a month, and when they no longer show the reaction should be regarded as having recovered. In a very large proportion of the cases diagnosed by mallëin the disease is limited to a few nodules in the lungs, and such cases quite commonly recover. Grooms attending the diseased animals should wear masks and gloves. Stables, harness, and tools should be thoroughly disinfected, and any old dressings which may have been used on glanderous lesions burned.

Treatment.—Mallëin has no curative effect. Improvement of horses under its use, which has been reported by Babes and others, was probably only the result of a natural tendency of the disease toward recovery under hygienic conditions and when it was not too far advanced. In man, favorable surroundings with nourishing and digestible food should be secured for every case of malleus. As in typhoid and other diseases which produce a progressive exhaustion, supporting treatment is required and stimulants must be used as well as suitable food.

If a point of accidental inoculation be known or suspected, it should be immediately laid open and thoroughly cauterized. Every abscess, as discovered, should be opened, drained, and dressed. Its cavity should be curetted and thoroughly disinfected by swabbing and irrigated with a ten- to twelve-per-cent solution of zinc chloride. Bullæ in the skin, as well as the more deeply situated

* Lancet, London, 1904, i., 364.

farcy buds, should be similarly treated with cleanliness and continuous antiseptic applications. Old nasal lesions may be treated on the same principles with curette, cautery, swab, or spray.

Glanderous infiltration of the eyeball or the orbital connective tissue is often a feature of advanced cases. When such exists, local surgical interference will not often avail the patient much. But Strzeminski reports a case of a glanderous nodule as large as a pea, on the lower eyelid of a young veterinarian, which he immediately excised and cauterized. It was the only existing lesion in the case, and the disease was cured.

In a case of laboratory glanders under the care of Prof. J. C. Stewart, of Minneapolis, and reported by him,* the disease developed on the sixth day after performing an autopsy on a glanderous guinea-pig, with a small open wound on the finger of the operator. No lesions were developed in the nares or skin, nor, so far as known, in the lungs. Four pus foci developed, two of them deep in voluntary muscles. A rather superficial cavity on the wrist having been first evacuated by incision and the bacteriological diagnosis established from the discharge, the remaining foci were treated as follows: An incision was made almost down to each pus cavity, the wound was filled with ninety-five-per-cent carbolic acid, the cavity was then opened by incision through this caustic antiseptic liquid. Bacilli were demonstrated in the discharges from these wounds for some time. They all healed well. The patient had recurring attacks of fever for nearly a year afterward, but ultimately made a perfect recovery.

The pathology of glanders and its relation to public health are admirably set forth in the Harben Lectures for 1904,† by J. McFadyean, a perusal of which is recommended to those who are specially interested in the subject.

ANTHRAX.

Synonyms.—Malignant pustule. Wool-sorters' disease. Splenic fever. Siberian plague. *Fr.* Le charbon; le sang de rate. *It.* Il carbonchio. *Sp.* El carbunclo. *Ger.* Der Milzbrand.

Definition.—The disease caused by an invasion of *Bacillus anthracis;* characterized by a specific lesion at the site of inoculation in the skin, with local œdema and lymphatic inflammation; or by intestinal or pulmonary lesions, with general infection, splenic enlargement, grave constitutional symptoms, and high mortality.

History and Distribution.—*Bacillus anthracis* was the first bacterium identified as the cause of a disease. Pollender observed it in the blood of infected animals in 1849, but did not suggest that it was the cause of the disease. Davaine first expressed such a belief in 1863, and in the same year he transmitted

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* Annals of Surgery, Philadelphia, 1904, xl., 109.
† Journal of State Medicine, London, 1905, xiii., 1, 65, 125.

the disease by blood inoculation. Koch, in 1876, obtained pure cultures and produced the disease by inoculation from them. Geographically and zoölogically anthrax is the most widespread of all infectious disorders (Osler). Nearly all the mammalia are susceptible. Among kine in Russia and sheep in France its prevalence presents a most serious economic problem. Limited epidemics among sheep occur frequently in England. The disease is rare in America.

Etiology.—*Bacillus anthracis* is a rod, 5 to 20 μ long and 1 to 1.25 μ in diameter. It multiplies by fission very rapidly and in cultures presents long, parallel-lying filaments. It is aërobic and facultatively anäerobic, non-motile, stains easily with watery solutions of aniline dyes and by Gram's method (see Fig. 14). On the surface of agar or gelatin the colony has the

Fig. 14.—*Bacillus anthracis*, Stained with Gentian Violet. × 1000. (*Sternberg.*)

characteristic form of a "medusa head" (see Fig. 15). In gelatin stab culture a week old the growth looks like an "inverted fir-tree," and the gelatin is slowly liquefied (see Fig. 16). In the presence of oxygen and a temperature of 25° to 40° C., it forms median oval spores, which are highly resistant to germicides and which, even in a desiccated state, retain their vitality and virulence for years. Stables and pastures where the blood of diseased animals has been spilt, and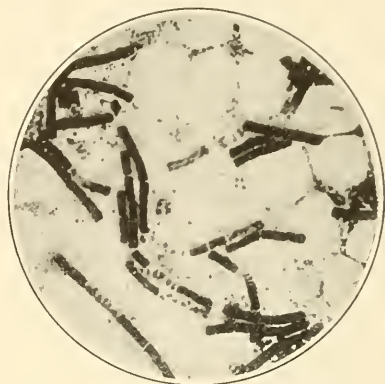 the soil where their carcases have been buried, thus remain infected for a very long time. Spore formation does not occur within the body. The bacilli are found in the contents of the malignant pustule, in the inflamed skin tissue at its base, and, in cases of general infection, in the blood stream, the capillaries of the spleen and other viscera, and in the secretions and excretions.
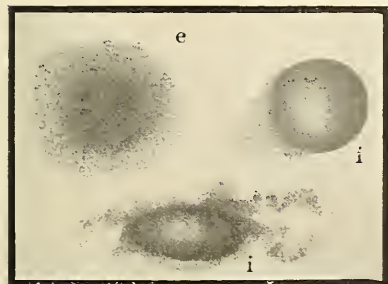

Fig. 15.—Colonies of *Bacillus anthracis* on Agar Plate, Four Days Old. × 60. On left, superficial colony (*e*); on right, one lying directly below surface (*i*); below, a deep-seated colony (*i*). (*Lehmann and Neumann.*)

Communication and Infection. — The herbivora are most susceptible to the disease, the omnivora less, and the carnivora least so. Algerian sheep are curiously immune. The disease, in cases of general infection, is transmitted from the mother to the fœtus in utero, and pregnant women usually abort. Infection of the lower animals usually occurs by ingestion, cattle and sheep acquiring the disease in infected pastures, the carnivora from eating the flesh of anthrax ani-

mals. In man infection sometimes takes place by ingestion or inhalation, but most commonly by inoculation.

Either spores or bacilli suffice for inoculation. Accidental inoculation takes place commonly on the most exposed parts of the body, generally the hands, arms, or face. In practically all human cases the infection is incurred in handling diseased animals, or their meat, hides, wool, or hair. Anthrax is thus, like glanders, a vocation disease, being practically confined to drivers, shepherds, butchers, tanners, workers in hair or wool, and stevedores who handle hides. The intestinal form of the disease has resulted from the ingestion of raw or under-cooked sausages. In an outbreak reported by Butler and Huber, twenty-five persons were infected by eating the flesh of an anthrax animal, and six died. Cases of infection from man to man are rare, and human epidemics do not occur. It appears probable that an attack of anthrax in man confers a lasting immunity (Tirado *).

Pathology.—The local tissue changes which ensue upon an inoculation with *B. anthracis*, whether the seat of infection be in skin, lung, or intestine, are due to a blocking up of the capillaries of the part by the multiplying bacilli. The blood stream is further impeded by the inflammatory swelling in the tissues surrounding the vessels, due to the irritation of the bacilli and their toxins, causing œdema, acute ischæmia, and necrosis. When the bacilli enter the blood stream, directly or through the lymphatic system, and the infection becomes general, the bacilli are found most abundantly in the spleen, and the inflammation and swelling of that organ are characteristic of systemic anthrax. They are found, too, entirely occluding the capillaries in liver, kidneys, lungs, and brain, causing tumefaction and hemorrhagic infarction in the internal organs, and multiple hemorrhages into the skin and mucous membranes. In the subcutaneous and submucous tissues and the serous membranes in such cases a bloody serous infiltration is found post mortem.

FIG. 16.—Gelatin Stab-culture of *Bacillus anthracis* Three Days Old, showing "inverted fir - tree." Liquefaction beginning above. (*Lehmann and Neumann.*)

Symptoms and Course.—The commoner forms of anthrax in man resulting from skin inoculation are: (1) the *malignant pustule* or *anthrax carbuncle*, and (2) the *malignant anthrax œdema*, both presenting localized lesions which demand surgical attention.

(1) The constitutional symptoms attending localized anthrax are those which attend the invasion of other acute infectious diseases. After an incubation period of from a few hours to three days, rarely longer, there are chilliness or rigor, moderate fever, and some local pain, usually not very severe. As the

* Revista med. de Chile, 1902, xxx., 349.

disease advances the pulse shows increasing rapidity and weakness. In fatal cases before death, and in favorable cases about the fifth day, the temperature usually falls to subnormal. Locally, the seat of inoculation begins almost immediately, or in a few hours after infection, to itch and burn. The patient will probably attribute these symptoms to the bite of an insect, and will scratch the spot for relief. During the first twenty-four hours an inflammatory and œdematous areola is developed about the spot, the inflamed lymphatic vessels and distended veins presenting reddish and bluish streaks in the surrounding skin.

A central papule appears, succeeded on the second or third day of the disease by a vesicle seated on an inflamed base, the so-called *malignant pustule*. This name for the lesion is a misnomer, as it does not contain pus, and when it remains the only manifestation of the infection it is not particularly malignant. Though painful because of the tension in the part, this local lesion is usually insensitive to touch. In about twenty-four hours the vesicle bursts, exuding serum. After its rupture a brownish base is left, which continues to discharge serum and which is converted by the fourth day into a brown or black central eschar, the circum-
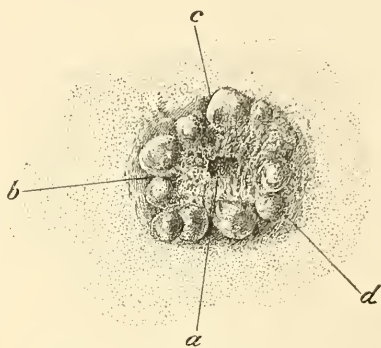
FIG. 17.—The Skin Lesion of Anthrax, Three Days Old. *a*, Central eschar; *b*, dried small vesicle; *c*, crown of small vesicles filled with bloody serum; *d*, bluish-red areola. (*After von Korányi.*)

ference of which is crowned with small new vesicles (see Fig. 17). These break down in their turn, and the eschar extends and becomes a slough. Other vesicles may appear near by, on the inflamed and œdematous base. General infection may occur at any time, and most of the deaths from anthrax occur from the fourth to the eighth day. If the disease remain local and the patient live until the tenth or twelfth day, separation of the slough sets in, with suppuration, and healing by granulation. In a large proportion of untreated cases, however, the disease is not thus self-limited, but the œdema and infiltration continue to spread, and lymphangitis and phlebitis with general infection and death ensue.

(2) In malignant anthrax œdema the local signs are different. The characteristic central papule and vesicle as described do not appear at the point of inoculation, but the inflammatory œdema rapidly spreads, with extensive and enormous swelling. Areas of necrosis appear here and there, or an extensive gangrene of the skin is developed, blebs filled with bloody serum preceding the sloughing. In a very large proportion of cases general infection occurs, and death ensues.

Less common forms of the disease are those in which the primary infection is intestinal or pulmonary. When infection has taken place by ingestion, the

primary lesions are usually in the intestines and mesenteric lymphatics. When the infection is inhaled, as in the "wool-sorter's disease," the lungs are primarily involved. In both *intestinal anthrax* and *pulmonary anthrax* we have a malignant type of disease with high fever, grave symptoms, rapid course, general infection, and death by collapse. These types of anthrax are beyond surgical relief.

Diagnosis.—All cases of illness among those exposed to anthrax infection should be looked upon with suspicion until anthrax can be excluded from the field of diagnosis. Pulmonary or intestinal anthrax in an early stage before general infection has occurred is difficult or impossible of diagnosis, except upon the history of occupation or of the probable ingestion of infected meat. The characteristic malignant pustule is not likely to be mistaken for any other sore. Cases of malignant anthrax œdema may be mistaken for acute phlegmonous cellulitis or for malignant œdema. In both these affections, however, suppuration ensues earlier than in anthrax.

The diagnosis can be clinched only by bacteriological examination.

1. Fluid from a vesicle or, in the case of general infection ensuing from pulmonary or intestinal anthrax, a drop of blood, should be spread on glass, fixed by passing only once through the flame, and stained: the very large bacilli, with their square ends, and in pairs or threads, are easily recognized.

2. A little of the fluid should be inoculated into a rabbit or guinea-pig. The animal will die in from twenty-four to forty-eight hours, and the bacilli can be demonstrated in its spleen or its blood.

3. If bacilli are not found in the smear, cultures from the fluid obtained should be made on the surface of agar or gelatin and in a gelatin stab, that the characteristic "medusa head," "fir-tree," and liquefaction may be observed, and bacilli stained from the cultures.

The animal inoculation is the most certain method of diagnosis, and a negative result is almost as valuable as a positive one. Both cultivation and inoculation experiments are apt to fail if the material employed be old or putrid.

Prognosis.—The collective mortality to be expected from all forms of anthrax in man, treated and untreated, is about 25 per cent. In Great Britain, during the six years 1899–1904, 267 cases were reported, with 67 deaths. Pulmonary and intestinal anthrax and those cases, at first localized, in which a general infection supervenes are almost invariably fatal. In Tirado's series of 77 cases receiving good treatment the mortality was 9 per cent.* The prognosis varies with the age and condition of the patient and the seat of the lesion. Children and enfeebled persons usually succumb to the disease. When the anthrax pustule or the œdema is situated on the neck, the prognosis, in spite of treatment, is very grave, the mortality in such cases being given by Hamer as 40 per cent. When it is situated on the face or the upper extremity, the mor-

* *Loc. cit.*

tality in cases promptly treated is from 12 to 15 per cent; when on the lower extremity, it is stated to be only 5 per cent. The anthrax œdema is more dangerous and less amenable to treatment than the limited anthrax pustule. The mortality varies greatly in different countries and climates. Anthrax in the tropics is less fatal than elsewhere, probably because of an attenuation of the virus by high temperature and sunlight.

Prophylaxis.—Infected animals must be isolated, their urine caught and disinfected, and their dung and bedding burned. The stable should be disinfected. If the temperature has not been above 70° F., any disinfectant capable of destroying spore-free bacilli will suffice. If the temperature has been as high as 80° F. for twenty-four hours, spores will probably have formed, and the strongest germicides must be used copiously. A hot solution of corrosive sublimate, 1:200, is perhaps the best.

Opening the carcass of an animal or the body of a patient supposed to have died of anthrax should be forbidden by law until a microscopic examination by some competent person has proved that the disease was of another nature. In transporting a carcass to the place of cremation or burial, the orifices of the body should be plugged, the whole wrapped in a wet antiseptic cloth, and the vehicle disinfected afterward. It is best to burn a carcass, placing it on some sort of improvised metal grating and making a fire of old tar barrels or wood and petroleum. If cremation is not feasible, then the carcass should be buried at least six feet deep, the top earth turned in, and the surface of the ground spread thickly with lime or burned off with a bonfire of litter.

Pasteur's anthrax vaccines are attenuated cultures which have been used extensively on the continent of Europe for the protection of sheep and kine. The mortality among unvaccinated animals attacked is about ten per cent; among the vaccinated, less than one per cent. Pasteur's vaccination has not been brought into general use in countries where anthrax is comparatively rare, as some risk attends it and the aggregate loss from vaccinating the healthy would be greater than the loss from the disease among unvaccinated herds. The immunity produced is an active immunity of transient duration. Sobernheim's combined active and passive immunizing method is safer and produces a more lasting active immunity.

Treatment.—Internally quinine, in dose of gr. v.–x. three times a day, has a favorable influence on the disease and has been regarded by some as a specific. It may be advantageously combined with carbolic acid in cautious dosage not exceeding gr. xv. a day, or more safely with carbonate of creosote in larger dose. Benefit has been attributed to ipecacuanha, both internally and as a local application to the raw surface left after excision and cauterization of the local sore. The most important elements in the constitutional treatment are supporting diet and stimulation. In cases of intestinal anthrax infection an emetic followed by an active cathartic should be exhibited as soon as such infection is

suspected, in the hope of discharging some of the virus and reducing the intensity of the infection. To the seat of localized external anthrax hot-water bags or constantly renewed poultices at a temperature of 120° to 130° F. may be applied, with the idea of keeping the tissues, to the depth of an inch or more, at a temperature at which the bacilli will cease to multiply.

Professor Sclavo, of Siena, after much experimentation, has produced a bactericidal protective serum from the ass, which he asserts to be under all circumstances harmless and which he gives subcutaneously in 20 to 40 c.c. dose, or in grave cases intravenously in 10 c.c. dose, repeated if necessary. He does not practise excision or cauterization of the sore. He states that improvement follows the injection almost immediately, and reports one hundred and sixty-four cases, with a mortality of six per cent. In two of the cases that recovered the bacilli had been demonstrated in the urine, in one of these in the blood as well. No recovery of a case in which bacilli were found in the blood has ever been reported from any other form of treatment. Within twenty-four hours after the injection the bacilli have disappeared from the fluid of the vesicle. Good results with Sclavo's serum have been reported from England.

Scharnowski treated a series of fifty consecutive cases by subcutaneous injection of carbolic acid, with only one death. In a very remarkable case reported by Strubell,* with the nose the seat of inoculation and primary lesion, excision impossible, and the face and neck extensively inflamed and œdematous, the patient received, in a period of eighteen days, more than four hundred hypodermic syringefuls of three-per-cent carbolic acid in and around the affected parts, and recovered without having at any time shown toxic symptoms from the drug. In anthrax there would appear to be a special tolerance for carbolic acid.

Most authorities are agreed that when a small abrasion or pimple is presented, which can be reasonably suspected to be the seat of an inoculation with anthrax, it should be immediately and thoroughly burned with the actual cautery. When the primary lesion of anthrax is recognizable, if its size and situation permit, most surgeons practise excision, followed by thorough cauterization either with the actual cautery or with ninety-five-per-cent carbolic acid. This is the usual treatment in England, and has been advocated and practised there even when Sclavo's serum has also been employed. Where excision is not possible, free multiple incision with cauterization has been recommended and practised. There are certain situations, as the nose, where no extensive excision would be possible; and on the cheek a large excision or extensive incisions and cauterization not only are very disfiguring, but sometimes by scar contraction cause ectropion or oral deformity requiring a plastic operation later. Objection to excision and incision has been made by Mueller, on the ground that it may open the way for bacilli, up to that time successfully isolated by nature, to enter the

* Münch. med. Wochenschr., 1898, No. 48, p. 1526.

blood stream. Following this idea, Mueller * and Ramstedt † have reported twenty consecutive cases of localized external anthrax treated expectantly by no other measures than rest, fixation, and elevation of the part, with local cleanliness or antisepsis (in some cases mercurial ointment was used), good diet, and stimulation. All recovered, though several were severe cases and in one the tongue was involved.

Among these conflicting opinions and practices, the surgeon must be guided by circumstances and use his own judgment in making choice of a mode of treatment suited to the case. There is much to show that anthrax, after its specific lesion is once developed, must be viewed and treated as a constitutional disease rather than as a local one, as in the cases of diphtheria and plague, even though the bacilli may remain localized and not escape into the circulation. Wet antiseptic dressings should always be applied to the malignant pustule, and the separating slough should be treated on general surgical principles. There can be no question of the value of supporting and stimulating treatment, and of good surgical care at all stages of the disease. When cervical swelling threatens the repiration, tracheotomy may save life. Paterson has reported the case of a man whose work it was to mix animal hair with lime for plaster, who sustained a compound comminuted fracture of the humerus. The fracture became infected with anthrax. Amputation at the shoulder was performed, and the patient recovered.

The Milroy Lectures of 1905,‡ on "Industrial Anthrax," delivered by T. M. Legge, will repay a perusal by those interested in the subject.

ACTINOMYCOSIS.

Synonyms.—Lumpy jaw (in cattle); ray-fungus disease. *Fr.* L'actinomycose. *It.* L'attinomicosi. *Sp.* La actinomicosis. *Ger.* Die Aktinomykose; die Strahlenpilzerkrankung.

Definition.—The disease caused by an invasion of *Actinomyces bovis;* characterized by local granulomatous infiltrations, with formation of abscesses and sinuses, and running a chronic course with or without serious constitutional disturbance.

History and Distribution.—Actinomycosis as a disease of cattle has long been known. Its etiology and pathology were not understood, however, till Bollinger's discovery in 1876 of the organism causing it. The researches of Israel, published in 1878, first directed attention to the prevalence and importance of actinomycosis in man. Ponfick, in 1879, showed the identity of the disease in cattle and man. Johne, in 1880, produced the disease by inoculation of a healthy cow with granules from a diseased one; in 1883 Israel transferred the disease

* Deutsch. med. Wochenschr., 1895, xx., 515.
† Münch. med. Wochenschr., 1899, xlvi., 617.
‡ Brit. Med. Journ., London, 1905, i., 529, 589, 641.

from man to rabbit by inoculation; and in 1890 Wölf satisfied the postulates of Koch, producing the disease in animals by inoculation with pure cultures of the fungus.

J. B. Murphy, of Chicago, in 1884, was the first to recognize and report a human case in this country. The disease in man has lately attracted more attention here. Ruhräh collected reports of seventy-two cases in North America up to October, 1899.

Etiology.—The organism causing the disease, *Actinomyces bovis* (Bollinger and Harz), *Oöspora bovis* (Sauvageau and Radais), or *Ray-fungus*, is one of the streptotricheæ, organisms which occupy an intermediate position between the true fungi (hyphomycetes) and the false or cleft fungi (schizomycetes or bac-
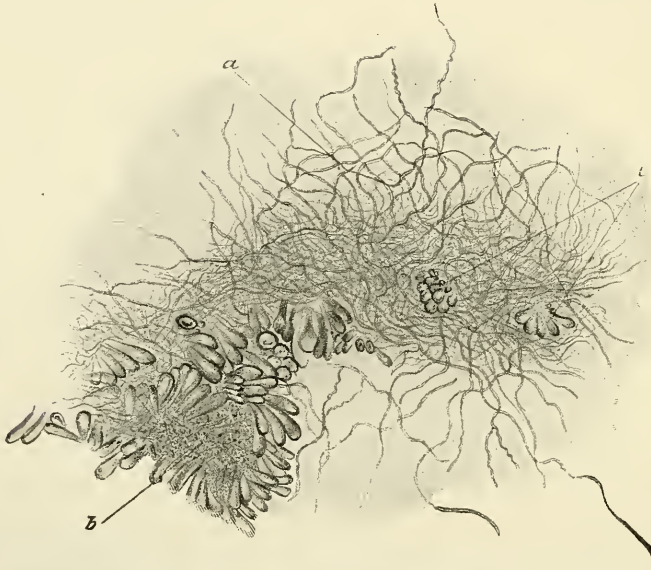

Fig. 18.—*Actinomyces bovis* from Human Lung, Showing Threads (*a*) and Clubs (*b, c*). (*Israel.*)

teria). Bright yellow granules, as large as a small pin-head, usually not more than 1 mm. in diameter, are found in the pus from the lesions; each of these is a colony of actinomyces which has been extruded from the necrosing tissue. Such a colony, selected from the pus or examined in a section of the diseased tissue, is seen to be composed of an irregularly round or reniform mass, having a structureless or amorphous centre of degenerated mycelium. From this centre the rods of the living mycelium radiate. They are straight or curved, often branching, from 3 to 6 μ in length, but end to end forming longer threads, and closely packed together in the mycelium. Outside of this mycelium are the characteristic "clubs," irregularly but concentrically disposed, their outer extremities bluntly rounded, their inner extremities tapering and pointing toward the centre of the colony, some of them free and others attached to or continuous with the mycelial filaments (see *b* and *c*, Fig. 18). These clubs are believed to repre-

sent a degenerative process of the end of the mycelial thread in which its envelope becomes softened and swollen. All these elements can be well seen in the fresh state without staining. The mycelium stains well by Gram's method, showing the rods to be composed of cell protoplasm and envelope. The clubs, however, do not take the violet, and are best counter-stained with orange rubin or picric acid. The ray fungus is both aërobic and anaërobic. It grows slowly but very well on glycerin-agar or potato, and thrives best at body temperature, 37° C. It grows on both gelatin and blood serum with liquefaction of these media. In cultures spores are formed. Though slight bulbous thickenings may form on some of the filaments, true clubs are not formed in cultures. The organism has a low vitality and is readily destroyed by antiseptics.

Communication and Infection.—Actinomycosis is chiefly a disease of kine, though horses and hogs are sometimes affected. Healthy cattle stabled with infected ones seldom contract the disease, nor does infection seem to be traceable from cattle to man. If infection from man to man ever takes place, it has not been demonstrated and must be extremely rare. The frequency with which the disease, in animals and man, is seated in the tongue, cheek, jaw, or neighboring parts suggests infection by food; and cereals, especially barley, have been charged with carrying the disease. Particles of grain have sometimes been found in foci about the mouth. It has been assumed that the actinomyces may have a parasitic or saprophytic existence on grain. It grows when artificially implanted on grain, though the organism has never been demonstrated in any other natural habitat than the lesions and discharges of the diseased. Whether or not a wound of the membranous surface is necessary for the entrance of the parasite is not known. In many cases of thoracic and abdominal actinomycosis it appears likely that the primary infection was pulmonary or intestinal. Wright * thinks it not unlikely that the organism may be a normal inhabitant of the buccal cavity and the gastro-intestinal tract of animals and man.

Pathology.—Whenever the organism finds a lodgment in the living body, it multiplies in typical colonies and forms a localized focus of the disease. If a pure actinomycotic infection has taken place, as long as it remains localized in the skin or in superficial tissue its development progresses slowly and with little or no constitutional disturbance. A nodule is formed, after some days or weeks it softens, becomes inflamed and adherent, and bursts externally, creating a sinus in the skin, tongue, cheek, or gum, which discharges a small quantity of semi-purulent fluid and shows no tendency to heal (see Figs. 19 and 20). The disease burrows deeper, setting up new foci; and extends superficially, forming new sinuses. Either from the outset, or in the course of the disease, a mixed infection takes place, and pain and fever with real abscess formation, due to the associated pyogenic cocci, give the clinical picture of pyæmia. The most striking characteristic of the slow and steady invasion of the actinomyces is its

* Journ. Med. Research, Boston, 1904–05, xiii., 349.

spread without any regard to the limits of organs or of the histological tissue in which it starts. It is not carried along the course of the lymphatic vessels and nodes. The disease process extends, that is to say, not by continuity, but *by contiguity*. Starting in the soft parts, it will attack the bone. Starting in the base of a lung, instead of spreading throughout the pulmonary lobe, it may traverse the pleura, setting up a limited pleuritic abscess, attack the ribs and

FIG. 19.—Actinomycosis. (*After Neumann.*)

sternum or perforate the chest wall, pierce the diaphragm, infiltrate the omentum, and, as in a case reported by Murphy,* float the spleen in a large, subdiaphragmatic abscess. In other cases the infection has burrowed its way along the spine, and has set up perityphlitic abscess, or psoas abscess, or has riddled the abdominal parietes with perforations. Metastasis occurs and the liver is not uncommonly infiltrated with the fungus.

Symptoms.—The varied gross pathology of actinomycosis gives rise to equally varied symptoms, which are more marked in mixed than in simple infec-

* North Am. Pract., Chicago, 1891, iii., 593.

tion, and more serious the deeper and more numerous and extensive the foci of the disease. Ruhräh has collected over a thousand reported cases in man, and finds that the head and neck are affected in fifty-six per cent, the digestive tract in twenty per cent, the lungs in fifteen per cent, and the skin in two per cent.

Diagnosis.—Chiefly because of the mixed infection and abscess formation usually encountered in actinomycosis, it is often mistaken for an ordinary *pyæmia*, its true nature being overlooked. The surgeon should have actinomycosis in mind in the presence of lesions for which it would account. Usually the characteristic bright yellow granules will not be seen in the discharge as it weeps from the sinuses, but on manipulation and firm digital pressure some of them

Fig. 20.—Actinomycosis Abdominalis. (*Vander Veer and Elting.*)

will be squeezed out in the pus. They are the more readily seen if the pus be spread on a piece of glass. The disease has frequently been mistaken for *sarcoma*, especially in cases where the bone is involved. In sarcoma, however, suppuration occurs later, if it occurs at all. The diagnosis of actinomycosis must always rest directly and finally on the demonstration of the fungus. In pulmonary actinomycosis the symptoms are the same as in *tuberculosis*, but by careful search the yellow granules can be detected in the sputum, and the practised eye will recognize the fungus in the fresh state under a low power. For a satisfactory demonstration characteristic granules should be crushed between two cover glasses, spread, dried, fixed by passing through the flame, and stained by Gram's method and orange rubin. The granules may be embedded in paraffin and cut into sections, or sections may be made of excised tissue.

Prognosis.—In cases in which the lesions are few, superficial, and accessible to surgical treatment, the prognosis is favorable. A guardedly favorable prognosis under medical treatment may be given in any case where it is probable that no important deep organ—as, for instance, the liver—is involved; and if there are no serious symptoms of a constitutional sort at the time the case comes under treatment. When the abdominal organs are involved the prognosis is bad, especially if there be a mixed infection with abscess formation.

Treatment.—No rules for prophylaxis can be laid down. With good care and good diet a small proportion of cases in which the disease is quite limited recover spontaneously. The only drug which has a decidedly favorable influence is potassium iodide in full doses, gr. xlv.–cxx. daily for an adult if the drug be well borne. Its value is unquestioned, and it should not be omitted in connection with surgical treatment.

Whenever the foci of the disease, nodules, abscesses, or sinuses, are accessible they should be removed by incision and evacuation of contents, curetting, and cauterizing, or by total extirpation. Every trace of the infection must be removed if possible. The abscesses in various organs and deep parts resulting from mixed infection must be treated appropriately. Injection of antiseptics, such as carbolic acid 1:20, silver nitrate 1:10, zinc chloride 1:8, and iodine, into the sinuses has been practised and sometimes results in a temporary healing. But such measures seldom reach and kill all traces of the fungus, which continues to proliferate and either causes the sinus to open again or burrows into deeper parts.

MYCETOMA.

Synonyms.—Madura foot; fungus disease of India. *Fr.* Le pied de Madura. *It.* La micetoma. *Ger.* Der Madurafuss.

Definition.—The disease caused by a local implantation and proliferation of *Streptothrix Maduræ* and possibly of other fungi; usually confined to the foot or hand, painless, and without constitutional symptoms.

History and Distribution.—The disease was described by Kaempfer in 1712 as *hypersarcosis ulcerosa pedum.* It has long been common in India. In recent times attention was first called to it by Gill, of Madras, in 1842, and Godfrey, of Bellary, in 1843. Vandyke Carter, in 1860, exhibited specimens to the Bombay Medical and Physical Society, and in his description attributed the disease to a fungus. Later, he gave it the name *mycetoma,* and his elaborate monograph with colored plates, published in London in 1874, remains the best delineation extant of its clinical and gross pathological aspects. The disease is endemic in many of the provinces of India. Occasional cases have been encountered in Cochin China, Egypt, Algiers, Italy, and North and South America. In 1895 Adami, of Montreal, and Hyde, of Chicago, observed the first cases reported in North America, and only four cases have been reported in this country up to the present time.

Etiology.—From 1892 to 1894 the parasitology of the disease was investigated by Kanthack, Hewlett, Boyce and Surveyor, Vincent, and others. In the *white* or *pale* or *ochroid* variety of mycetoma they found constantly present a ray fungus, which, in the lesions and in pure cultures, closely resembles Actinomyces bovis. Vincent gave it the name *Streptothrix Madura*, by which it is generally known. Kanthack proposed to call it *Oöspora Indica*. Following Silberschmidt's idea of making "Actinomyces" the genus, W. R. Stokes proposes to call it *Actinomyces Maduræ* and consider it as one of seven known species of actinomyces, several of which are pathogenic for man or animals. It differs from Actinomyces bovis in having thicker mycelial rods, staining more readily with simple basic aniline dyes, not liquefying gelatin, not growing on blood serum at all, and not being pathogenic to animals.

The cause of the *black* or *melanoid* variety of mycetoma is not well settled. Some observers are of opinion that this is a later stage of the ochroid form or a varied manifestation of the same disease, and that the black granules are formed by a central degeneration of the mycelium of the streptothrix. Kanthack * supports this view, and describes a specimen examined by him which showed all the transition forms from the perfect type of ray fungus with peripheral clubs to the unrecognizable black or brown pigment masses. His conclusion is: "There is no doubt that the fungus is a ray fungus; . . . the question arises whether it is a distinct variety or a degeneration form of the ochroid parasite." In a case at Boston in which the diagnosis of melanoid mycetoma was made, Wright† made cultures from the black granules and obtained a fungus in the mycelium of which, in old agar and potato-infusion cultures, black "sclerotia" were formed, and which he believed to be the organism which caused the disease. He considers it to be a true mould (hyphomyces), and not a ray fungus (streptothrix). This view has not yet been confirmed by any other observer. Animal inoculations with both the black granules and the cultivated fungus were without result.

It is possible that under the head of mycetoma we include two or more diseases which are etiologically distinct. Except for the varying color of the granular concretions in the foci, the varying forms of the disease are alike in their gross pathology and clinical course and in the treatment they require.

Communication and Infection.—The lower animals appear to be immune to mycetoma. No natural habitat is known outside the diseased tissue of man for the fungus which causes it. Of 100 cases in India collected and analyzed by Bocarro,‡ all were dwellers in the country and 91 were tillers of the soil; 92 cases were in men and 8 in women. In many cases the patients referred the beginning of the disease to a prick with a thorn or splinter, or to some other trifling injury.

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* Journ. of Path. and Bacteriol., Edinburgh and London, 1892–93, i., 140.
† Journ. of Exper. Med., New York, 1898, iii., 421.
‡ Lancet, London, 1893, ii., 797.

Pathology.—In Bocarro's series of 100 cases the disease was located in 93 on the foot, 3 on the hand, 2 on the leg, 1 on the shoulder blade, 1 over a sacroiliac joint. In the two cases on shoulder and sacrum the disease was of the melanoid variety and there was no doubt about the diagnosis. As in actinomycosis, the process extends in the affected part *by contiguity,* disregarding anatomical boundaries. General infection or metastasis through the blood is unknown, nor is the disease carried along the lymph stream.

The proliferation of the fungus lodged in the subcutaneous tissue sets up a reactive inflammation, by which nature endeavors to arrest the process and shut off the parasite. For this reason the focus in the soft parts is surrounded by a
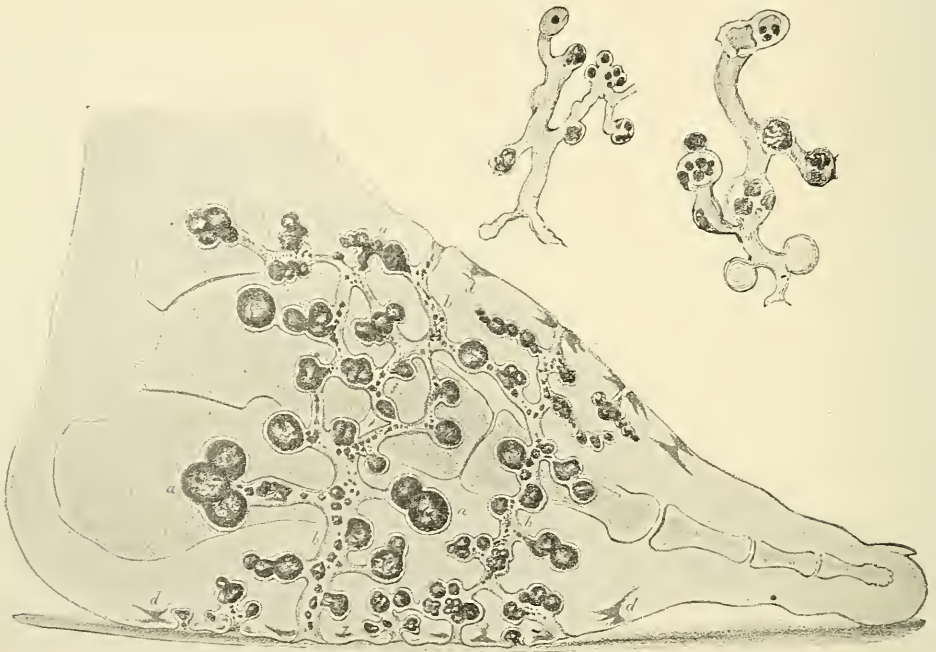

Fig. 21.—Mycetoma. Melanoid variety. Mode of invasion of the growth. Semi-schematic. At *a, a,* cyst-like cavities filled with the black, roe-like, granular masses; *b, b,* communicating sinuses, with *c, c,* external openings; and *d, d,* pinkish stains or streaks in the skin near the openings. Above, are two canals traced out of an actual specimen. (*After H. V. Carter.*)

zone of proliferating cells and more or less organized fibrous tissue. Around the foci in the bones this forms a tough membranous capsule which can be enucleated entire. The foci vary in number and size and distribution. They are connected, one with another, by a network of ramifying sinuses (see Fig. 21). In the early stages the soft parts and in later stages the bones are riddled with the foci and sinuses. Tendons and fasciæ resist the process longest. On section of a far-advanced mycetomatous foot or hand, an oily, greasy surface is shown, the soft tissues have lost their anatomical character and are blended into a tumefied, pultaceous, nondescript mass, and the bones are rarefied and partially absorbed.

Each distinct focus consists of a cyst-like cavity, from a mere speck to as large as a walnut in size, filled with the concretions which are typical of the disease, surrounded with a semi-purulent, oily fluid, which may or may not be malodorous. The typical concretions in the *white, pale,* or *ochroid* variety of the disease consist of small yellowish or pink granules, held together by inspissated grease in masses which have been compared to fish roe. Similar masses, but of a black color, exist in the *melanoid mycetoma.* It is the recognition of these roe-like masses in the discharge which usually establishes the diagnosis. In rare instances the granular concretions are absent and the sinuses and cysts are filled with the oleaginous, purulent fluid only.

Fig. 22.—Mycetoma of About Two Years' Standing. (*After Legrain.*)

Symptoms and Course.—As already stated, a large proportion of the patients will refer the beginning of the disease to a fester from the prick of a thorn or to some other slight injury. When this is not the case and the disease appears to the patient to have arisen spontaneously, the first symptoms are a localized tenderness, soon followed by a local tumefaction. A nodule is formed at the affected spot, varying in size from a pea to a small marble, and surrounded by a more or less diffuse inflammation (see Fig. 22). The overlying skin gradually becomes inflamed, thickened, and adherent. "The ball of the thumb or of the great toe, or the pads of areolar tissue and fat along the bases of the fingers and toes, are favorite initial seats of the disease" (Bocarro). The progress of the inflammation and the infiltration of new tissue on sole or dorsum or between the

toes gives rise to characteristic deformities. The toes are tilted upward or apart, or adducted or abducted; and the plantar tissue bulges downward, keeping the toes off the ground, obliterating the arch of the foot, and giving the member a shapeless or "globose" appearance. The growth, however limited, is never so superficial as to involve the integument only. The soft parts, especially the padding of areolar tissue and fat, sometimes with the muscles, are first implicated, and later the bone and cartilage are invaded. The progress of the disease is slow. In from six months to two years the growth softens and a sinus opens spontaneously through the skin, discharging a sero-purulent fluid, containing the yellow or pink roe-like granules of the white variety or the black granules of the melanoid form. In the course of from two to ten years or more, the process extends through the affected member till its natural form and the normal character of the tissues are no longer recognizable, and the part is riddled with foci and communicating sinuses, from twenty to fifty of which may open externally. In its most advanced stage the foot or hand becomes "an enormous globe of hypertrophied tissue, drilled all over with holes." Probes pass easily into the mass from different directions, and encounter each other in the interior. The affected part is usually elastic to the touch and does not pit on pressure. Sensation is preserved in the skin, but there is no pain in the part and no constitutional disturbance, the patient complaining only of the inconvenience of the heavy, useless mass into which his foot has been converted.

Diagnosis.—Until it was more carefully studied and differentiated, mycetoma, like actinomycosis, was sometimes mistaken for *sarcoma*, or for a localized *tuberculosis*. Such mistakes are not likely to occur now, especially where mycetoma is endemic. The diagnosis can be made almost with certainty from the gross appearances which have been described and the characteristic yellow, pink, or black granules, which can be expelled from a sinus by manipulation and pressure, or demonstrated in masses by incision into one of the larger foci. This material is, as Manson says, "unlike anything else in human morbid anatomy."

Prognosis.—The prognosis is favorable. Surgical treatment in Bocarro's series, collected in 1893, resulted in complete cure of ninety-eight per cent of the cases.

Treatment.—Beyond advising that shoes or sandals be worn to protect the sole of the foot, no rule of prevention can be laid down. No other care is needed. The disease is confined practically to the barefoot poor. There is no medicinal treatment for mycetoma. Because of the analogy, especially of the white variety, to actinomycosis, potassium iodide has been tried, but it is entirely without influence on the course of the disease. Unlike actinomycosis, mycetoma never shows any tendency to spontaneous cure. It will inevitably recur and extend after any imperfect attempt at eradication which leaves *in situ* some of the diseased tissue containing the fungus. The only treatment for mycetoma is a rad-

ical surgical treatment which removes the diseased part completely. This may be effected, in the case of a very limited involvement, by incision of the diseased portion or by a partial amputation. In the majority of cases amputation of the entire foot is required, and this is permanently successful. Dymock mentions a case, however, in which, after amputation in the leg, there was a recurrence in the thigh, necessitating a second amputation an inch below the lesser trochanter.

RHINO-PHARYNGITIS MUTILANS.

Definition.—A peculiar destructive ulceration of the naso-pharynx prevalent in certain limited areas in the tropics; without constitutional symptoms and usually running a self-limited course with a tendency to cicatrization. It is probably caused by a local fungoid or bacterial invasion.

History and Geographical Distribution.—Lesions similar to those which characterize this disease were briefly mentioned in 1839 by Maxwell,[*] who believed them to be sequelæ of frambœsia (yaws). Numa Rat followed him in this belief and so described the sixty cases which he encountered in a limited district on the windward side of the island of Dominica, West Indies.[†] C. W. Daniels, who encountered cases in Fiji, was the first to throw doubt upon their connection with yaws.[‡§] The disease has puzzled many observers who have seen it only casually and who have attributed its lesions to leprosy, syphilis, or tuberculosis. It was differentiated from these diseases and from yaws, and described as a disease *sui generis,* by the present writer, first in 1904,[||] and again more fully in 1906.[¶] *Rhino-pharyngitis mutilans* is known to exist in only a few limited areas in the tropics. It has been shown to be exceedingly prevalent in Fiji and in Guam, it has been observed in portions of the Caroline Islands, and it appears to prevail extensively in a limited district in the West Indian island of Dominica, where its lesions have been described by Numa Rat[**] who supposed them to be sequelæ of frambœsia. A case recently seen in New York in the person of a negro, a native and resident of Panama, and reported by Fordyce and Arnold,[††] was quite probably a case of this disease.

Etiology.—Of the specific cause of the disease nothing is at present known. It affects persons of all ages from infancy to old age; and, from the fact that several members of the same family are often seen to be affected with only its peculiarl esions and to be otherwise in good health, the disease would appear

[*] "Observations on Yaws." Prize Essay, Edinburgh, 1839.

[†] "Yaws: Its Nature and Treatment." London, Waterlow & Sons, 1891.

[‡] Selected Essays and Monographs, New Sydenham Society, London, 1897.

[§] Brit. Jour. Dermat. London, 1896, viii. 426.

[||] Report Surgeon-General U. S. Navy (1904-05), 1905.

[¶] Jour. Tropical Medicine, London, Feb. 15, 1906, ix.–47.

[**] *Op. cit.*

[††] Jour. Cutan. Dis., New York, January, 1906.

to be contagious. It may not improbably be caused, like blastomycetic dermatitis, or like mycetoma, by the local invasion of a parasitic organism. No cases of the disease have yet been reported in others than Malays and negroes.

Clinical Course.—The patient, if seen early, as few are, complains of sore throat. On examination an ulcer is seen on the back of the pharynx, on a posterior faucial pillar, or on the free edge of the palate. It is superficial, movable, covered with a thin, dirty, brownish-gray pellicle of slough. This appears to be the initial lesion. The pellicle breaks down and leaves an ulcer which steadily increases, advancing up the throat into the posterior nares. The disease begins in the soft parts, but, after reaching the soft palate and

Fig. 23.—Rhino-pharyngitis Mutilans. Late stage of a severe case with complete destruction of hard palate and nose; and involvement of eyelids, keratitis and blindness resulting. (From a patient in Guam.)

eating its way through its entire thickness, attacks the bone of the palate and nasal septum, finally destroying these entirely. The disease process, a serpiginous ulceration, after being thus active and advancing for months or even years, usually arrests itself at this stage, the ulcers healing, and leaves the victim with no septum, the nasal cartilage and skin fallen in, and the nose and mouth one large cavity. The faucial opening is apt to be narrowed by cicatricial tissue, making deglutition difficult. The disease rarely, if ever, advances downward from the pharynx. The larynx is unaffected and phonation remains perfect, though articulation and the quality of the voice are deranged, as in

a bad case of cleft palate. There are no constitutional symptoms. The patients, if so in the first place, remain well-fleshed, strong, and able to follow their usual avocations. The disease process having ceased, the patient carries its marks in palatal bone destruction and pharyngeal scar tissue to old age, whence the name *rhino-pharyngitis mutilans.* In a few of the cases, fewer than ten per cent of them, the process is not arrested at this stage, and the ulceration destroys the cartilage and skin of the nose and advances upon the face. Occasionally the process extends up through the nasal ducts into the conjunctivæ, where it produces in the eyelids an excessive growth of granulation tissue with inability to close the eyes, keratitis and blindness resulting. The tongue is unaffected. The upper lip always remains as a bridge across the large opening in the face; but above it, through the anterior nares, one looks into the mouth and down the throat. Even in these most extensive and aggravated cases, however, there is no evident impairment of the general health.

Diagnosis.—Rhino-pharyngitis mutilans must be distinguished from *leprosy* by the tendency to a spontaneous cure, the absence of leprous lesions elsewhere, and the absence of *Bacillus lepræ* in the lesions of this disease; from *tuberculosis* by the non-existence of tuberculosis in other organs or parts, the absence of any tendency to downward extension and laryngeal involvement, and the absence of *B. tuberculosis* in the lesions; from *acquired syphilis* by the absence of any signs or history of primary or secondary syphilis and by the onset of the disease in infancy and childhood; from *hereditary syphilis* by the absence of any of the signs of that disease and by its incidence in the healthy children of healthy parents. In any of the few localities where the disease is known to be prevalent this fact will help to a diagnosis.

Prognosis.—In natives who are well provided with the necessities of life, who live in comparatively good hygienic surroundings, and who can be kept under observation and treatment, a favorable prognosis can be given for most cases. Before the fifth year of life the disease is accompanied with moderate fever and is apt to be fatal, the only two deaths in the writer's experience of more than forty cases having occurred in children of three and four years.

Treatment.—The infection is difficult to eradicate, especially in cases where the serpiginous ulceration has advanced into the nares and is difficult of access. In the few cases seen early, when the disease is limited to the pharynx, and in the still rarer cases in which its beginning is visible in the anterior nares, cauterization with the silver-nitrate stick may be practised. Daily spraying with hydrogen peroxide is effective in removing the sloughing surface of the ulcer and developing a healthy granulating surface, and the use of a detergent and stimulating gargle is beneficial. In conjunction with the appropriate local treatment, potassium iodide internally in full doses is usually well borne and has seemed to the writer to have a decidedly favorable effect upon the course of the disease.

SCURVY.

Synonyms.—*Lat.* Scorbutus.　*Fr.* Le scorbut.　*It.* Lo scorbuto.　*Sp.* El escorbuto.　*Ger.* Der Skorbut.

Definition.—A general dyscrasia resulting from defective diet; characterized by anæmia and debility, swollen spongy gums, subcutaneous and intramuscular indurations and swellings, and a tendency to hemorrhages and tissue degenerations.

History and Distribution.—Scurvy has been known from ancient times. In modern history its ravages have been chiefly in camps and prisons and among the crews of vessels keeping the sea for a long time. Within the past half century improved provisioning has eliminated it from the navies of the leading powers, and reduced it to a minimum in the merchant marine. Several factors have contributed to this result, the chief of which are the advent of steam navigation, with shorter voyages and more frequent access to fresh-food markets; improved methods of keeping provisions on board; an increased variety of preserved meats, vegetables, and fruits available for sea stores; and legal regulation of seamen's rations. Scurvy appeared in prisons and besieged cities during the American Civil War, Franco-German War, and South African War, and it still prevails extensively among the poor in Russia and Siberia.

Etiology.—Scurvy results from a defective diet, in which *fresh organic substances, animal or vegetable, are lacking.* For the maintenance of health and the power to resist disease, a dietary is required, the assimilation of which will maintain the due relative proportion of the many organic and inorganic components of blood and tissues. Under circumstances where a well-balanced dietary is not procurable and persons have to be subsisted largely on preserved fish, flesh, and cereals, they are likely to develop scurvy. The theory once held that scurvy was caused exclusively or specifically by the absence of fresh vegetables and fruits, with the vegetable acids they contain, from the diet, is not tenable. Not only do some races, as the Esquimaux of North Greenland, maintain health without such foods, but the experiences of Neale,[*] Jackson, and Nansen in the Arctic show that, in the absence of fresh vegetables and under conditions of bad hygiene, crowding, short rations, and extreme hardship for prolonged periods, when plenty of fresh meat is available scurvy need not be feared. Just what disturbance occurs in the balance of nutrition and the composition of the blood and tissues, and how it occurs, have not been made out; but that scurvy is always the result of lack of sufficient fresh organic matter in food, and is invariably and only cured by supplying that lack, there can be no question. We have, therefore, all the knowledge necessary for dealing with the disease, whatever its essential etiology.

[*] Practitioner, London, 1896, lvi., 585.

Among special theories advanced as to its essential cause and nature may be mentioned these: that it is caused (1) by deficiency of potassic salts in the diet (Garrod); (2) by absence of the organic salts of potassium, resulting in a diminished alkalinity of the blood (Buzzard, Taylor, Chalvet, Ralfe); (3) by toxic materials formed in the decomposition of imperfectly preserved meats (Nansen, Jackson, Harley); (4) by a specific microbic infection. Babes brought forward a bacillus and Testi a diplococcus as the cause. None of these theories has been substantiated by any sufficient evidence. Infantile scurvy (Barlow's disease) occurs in the children of the well-to-do, at ages of six to eighteen months, who are fed on condensed milk and other patent preparations to the exclusion of cow's milk and other fresh foods.

Pathology.—There is an anæmia without leucocytosis. The red corpuscles may be reduced slightly or all the way to 2,000,000, according to the severity of the case. The gums are inflamed, swollen, sometimes ulcerated, and often bleed at the touch. Serous effusions are found, and hemorrhages in the membranes, muscles, and organs. In children rarefaction of the bones occurs, with separation of epiphyses or fracture of the shaft, especially at the sites of subperiosteal hemorrhage; and it has occurred that such fractures, with associated scorbutic ecchymoses and swellings, have been mistaken for the results of violence and led to criminal prosecution of parents. This occurred in a case in which five long bones were found post mortem to be thus fractured. This condition of bone has been called by Sutherland * *fragilitas ossium scorbutica.*

Symptoms and Course.—The disease comes on insidiously. There is a stage of physical weakness and mental apathy, with moderate loss in weight, sallow skin, shortness of breath and œdema at the ankles from enfeebled heart action, and fleeting pains. Following this the gums become swollen and vascular, and irregularly located tender swellings appear on the bones and in the muscles, particularly in the muscles of the calf or the popliteal space. Skin hemorrhages, usually ecchymotic, seldom petechial, appear, and epistaxis is not uncommon. There is constipation, the urine is scanty, but the tongue remains clean, the appetite is fair, and there is no fever. The temperature may even be slightly subnormal. Hæmaturia is rare. There is usually little loss of the subcutaneous fat. Hemorrhages into the tissues cause brawny, painful swellings. They are apt to occur in parts subjected to bruising or other slight injury. Melæna is rare.

The characteristic signs of infantile scurvy, according to Barlow, are: " (1) Predominance of lower limb affection, in which there is immobility going on to pseudo-paralysis; excessive tenderness; general swelling of the lower limbs; skin shiny and tense, but seldom pitting, and not characterized by undue local heat; on subsidence revealing a deep thickening of the shafts, also liability to fracture near the epiphysis. (2) Swelling of the gums about erupted teeth only, varying from definite sponginess to a minute transient ecchymosis."

* Edinb. Med. Journ., 1898, n. s., iii., 351.

There appears to be also a peculiar liability to deep orbital hemorrhage, producing proptosis of the eyeball.

Diagnosis.—The swollen gums prone to bleed, the foul breath, the brawny, deep swellings, and the large ecchymoses, usually in the lower extremities, are characteristic. The absence of associated diffused petechiæ is a differential point against *purpura*. Talbot * maintains that there is an interstitial gingivitis, resulting from bad food and bad hygienic conditions, which should be differentiated from scurvy. A dietary history can often be elicited which will confirm the diagnosis in cases where the discovery of scurvy is a surprise. Thus the disease is sometimes seen in women who substitute an habitual indulgence in the "toast-and-tea" habit for regular and proper meals of nourishing food; and the writer saw a case at Newport, in consultation with Dr. Bellamy, in the person of a wealthy Englishman mak'ng the *tour du monde*, who had lost his appetite for a proper variety of food and his ability to assimilate it through a prolonged indulgence in alcoholic spirits. The case was typical and serious, with grave blood dyscrasia and many enormous ecchymoses, but the patient recovered promptly on the withdrawal of alcohol and the enforcing of a proper diet.

Infantile scurvy must be distinguished from *rickets*, with which it is sometimes associated in the same subject. The surgeon should have in mind the possibility of an insufficient patent-food diet, more likely among children of the well-to-do than among the poor. Epiphyseal separation, with swelling of a joint, has been mistaken for *fracture*, for *sarcoma*, for *coxalgia*, for *tuberculous ostitis or arthritis*. A scorbutic swelling due to subperiosteal hemorrhage may be mistaken for a *rheumatic swelling* or for *subperiosteal abscess*. The orbital hemorrhage, with proptosis, was once mistaken for *sarcoma of the eye*, in a child of nine months.

Prognosis.—In all surgical cases, and especially in operative ones, with co-existent scurvy, a favorable prognosis cannot be given until the scurvy has been cured. The death rate in scurvy among adults is very small—during the past twenty years about half of one per cent; but, owing to the danger of syncope on slight exertion, the prognosis in severe cases should be a cautious one. With the patient in a state of advanced exhaustion death sometimes occurs from a hemorrhage (sometimes from the bowel) or from a sudden pericardial effusion which arrests the heart.

Prophylaxis.—Ships, military expeditions, and exploring parties should include in their stock of provisions as great a variety of fresh vegetables and of canned vegetables and acid fruits as they can carry and keep. Among anti-scorbutic stores canned tomatoes may be mentioned as valuable, easily obtainable, and cheap. Ships should invariably draw on the fresh-food market when in port. Lime juice, while not having the specific value with which it has been credited, goes far as a substitute for fresh fruit when that is not obtainable.

* Medical News, New York, 1904, lxxxv., 339.

The crew of the ship that rescued Neale and his companions had plenty of lime juice and plenty of scurvy among them, while the twenty-five men who had been twelve months in the ice without lime juice, but with a daily allowance of fresh meat or blood, were all well. In the absence of fresh vegetables, fresh meat in sufficient quantity will forestall scurvy. Pemmican, containing dried meat and raisins, has a certain antiscorbutic value, though a small one. Arctic sledge parties should secure as much meat as possible by hunting. The present Shipping Articles for American merchant vessels include stipulations as to rations which, if observed, as they are in the vast majority of cases, make the appearance of scurvy impossible.

Treatment.—A grave case of scurvy should be put to bed and kept recumbent and warned against the danger of exertion. Until some ground has been gained against the disease, the mere exertion of sitting up may produce a syncope. An antiscorbutic diet, consisting of eggs, fresh milk, fresh meat, and vegetables in suitable variety, should be inaugurated at once. The juice of a few oranges or a certain amount of lemonade or lime juice is a useful adjuvant to the diet. A tonic may be given. Iodides are contraindicated. To infants, mother's milk or cow's milk should be given, and a few spoonfuls of orange juice or of scrapings of a sound, ripe, fleshy fruit daily.

The pathological manifestations of scurvy are prone to develop at the site of traumatisms, recent or old. Not only is the repair of a recent fracture, for instance, delayed by the existence of scurvy, bone formation being arrested, but callus already formed for the repair is sometimes softened and absorbed. In separation of epiphyses in infants, or in the spontaneous fractures described, coaptation splints or a light plaster dressing may sometimes be applied with advantage, until the antiscorbutic diet has made itself effective. Injuries to the tissues of scorbutics are liable to result in ulceration and gangrene, and operations will not be successful until they have the benefit of a proper diet. Incision for the removal of extravasated blood under the periosteum is not advisable, even though the periosteum be widely separated from the bone.

The condition of the mouth must receive attention. Antiseptic, detergent, and stimulating mouth washes should be employed, ulcers on the gums should be pencilled with copper sulphate or a weak solution of silver nitrate. Ulcers on the body, resulting from sloughing, should be washed and dressed. Even the worst will usually heal rapidly under the constitutional treatment. If subcutaneous and intramuscular swellings show little tendency to absorption, gentle massage may be employed and light pressure made with a flannel bandage.

PART VII.

GENERAL SURVEY OF TUBERCULOSIS AND SYPHILIS IN THEIR RELATIONS TO SURGICAL WORK.

TUBERCULOSIS, FROM A SURGICAL STANDPOINT.

By V. P. GIBNEY, M.D., LL.D., New York City.

TUBERCULOSIS invades so many organs and tissues of the body not pulmonary that the profession has come to look upon these lesions as surgical rather than medical. Even the lung is invaded by the scalpel in the hands of certain bold surgeons, and the time may not be far distant when circumscribed lung areas, walled off by connective or reparative tissue, can be removed, thus adding another victory for surgery. There are many cases already on record where Nature herself has thus handled the tuberculous process in the lung. An abscess develops in this walled-off portion, an exit is effected through the chest walls, and thus one may say that, to all intents and purposes, a cure has been accomplished. It will be seen, therefore, that tuberculosis should assume an important place in a work on surgery. It is seldom that any tuberculous disease runs its course without the aid of the surgeon. Cutaneous lesions, as well as those involving the deeper structures, may yield for a time to various modern therapeutic agents, such as the x-ray, the radium treatment, the various caustics, climate, etc.; yet this disease has a way of localizing itself in the shape of tumors or an infiltration demanding radical measures. In brief, it may be regarded as a localized inflammation directly traceable to the Bacillus tuberculosis. While there are shades of difference in the way in which these organisms attack the various organs of the body, yet there is one feature which characterizes their action in all these attacks, namely, persistence. The bacilli (see Plate X., Figs. 1 and 2) enter the human system, as a rule, through the air passages, find lodgment in the mucous surfaces, especially those covering the glands, and in rare instances may even pass through normal mucous membrane. They then remain in this locality for varying periods of time without causing disturbance of any kind. At some later time, however, there comes a period of physical depression or a diminution of the individual's resisting power. Then the bacilli, coursing through the blood supply, take up their abode in some organ, the resisting power of which is very low or in which there is an increased blood supply. This hyperæmia may be due to trauma or to exposure from cold, as a result of which a congestive area is established. Take, for instance, the epiphyses of the long bones in a growing child, in what is known as the developmental period of life. The germs, once colonized, multiply rapidly, thus establishing a focus of disease, the first lesion being an inflammatory centre, which breaks down under the influence of bacil-

lary propagation. This focus enlarges—in some cases under the influence of traumata, in others under that of impaired nutrition—and the process extends until it involves the whole epiphysis, the central portion breaking down into caseation. Finally, the joint becomes involved, and we have the condition known as tuberculous bone or joint disease. The same process goes on in the spinal column, the bacilli lodging in the centres of the bodies of the vertebræ, and by a slow or a rapid process the neighboring vertebræ become involved. The destruction goes on with very little interruption, and we have the bosse, or hunchback, with all the distressing symptoms of a Pott's disease of the spine. In the same way the liver, the spleen, the mesenteric glands, the kidneys, the testicle, and the bladder may become involved. If one, therefore, bears in mind the persistence of the process, a diagnosis can be made with a reasonable degree of certainty, and this, after all, is the important feature in surgical practice. When we speak, therefore, of tuberculosis of a joint, or of the lung, or of any of the important organs, we mean that the bacilli tuberculosis have invaded the tissues and that a chronic destructive lesion has thus been established. There are really very few tissues in which tuberculosis takes the form of an acute process. For instance, the pia mater of the brain, if attacked by the bacilli, becomes rapidly inflamed, the products encroach on vital parts, and we have a typical or an atypical tuberculous meningitis.

USUAL MODES OF INVASION.

The above will suffice to define the term "tuberculosis," and will give one a fair idea of its nature. Yet it may not be amiss to enter a little more into detail, and for this purpose let us enumerate certain facts that are well established. The insidious invasion has already been mentioned. The tendency of the disease to remain circumscribed, its slow encroachment on neighboring parts, and its gradual destruction of tissue are quite sufficient to enable one to recognize the process when it invades an organ. Take, for example, its manifestations in the skin, where one can study the process with advantage. A small pimple first appears, and this makes very slow progress; certain tissues break down, and we have lupus—only one of the many tuberculous lesions of the skin and subcutaneous tissues. Quite frequently an acute process is developed, and this is known as an exacerbation. The term "exacerbation" is one very commonly used in describing the acute processes which run a varying course. These depend on fresh exposures, with a rapid involvement of contiguous tissues, often following some traumatism, and the original focus undergoes an increase in size as an end result of the exacerbation.

For a number of years past it has been the custom of the writer, in his lectures, to draw a comparison between the process as it involves the lung and that in which an epiphysis of one of the long bones is the seat of the disease. In the

EXPLANATION OF PLATE X.

Fig. 1.—Section of the Lung in a Case of Miliary Tuberculosis. *a*, Tubercle containing numerous bacilli; *b*, tubercle with fewer bacilli; *c* and *d*, tubercles with cheesy centre and containing no nuclei; *e*, cross-section of a blood-vessel surrounded by a deposit of pigment. Magnified 50 diameters.

Fig. 2.—The Blue-Colored Portion of the Tubercle *a* in Fig. 1. The bacilli are stained blue, the nuclei of the cells brown. Magnified 700 diameters.

Fig. 3.—Section of a Patella Removed from a Patient Suffering from a Tuberculous Knee. It shows a perforation as clean-cut as if it had been bored by a gimlet.

Fig. 4.—Head of Femur Partially Destroyed by Tuberculous Disease. A portion of the neck of this bone is also involved.
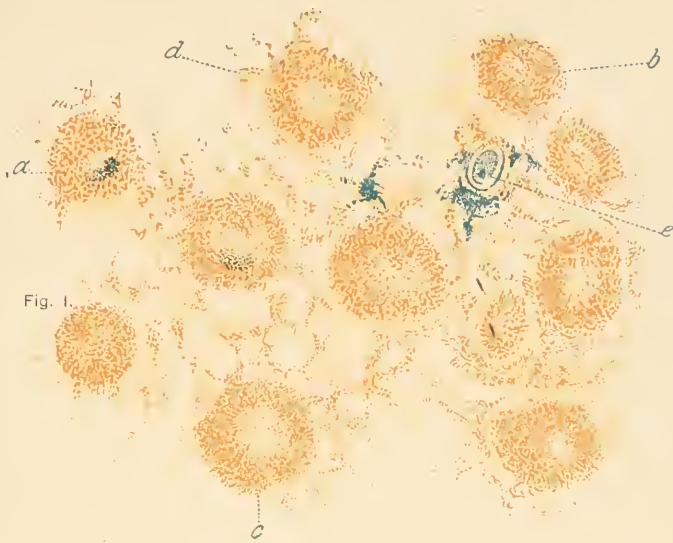
Fig. 1.

Fig. 2.

Fig. 3.　　　　　　　　　　　　　　Fig. 4.

TUBERCLE BACILLI. (*KOCH.*)

TUBERCULOUS DISEASE OF BONE. (*GIBNEY.*)

lung we have a small, yellowish focus, first appearing in the apex of the organ, or in some cases in the lymph nodes at the point of bifurcation of the bronchus. This process may remain quiescent for a long period and be quite overlooked by a skilful diagnostician; yet, as a rule, care in observation will detect it, and a diagnosis may be made beyond question. Next, the patient seemingly contracts, what is familiar to all, a "cold"; the process in the lung at this time extending to the tissues lying contiguous to the focus, and establishing a condition of consolidation, limited to a small area. As this exacerbation subsides, the consolidation becomes less pronounced in the periphery, and we recognize the fact that a cavity has begun to form in the centre of the solidified area. So in the epiphyses, the tissue of which is similar to that of the lung, the changes follow in about the same order. There first appears a small, yellowish focus, which interferes with the nutrition of the limb as well as with its function, and induces reflex pains. A diagnosis at this juncture is difficult. Under the influence of trauma an exacerbation is developed, the parts about the joint become acutely sensitive, function is impaired to a still greater degree, and deformity results. Under the influence of rest and local measures, the exacerbation subsides and the function of the joint undergoes improvement, so that in exceptional cases we have what seems to be a cure. Certain pathological conditions, however, are usually still present in such cases, and they indicate that there has simply been a clearing up of the inflammatory process about the periphery of this focus, while the focus itself becomes larger, a cavity is formed, and we have caseation. In other words, death has taken place, and the products of the necrosis remain as a foreign body, so to speak, in close proximity to the joint. To carry out the analogy still further, we may state that under repeated exacerbations the focus in the lung becomes a large cavity, the pleura is involved by contiguity, and there develops a pleurisy with effusion. This marks a more advanced stage in pulmonary tuberculosis. In the case of the epiphysis something very similar takes place. Under the influence of repeated exacerbations the cavity becomes larger, the cartilage of incrustation is invaded, after a while the synovial membrane becomes involved, and we then have a tuberculous synovitis secondary to the epiphysitis. At the same time the external evidences of the underlying disease become more pronounced; one can get fluctuation, and, if an exploration is made, the fluid can be taken from the synovial sac, just as it often can from the pleural sac. As a still further evidence of the analogy between the two tuberculous processes, we may state that, similarly to what takes place in the pleural cavity, in which, when a perforation becomes established, we find a pyopneumothorax, demanding surgical interference, there develops in the joint a perforation of the synovial sac, and through this opening pus escapes from the original focus into the articular cavity, establishing a purulent tuberculous arthritis. It is by such a method of comparison that the teacher can easily make it clear to his pupils that in all essential respects the pulmonary and the articular forms of tuberculosis

manifest the same tendencies and behave in very much the same manner when they are subjected to the same conditions.

One advantage which the articular form of tuberculosis has over the pulmonary is to be found in the fact that, in the former, mixed infection is of less frequent occurrence. In the pulmonary form the air, which is a necessary factor in the production of mixed infection, constantly finds easy access to the parts; while, in the case of an articulation, the air, and consequently the mixed infection, can be introduced only in some unusual—that is, unnatural—manner. A tuberculous lesion in any organ, uncomplicated by mixed infection, is regarded by surgeons as much less virulent and easier of management. Before the days of aseptic surgery, such experienced surgeons as Billroth and Pirogoff advised that cold abscesses, which we now recognize as the product of a tuberculous process, be let severely alone, because they were convinced that, so long as air did not gain access to the parts, the case could be the better managed. At the present time these abscesses, if tapped for the purpose of examination of the contents, show absolute sterility. This statement is made with very little reservation, because the writer has had occasion to make a large number of such examinations and he has found that the exceptions are scarcely sufficient to establish the rule.

From the above it will be seen that tuberculosis in the early stages of its development is simple and uncomplicated. The complications enhance its value as a destroying agent.

As illustrating the prevalence of tuberculous diseases among children, the statistics of the Hospital for the Ruptured and Crippled for the last ten years show that, of 100,294 new cases coming under observation in the out-patient department, 52,462 were such as came under the care of the orthopedic surgeon, and 47,832 were classified under the heading of hernia. Taking the orthopedic figures as a basis for comparison, we find that 8,176, or 15.6 per cent, were tuberculous.

ORGANS MOST FREQUENTLY INVADED.

It is not an easy matter to state, with any degree of accuracy, the relative frequency with which the different organs are involved, but, so far as one may judge from statistics, it is safe to say that the lung is the organ most frequently affected. Next in order, I am sure, come the lymphatic nodes, and, following them, the epiphyses, which include the joints and bones generally.

The period of life is a predisposing cause, and tuberculosis is probably more frequent—at least as a disease which calls for active interference—in the bones and joints in child life than is pulmonary disease; and yet, at the same time, it is generally conceded that the lesion, as it affects the epiphyses, is secondary to that in the lung. As an instance of a very common mode of development in a case of tuberculous bone disease, I will quote the following: A child is nursed by

the mother for nine or ten months of life; then it is given one of the many proprietary preparations, and evidences of impairment of nutrition soon show themselves. A broncho-pneumonia develops and runs a varied course. At the start the disease in the lung manifests itself as an ordinary pneumonia, and for a time runs what is supposed to be a natural course; but some elevation of the body temperature continues, notwithstanding an apparent improvement in the general condition. A secondary attack follows, and some months later the child begins to limp or to show some stiffness in the back—symptoms of an early hip or spinal disease which startle us with their appalling suddenness. The diagnosis, despite these symptoms, is often not made until deformity arises, and then the connection between the previous broncho-pneumonia and the lesion in the hip or spine becomes apparent. The frequency of experiences like the above may be inferred from the fact that as many as three histories of a similar nature have been recorded by the writer in a single day. We are forced to the conclusion, therefore, that in childhood, as well as in adult life, the air passages are in all probability the portals of entry for the bacilli; and the statement recorded above must hold, as we believe, for all periods of life.

Whooping-cough, it should be added, is another common precursor of tuberculous joint disease in children. In analyzing, many years ago, eight hundred and sixty cases of joint disease, from an etiological standpoint, the writer found that in a large proportion the disease was preceded by whooping-cough or by measles. Now, as measles is known to affect the air passages quite as frequently as it does the skin, it is fair to assume that the bacilli have gained entrance to the lungs during an attack of measles. But more especially is this true in whooping-cough, in which disease, owing to the fact that the paroxysms have rendered the air passages vulnerable, the latter afford easy entrance to the tubercle bacilli.

In a certain number of cases the sequence of pathological events justifies the belief that a carious tooth has furnished the starting-point of the subsequent tuberculous disease. As an instance take the case of a physician, who suffered in early youth from frequently recurring attacks of toothache, always in the same region of the jaw. Then a fistulous opening formed, and for a period of several years he found that at almost any time he could, by pressing upon the gum below a certain tooth, force a drop or two of thick pus through a small, usually invisible opening at the junction of the tooth with the gum. During these years there were no manifestations of disease in any other part of the body, and the general nutrition, at best not very good, remained unchanged. Finally, at the age of twenty-four or twenty-five, he began to complain of pain in the lower part of his back, and in a short time there were unmistakable evidences that a tuberculous process had become established in one of the lower spinal vertebræ. It was only after the lapse of several years that healing of this focus of tuberculous disease was finally accomplished, the degree of deformity which it had produced being barely recognizable upon superficial investigation.

That the carious tooth or the resulting abscess of the gum served in this case as the portal of entry for the tubercle bacilli is rendered likely by the fact that, during the intervening years, there occurred no illness of any kind—pharyngeal, bronchial, or pulmonary—which might have prepared the way for the later Pott's disease of the spine.

A few years ago Koch made a statement, at a meeting of the British Medical Association, that bovine tuberculosis could not be transmitted to the human being, and *vice versa*. At that time he was unable to prove the former, but he had abundant proof of the latter. This dictum by so eminent an authority gave an immense amount of relief the world over, because it had been so freely stated that the milk of a tuberculous cow was capable of transmitting tuberculosis through the intestinal tract. Pathologists and clinicians, both in this country and abroad, set to work to disprove what Koch had stated, and up to the present time they have failed to furnish a satisfactory refutation. It remains, therefore, unproven that the milk of a tuberculous cow can produce in a human being genuine tuberculosis; but it has been pretty well established that milk from such a cow can produce in the intestinal tract a modified form of tuberculosis, or a bovine tuberculosis, corresponding closely to the old disease known as scrofula or struma, and there are enough instances on record to establish the facts that ordinary white swelling, say, of the knee, or common hip disease, can be developed from the bacilli in the milk of a tuberculous cow.

The diseases of the hip, knee, and spine just mentioned do not behave in the same way as does pulmonary tuberculosis, and it is very likely that the air itself, which comes so intimately in contact with the foci of tuberculous disease in the lungs, bears to them the various cocci which are capable of establishing a mixed infection. After the joint has been opened, either by the surgeon's knife or by nature, and has become exposed to the germs afloat in the air, we have a disease practically the same as that which exists in a tuberculous lung; viz., a mixed infection going on to rapid destruction of tissue, high body temperature, exhaustion, etc., with all the consequences, such as amyloid degeneration of liver, kidneys, etc. It is well, then, to bear in mind that, while tuberculosis, as it exists in one of the joints, is different from the same disease as it exists in the lungs, the articular lesions themselves may, through improper surgical management, become as serious an affair, just as great a disturber of the various bodily functions, as a pulmonary tuberculosis.

The lymphatics are so intimately associated with all phases of tuberculosis, and those of the neck play so important a part in the surgery of this region, that we may justly regard them as those parts of the body which most commonly exhibit an infection with tubercle bacilli. The importance, too, of an early recognition of such a tuberculous infection of the lymph nodes cannot be overestimated. Dowd, in a recent paper in *The Annals of Surgery* (July, 1905), reviews, along with other statistics, those of the first twenty years of the Jenner

Children's Hospital in Berne, as compiled by Demme; and he finds that in 145, or 21 per cent, of the patients who were affected with pulmonary tuberculosis, the disease first developed in the cervical lymph nodes. He also finds that 57, or 8.2 per cent, were affected with tuberculosis of the intestines; that in 24, out of a total of 692, tuberculosis developed in the pia mater; and, finally, that in 25 there was tuberculosis of the kidneys, and in 6 tuberculosis of the epididymis—a total of 29.2 per cent, as compared with the 21 per cent of cases in which the disease affected the cervical nodes. Dowd found the throat the most common portal of infection, viz., in 86 per cent of the cases. "The mucous membrane absorbs, the lymphoid material harbors, and the lymph channels carry the tubercle bacilli" (J. Wright).

It is often an exceedingly difficult matter to make a diagnosis between tuberculous lymph nodes and those affected with a simple process of hyperplasia; in fact, it is not infrequently necessary to extirpate the suspected node and then to subject it to a microscopical examination and to the test of cultures before one can determine the real nature of the disturbance affecting the node. Where suppuration exists, the diagnosis, of course, is easy. One must also differentiate the condition from a syphilitic lymphosarcoma and from a branchial cyst. In making a diagnosis, however, it is of great importance to investigate the mode of invasion, and to note, as favoring the presence of tuberculous disease, the extreme chronicity of the affection and the occasional slight rises in body temperature. In case of need one may resort to an exploratory incision.

After the cervical lymph nodes come the mesenteric nodes and the peritoneum. The studies of various abdominal surgeons have shown that tuberculosis of the intestines and mesentery is of frequent occurrence. William J. Mayo, of Rochester, Minn., reports that in St. Mary's Hospital, from October, 1894, to October, 1904, 6,408 abdominal operations have been performed, of which number 5,687 were intraperitoneal, and that, of the latter, 184 (3 per cent) were performed for some variety of tuberculosis. He found localized intestinal tuberculosis 21 times—13 primary and 8 uncertain. In 1,888 operations for appendicitis, tuberculosis of the appendix was found 29 times. The lymph nodes in the meso-appendix were often invaded. This surgeon also found tuberculosis of the Fallopian tubes 44 times without tuberculous peritonitis. Tuberculous peritonitis occurs much more frequently in the female than it does in the male, and Mayo attributes this to the fact that the Fallopian tubes are so often the seat of an independent tuberculosis. He further states (*Journal of the American Medical Association*, April 15, 1905, page 1158): "Tuberculosis of the intestine occurs in three forms: 1. Multiple ulcers, due to inoculation from sputum swallowed by tuberculous patients, which at once demonstrates the possibilities of intestinal infection. 2. Single or, at most, a few ulcers, usually in the ileum, which have a marked tendency to heal with stricture formation. Such cases

come to the operating-table with obstruction. 3. Conglomerate tuberculosis, usually of the cæcum at its juncture with the ileum, giving rise to tumor and having the macroscopic appearance of carcinoma. The last two forms are often, if not usually, primary and due to accidental inoculation." This author also states that tuberculosis of the vulva, vagina, and cervix is very rare, and is largely confined to young girls before puberty and to old women after the menopause.

It is well to remember a fact to which Dr. J. B. Murphy, of Chicago, called attention a few years ago, namely, that a close relationship exists between tuberculosis of the tubes and a general tuberculous peritonitis, for operations on the peritoneum fail frequently when the primary cause is not discovered. It is only a few years ago that peritoneal tuberculosis was regarded as beyond the pale of surgery. However, since 1902, when Ochsner, in a *résumé* of this subject read by him before the American Surgical Association, proved that laparotomy and evacuation of the ascitic accumulation exerted a beneficial effect upon the disease, much evidence of the incorrectness of this view has accumulated. It has been further established that in many cases a cure may be effected by a simple abdominal incision and drainage, and men are now seeking an explanation for the curative effects of operative procedures in this form of tuberculosis.

The male genital organs, such as the bladder, the testis, and the prostate come next in the order of frequency. While there are a few observations which seem to prove the primary involvement of these organs, the general impression prevails that they are only secondarily affected by tuberculosis. For instance, patients suffering from tuberculous hip disease or spinal disease have, after one or two years, developed tuberculosis of the testis, and later of the prostate.

As regards the kidney, liver, and spleen, it may be said that the kidney is more frequently involved than the liver or spleen. The same degree of insidiousness in onset is to be noted in these lesions of the organs just named, and diagnosis becomes an exceedingly difficult matter. This, however, is not the place where a detailed discussion of the difficulties experienced in making a diagnosis may properly be introduced. For this information the reader must consult the special articles in later volumes; the writer can only dwell in a general way on the symptoms and signs common to all tuberculous developments. While I shall make no attempt to outline the surgical procedures which may be employed to advantage in the management of the disease as it affects the organs just mentioned, I may be permitted to remark that local and constitutional measures should not be continued for too long a time, and that a practical surgeon should be called upon in all cases of doubt. There is no organ really within the abdominal cavity that is not comparatively easy of access, and current literature is full of the victories of surgery in this field.

COURSE OF THE TUBERCULOUS PROCESS.

Mention has already been made of the rate of progress of the disease. Thus, for instance, when the pia mater is once attacked, the disease quickly encroaches on the tissues bordering thereon, and pursues here a very rapid course. This, however, is not true of many of the organs. Take, for instance, the epiphyses. One seldom regards an acute epiphysitis as tuberculous; in infancy it is usually an acute infectious process, and the parts are filled with streptococci and staphylococci. But when once the bacilli of tuberculosis are lodged in the epiphysis, they seem to select for their abiding-place one or two of the centres of development. It has been supposed that the predilection of the bacilli for this locality is due to the fact that the blood supply in this region is, at this stage of development, quite abundant. The process of destruction advances very slowly and is marked by exacerbations. These exacerbations are very important in their relation to the question of diagnosis. If one, for instance, is careful in obtaining the clinical history of a case of hip disease, he will find that there was a slight exacerbation at the outset. The child cried out at night as if in pain, the limb was drawn in slight muscular spasm, but not enough to waken the child from sleep. Such a night attack is usually preceded by a little lameness or unsteadiness in gait; and these signs, taken in connection with the pain at night and the little stiffness, constitute what is known as an early exacerbation. If at this time the child should get a slight fall or tumble, sharp pain may follow within a day or two, and naturally the mother looks upon this trauma as the cause of the disease. The physician, however, keeping in mind constantly the etiology of tuberculous disease, will not be misled by the mother's suggestions. He will understand that the slight weakness or disability caused by the presence of the bacilli in one or two of the centres of development of the epiphysis, or on the distal side of the diaphysis, will account for the fall, and the latter in turn, it may be assumed, will act as an exciting cause of an exacerbation. A little dexterity in cross-examination will bring out these points in nearly every instance. On the subsidence of the exacerbation there will be a recrudescence of the hyperæmia or congestion about the foci of disease. Weeks or even months—the writer has known this period to extend into one or two years—may elapse before another exacerbation, induced in the same way by trauma, occurs. Some argue that these remissions may be prolonged by improved nutrition, and that even slight traumata will exert no influence; but, in the experience of orthopedic surgeons, good nutrition and the greatest amount of care on the part of the nurse or attendant are inefficient factors in warding off exacerbations. Protection to the joint has long been regarded as about the only way of limiting the disease in its progress; and sometimes the most perfect protection fails, and exacerbations occur with annoying frequency. It is not, however, among the cases in which the joint

has been properly protected that one must look for a natural history. A common type of history will read about as follows: The first exacerbation, rather slight and of short duration, was followed by very good use of the limb, and there was little impairment of function; the second and third ones, which were separated the one from the other by an interval of a few weeks, were sharper and lasted longer—say, from one to two or three weeks. Even after these exacerbations the limb remained, as is often the case, in a very good position, and the gait was only slightly impaired. Later, still other exacerbations followed, and it was easy to note that these later exacerbations had left the limb more and more crippled, the deformity being in the direction of flexion and adduction. After a while, as the original focus of disease enlarged and encroached upon the joint, perforation finally took place, and there was established a cold abscess. A similar history may be obtained in the case of tuberculous ostitis of the knee—common tumor albus, or white swelling; and the same statement is true of tuberculous disease of the ankle, shoulder, and other joints. It will be seen, therefore, that the destructive process may continue for from three to five years. The writer found, in his analysis of eight hundred and sixty cases already referred to, that the average duration of tuberculous bone disease was about three and a half years. The cases from which this analysis was made were treated on the purely expectant plan, and no means were ever employed for preventing trauma or for controlling the exacerbations induced by the trauma. In other words, they ran a perfectly natural course, and it was from this study that so much was learned about the normal course of tuberculous disease involving the bones and joints.

In the spinal column the progress is also slow and marked by exacerbations. The bodies of the vertebræ are made up of cancellous tissue exactly like that of the epiphyses, but the joints involved are different from those of the hip, knee, or ankle. The intervertebral discs separate the bodies, and the joints are of the simplest kind. When the bacilli gain access to the medullary canal, the tuberculous disease advances more rapidly and does not depend upon traumata for exacerbations. The tissues involved are more intimately connected with the blood-vessels and lymph channels, so that the process is naturally more acute and terminates either in destruction of life or in the old-fashioned "bone abscess." In the former instance life is terminated usually by general involvement, such as acute miliary tuberculosis. A child, for instance, who has a tuberculous osteomyelitis develops more frequently tuberculous meningitis than one who has a simple tuberculous epiphysitis. This has been the experience of the writer. With this knowledge, one would naturally feel it to be his duty to interfere promptly, and this explains why surgeons regard osteomyelitis as a disease that is not to be trifled with by expectant therapeutics. If the process is mild, then surgical measures are not called for until a later period, when signs of an abscess in the centre of the bone have developed. These bone abscesses are so often

overlooked that for a long time, amounting sometimes to years, treatment suitable for rheumatism, for syphilis, for periostitis, or even for sarcoma, may be carried on. A close study of the case ought to enable one to reach, at an earlier stage, a diagnosis of the true nature of the disease. A cold abscess in the upper third of the tibia, or in the femur, or in any of the long bones is not unlike a cold abscess in the soft parts, except that it is more difficult to recognize. When such an abscess is located in the bone, we have localized pain, boring in character at times, and tenderness on deep pressure, but without any enlargement of the bone itself. In periostitis there is enlargement. In a sarcoma we have enlargement. Rheumatism involving the bones alone is not recognized by clinicians. Hence, if we are at all in doubt, we may resort to the x-ray and to exploration. The x-ray will show a single light spot, rather than multiple light spots, as in the case of sarcoma, and a drill thrust into this light area will determine the presence of pus.

The sheaths of tendons, more particularly those of the forearm, but also at times those of the lower extremities, are not infrequently invaded by the bacilli of tuberculosis. The resulting process in such cases is slow in development, and it is characterized by occasional exacerbations and especially by the presence of small bodies, which, under the palpating finger of the examiner, feel like grains of rice.

Enough has been said concerning the slow progress of the disease now under consideration to give one a fair idea of the rate of development and of that essential characteristic—*persistence*.

DIAGNOSIS.

In a general way syphilis in its various manifestations, tumors of all kinds, benign or malignant, and deformities resulting from contusions or incomplete fractures are to be differentiated from tuberculosis. A detailed, painstaking history of the case, a knowledge of the lesions of these different diseases, and a careful local examination, not only of the parts involved, but also of the same parts on the other limb, will enable one to make a reasonably sure diagnosis.

The failure to make a correct diagnosis is generally due to a slovenly habit of not thoroughly examining the parts and testing the functions by a comparison between the sound and the affected limb. A good physical diagnostician familiarizes himself with the functions of the lung in every part; he compares the two sides. A good surgeon, in looking for a fracture or a dislocation involving a joint, tests the functions of the joint under consideration as well as the corresponding normal joint. He studies the contour, takes measurements, and refreshes his anatomical knowledge on the spot. So in disease involving ends of bones and joints, he should take advantage of what nature has provided him, viz., the same joints and bones on the opposite side, by examining which he can

make instant comparison. Patients do not object to the little exposure necessary for a thorough comparative examination.

The nature of the lesion is very often overlooked by a failure of the physician to make a careful examination, not only of the parts affected, but of the functions belonging to the parts involved. Take, for instance, the hip. It is generally possible to examine the other hip, for it is only in exceptional cases that both hips are involved. It is a common error, in making such a test of the functional integrity of a joint, to move the hip about in such a manner as not to complete any one movement. The examiner is very apt to rely on palpation and on the pressing of the joint surfaces together, while he ought to know that in the early stages of the disease the joint surfaces are not involved. Then, again, the parts are usually examined with the removal of very little clothing, whereas the physician who undertakes to make a diagnosis of a lesion of the joint should have every particle of clothing removed from both lower limbs. The examination should be made upon a table with very little covering over it. Measurements should be employed, so that one may learn accurately whether atrophy has, or has not, taken place as a result of disease involving the nerve supply. The tests should be applied to the sound limb first and then to the affected one. Any little difference in flexion or extension, in abduction or adduction, or in rotation, should be noted. The gait should be carefully observed, and so also should the position of the limbs in sitting or in standing. If, after all these tests have been made, the surgeon is still in doubt, let him sit down patiently and get a history of the invasion, a personal history of the child, its habits of feeding, the kind of food it has had, etc. With this knowledge in his possession, and with a knowledge of the functions of the joint in the vicinity of which the lesion is believed to exist, he should have no special difficulty in making a diagnosis. As another example, let us take the spinal column. In testing the mobility of this part of the human frame, the surgeon should make the patient perform all the motions which the spinal column is normally capable of making. It is assumed, of course, that he himself is familiar with the normal action of this structure; but if he is not sure that he possesses this knowledge, he should apply the tests to himself, or, better still, to a healthy individual of the same age as the patient. He should also remember that reflex spasm may exert an important influence on the degree of mobility of the spine—and, indeed, for that matter, on the mobility of the hip, the knee, or any other joint of the body. The existence of such spasmodic action may be interpreted as favoring the diagnosis that a lesion exists in the body of one of the vertebræ, in the case of the spinal column, or in an epiphysis, in the case of the knee or hip joint. The patient's gait in walking also affords valuable aid in determining the presence or absence of anything abnormal in the condition of the spinal column.

The tuberculin test has not proven of great value in the hands of the writer of this article. Time and again, at the Hospital for the Ruptured and Crippled,

we have employed tuberculin for diagnostic purposes, but the bone and joint le-
sions were so manifest and were so often complicated by bronchial lesions that
the tests were inconclusive. From a study of the literature one gets very little
encouragement, and yet, where a diagnosis is impossible by means of a clinical
history and a thorough physical examination, one would naturally resort to the
use of tuberculin. It should be stated, however, that some orthopedic surgeons
claim that a diagnosis can be made in tuberculous lesions in the early stages with-
out the aid of tuberculin.

Finally, if a diagnosis cannot be made by any of the methods already men-
tioned, recourse may be had to an exploratory incision, which will render possible
an actual examination of the tissues. This is rarely called for, however, and
then only when there is a suspicion of malignancy; but even here the history of
the case usually suffices for the determination of the truth.

So far as the various acute lesions are concerned, there should be no special
difficulty in differentiating them from tuberculous disease, which is so markedly
chronic in its nature.

TREATMENT AND SURGICAL PROCEDURES.

We come now to the therapeutics of tuberculosis by surgical means. Given
the knowledge of the behavior of the bacilli in the different regions already men-
tioned, the slow mode of development, the destruction of tissue after tissue by
continuity and contiguity, it now follows that rest to the part in the early stage
is of great importance. The physician whose life has been spent in the manage-
ment of pulmonary tuberculosis often longs for some means of giving rest to a
part of the lung involved, or the whole lung, and he is inclined to envy the sur-
geon who has much to do with tuberculous bones and joints. In the case of the
lymph nodes, pressure, which secures rest to the parts, is often employed with
decided benefit. In bones and joints one feels that if the joint can be kept abso-
lutely immobile, the process in the adjoining epiphysis will the sooner subside
and the joint itself be saved from involvement.

After rest and protection come operative procedures, such as the removal of
the focus, as soon as it has been located by clinical signs and by the x-ray; the
evacuation of abscesses in an absolutely aseptic way, in order that their con-
tents may remain sterile for as long a time as possible; the correction of de-
formity by manual force, by mechanical means, and by the free use of the knife
and chisel. The writer has had more experience in the management of bones
and joints than he has in the treatment of the other parts of the body which
are directly invaded by the bacilli, and he therefore hesitates to discuss the
surgical treatment, for instance, of lymph nodes, or of abdominal tubercu-
losis, or of the brain or the special organs. He does not hesitate, however, to
recommend the removal of foci in the neighborhood of joints at as early a date

as possible after it has been shown that rest and protection, combined with the advantages which climate and change of air give, cannot arrest the disease. The great aid which orthopedic appliances afford in the management of bone tuberculosis is to be found in the fact that they enable the patient to secure a change of climate and of air—important factors in limiting the ravages of the bacilli. Improved nutrition and a regular mode of living tend to increase the vital resistance of the tissues. Now if we select a time when the vital resistance has been raised to the highest pitch, and during this period are able to remove, by operative measures, the entire focus of tuberculous disease before the bacilli have reached some important joint or some vital organ, we shall in many instances secure results of the highest value. In the case of the spine the problem is much more difficult to solve. Spinal operative surgery is still in its infancy, and, while the focus of the disease in the spine may be reached and perhaps the greater part of the diseased bone removed, it is nevertheless almost impossible to destroy all the bacilli. Then, besides, it is hard to keep up fixation apparatus during the reparative process, and as a result we often have extension of the disease to the meninges or the thoracic or abdominal viscera.

A question of great interest is, How far can surgical treatment modify the various forms of surgical tuberculosis? As an answer to this question it may be said that prompt measures will either stay the progress of the tuberculous disease or completely remove it. The focus of the disease, even when it is located in some important region, like the brain, a lymph node, or the testicle, is not always of itself a very serious matter. The chief danger, inseparably associated with such a focus, lies in the fact that from it tubercle bacilli may push their way into the neighboring tissues or organs, and do a great amount of damage or even cause the patient's death. So long as a process in the lung, for example, can be kept from spreading, repair will take place about this focus, and a cure may in this way be effected. There are many instances where a focus has been thus walled off in the epiphysis, and has remained there, as a harmless foreign body, for fifteen or twenty years. One, of course, realizes that "an empty house is better than a poor tenant," that it would be better to get rid of this mischief-making focus; yet, if the danger of removal is greater, then surgery need not interfere. But surgery is becoming so precise and a surgeon's armamentarium is so complete, that harmless explorations may be made, and even the contents of a focus be removed through a comparatively small opening. Then, again, with the modern means of rendering parts aseptic, mixed infection ought to become practically a thing of the past.

There is one product of tuberculous disease that has proved a stumbling block, not only to the operative surgeon, but to the orthopedic surgeon as well; I refer to what is known as the cold abscess. In adult life or in child life this variety of abscess is comparatively harmless so long as it is not complicated by mixed infection. The operative surgeon is often inclined to resort to a free incision

with the knife and to complete eradication of the abscess with scissors and spoon, believing that he will be able to avoid the danger of infection in the subsequent dressings.   Nevertheless, no matter how careful he may be, the wound sometimes leaks, the sac refills, and ultimately there develops a sinus which requires a long time for healing.   The author of this article has had a varied experience in the management of these abscesses, and he feels that the question of how best to manage them is not yet settled.   He relies on aspiration, so long as the contents can be evacuated through a large needle.   If this procedure is found to be impossible, owing to the presence of broken-down material in the fluid, a very small incision may be made and the contents of the abscess squeezed out; after which the opening should be promptly closed, by a sterile pad and adhesive strips, by the application of collodion, or by means of a kangaroo suture. One must be very careful, however, not to make the incision too large nor to use the curette or one's finger.   Notwithstanding the enormous amount of testimony that is to be found throughout surgical literature in favor of using the iodoform emulsion in the treatment of these cold abscesses, orthopedic surgeons in general are not disposed to commend the procedure.   That an abscess should be limited in its area is very important; the burrowing between muscles and fasciæ in the neighborhood of vessels should not be permitted.   The abscess frequently disappears under simple protective treatment and rest to the parts.   This fact should not be lost sight of.   The surgeon is justified in regarding a cold abscess with indifference so long as it shows no signs of encroaching upon the joint, and so long as it does not invade vital tissues or organs—such, for instance, as the femoral vessels and the chain of lymphatics in this region. Even in Scarpa's space or in the popliteal space a cold abscess may be left alone, if it shows no tendency to increase in size.   If one must interfere, let aspiration be employed first, repeatedly; then small incisions; as a last resort, one may make an incision large enough to lay bare the track as far as to its source and to remove all the tissue which has been invaded by the bacilli.   Conservatism, however, should characterize the surgical treatment of tuberculosis when it involves the bones and joints.

Excision or resection of the joint has played so important a part in the surgical treatment of tuberculous disease that some reference to the subject must be made in the present general survey.   During the last two decades the knowledge of tuberculous disease, as it comes under the observation of the surgeon, has made a great advance, and as a consequence local foci are now discovered much earlier than they formerly were, and the natural course pursued by a tuberculous process is much better understood.   As a further result of this increase in knowledge, cures are more frequently recorded and there has been a marked falling-off in the number of excisions performed.   In other words, the disease now only exceptionally reaches those advanced stages in which the operation of excision is called for.   On the other hand, this operation is still frequently performed for

the purpose of enabling the patient, an adult, to return to work; for an excised knee, in a laboring man, is infinitely superior to one which is only partially cured and which is capable of performing only limited movements. In the case of patients in other walks of life, a small range of motion is better than no motion, because there is always the hope that this range may be increased.

PROGNOSIS.

The prognosis in any given case depends largely upon the degree of thoroughness with which the treatment is carried out. Incomplete surgical measures are of little value. On the contrary, they should be discouraged. A fatal issue is the exception in the tuberculous lesions of nearly all the organs that have been considered in this article. The lung itself heads the list in mortality. A good prognosis should mean—in the case of a tuberculous joint disease, for example—a stable limb in good position for sitting or standing, with complete arrest of disease, whether the focus has been removed by operation or in the natural way (*i.e.*, through the formation of an abscess and afterward of reparative tissue). Cicatrization naturally takes place around a healed focus, and, if the destructive process has extended to the joint, we have the capsule and the ligaments all more or less shortened, and in some instances a subluxation or a luxation is present. Surgery, of course, should not only prevent an extension of the disease, but it should also relieve deformities, and the time is close at hand when, we feel assured, it will remove ankylosis, which is one of the unfortunate results of the tuberculous process in the neighborhood of a joint. In tuberculosis as it affects the spinal column, especially the dorsal region, the results, while not fatal, are frequently very distressing. The chest walls are changed, breathing is impaired, and important abdominal organs are crowded upon by the shape of the ribs and by the bosse. There is also one other residual trouble which is sometimes observed in these cases; I refer to the various forms of intercostal neuralgia, which are so persistent in old deformities of the chest and spinal column, and cause the patient so much distress.

SYPHILIS, FROM A SURGICAL STANDPOINT.

By EDWARD L. KEYES, Jr., M.D., Ph.D., New York City.

SYPHILIS requires a surgeon's diagnosis, but rarely a surgeon's treatment; for, though this protean disease simulates very closely many surgical disorders, it has few truly surgical complications.

In its earlier stages syphilis interests the dermatologist, the laryngologist, and the internist almost exclusively; but, in the later years of its course, it produces lesions of a character more destructive and less typical, and these lesions often resemble similar processes, neoplastic or tuberculous in character—processes which, if syphilitic, usually require medical treatment; if tuberculous, may require surgical treatment; and if neoplastic, are purely surgical. In exceptional instances, however, and notably in late bone syphilis, the destruction of tissue by syphilitic inflammation may be such as to require surgical interference; *e.g.*, for the removal of dead bone.

Thus, the earlier and more characteristic manifestations of syphilis interest the surgeon only indirectly; *i.e.*, only inasmuch as a knowledge of the nature of syphilis and of its earlier and more typical expressions is essential to the understanding of its later and less typical manifestations and to the differentiation of these from other surgical diseases.

Hence it seems proper to begin with a discussion of the nature of syphilis, to proceed with a consideration of its characteristics as an acute disease, and then to investigate more minutely the local forms of the disease that enter directly into surgical practice.

Syphilis is apparently divisible into three stages, and, since the time of Ricord, it has been customary to speak of primary syphilis, manifested by the occurrence of a lesion at the site of inoculation and the enlargement of the adjacent lymph nodes; of secondary syphilis, manifested by lesions that are, generally speaking, diffused, superficial, and infectious; and of tertiary syphilis, with lesions localized, grave, and not infectious. And it has been generally conceded that these three periods of the disease follow in succession, one upon the other, with more or less distinct periods of incubation.

Such a division is useful from a clinical standpoint, but it is impracticable as a hard-and-fast rule of theory or of practice. For the patient may have syphilis, though he escape any one of the three stages of the disease. Thus, of all cases, not more than twenty or thirty per cent reach tertiary syphilis. Children with

inherited syphilis never have a primary lesion; and there are a very few cases recorded in which, though the patient had an indubitable chancre and years later had tertiary manifestations, yet the closest scrutiny failed to discover any secondary symptoms.

Moreover, the periods of the disease are often confused in point of time. Thus the *tertiarisme d'emblée*, upon which French writers insist, merely means that grave, localized, tertiary lesions sometimes occur while secondary lesions are still manifest upon the body or even before these secondary lesions appear.

This apparent confusion of the types of the disease is, however, in reality not a confusion at all, but simply an indication that syphilis—be it primary, secondary, or tertiary—is still syphilis, and that the reasons why there are three types of the disease, and why the patient usually progresses with a certain regularity from one type to the other, are to be found in the fact that most people react to the virus of syphilis in a given way. Hence, although a relative immunity on the part of the patient may reduce the symptoms to almost nothing, or a relative vulnerability may permit exceptional, grave, tertiary lesions to appear early in the disease, the progress of the usual type and these variations of unusual type arise from qualities of the patient's constitution, and not from any difference in the syphilitic disease with which he is infected.

Up to the present time the cause of syphilis has not been discovered. Whether the Treponema pallida (Spirochæta pallida) of Schaudinn or the Cytorrhyctes luis will prove to be the infectious agent is by no means certain as yet. The former is, at the moment of writing, a very strong claimant whose pretensions, we can but hope, may prove valid.

Until the exact nature of the infectious agent in syphilis is known, the present divergence in the opinions of the best authors upon many important questions of the duration, the inheritance, and the infectiousness of the disease will doubtless not be entirely resolved. At present, we have only clinical facts and scientific analogies to guide us in our interpretation of the phenomena of syphilis; and how misleading such analogies may be is nowhere more clearly shown than in the history of the opinions held concerning this disease.

Syphilis is certainly an infectious disease, and, by analogy, we may assume that it is caused by some living agency, some animal or vegetable parasite. As in all infectious diseases, there is a period of incubation between the time of inoculation and the first evidence of the disease. Then follows a lesion, often characteristic, at the point of inoculation; afterward comes a period of relative calm, during which the patient manifests more or less marked evidences of systemic intoxication; then a period of secondary lesions. After this, it is impossible to generalize. The varying influences of constitution, habit, and treatment so modify the further course of the disease that a general rule cannot be laid down. Many persons have no further symptoms, while others go on through a varying course of greater or less malignancy.

The most singular and confusing qualities of syphilis are those manifested in the so-called tertiary lesions and parasyphilides, and in the transmission of the disease by heredity. Were there no tertiary syphilis, the theory of the disease would be much simpler. The secondary lesions, whether lasting only a few weeks or several years, are all evidently acute, infectious manifestations of a disease comparable in a general way to the other exanthemata. After a certain length of time they cease to reappear, and if, after the lapse of five years, they do not recur, the acute infectious disease may be regarded as ended.

But tertiary lesions are amenable to no such law. Perhaps they do not appear at all: perhaps they occur in great profusion within six months of inoculation: perhaps an interval of ten, twenty, or thirty years elapses, during which the patient is apparently in perfect health, and at the end of which—for no obvious reason—a characteristic, tertiary outbreak occurs.

Certain facts in relation to the inheritance of syphilis would make it seem probable that the disease may be infectious even at this late period. It is true, experimental inoculations from tertiary lesions always fail, and, clinically at least, these lesions are not inoculable. But it seems highly probable that the bacterial cause of syphilis—if it be a bacterial cause—is still present in the bodies of those persons who continue to have tertiary lesions, although, fortunately, it is not transmissible by the secretions of these lesions to other persons.

This quality of syphilis—to be apparently cured and yet to break out again after an interval of many years—is comparable to the similar quality of tuberculosis, with this great difference, however, that, in the case of tuberculosis, the recrudescence of the disease is usually a lighting-up of an old focus, whereas, in syphilis, it is impossible to say where the disease lies hid during the period of its quiescence.

An allied mystery is furnished by those lesions which Fournier has appropriately termed parasyphilides. Chief among these stand locomotor ataxia and paresis. So often do we obtain a history of previous syphilis from those suffering from these diseases that one is tempted to believe that every patient suffering from ataxia or paresis has had syphilis. Yet the treatment by mercury and the iodides, so successful in purely syphilitic conditions, produces meagre and unsatisfactory results here. Add to this the fact that in certain oriental countries, in which syphilis is endemic and afflicts seventy or eighty per cent of the population, ataxia and paresis are practically unknown, and we are forced to the conclusion that, while syphilis is commonly a partial cause of these diseases, it is not the sole cause, but requires certain other elements of modern life—such as excesses in alcohol or in nervous strain of one sort or another—to produce them. We need not go deeper into these questions here. They do not directly concern the subject, but are of interest only inasmuch as they demonstrate those mysterious qualities which make syphilis unique among diseases and for the explanation of which we await the discovery of its cause.

INFECTION, IMMUNITY, AND HEREDITY.

The clinic proves that man acquires syphilis by contact of the secretions from a primary or a secondary syphilitic lesion, or perhaps by contact of the blood serum of a recently infected patient with some part of the body bereft of its normal epithelial protection. Thus, the sole protection against infection with syphilis is the possession of skin and mucous membranes absolutely intact. The virus may be deposited upon such integument without harming its possessor, but the least abrasion or ulceration makes him vulnerable to the syphilitic virus.

Hence syphilis is essentially a venereal disease only because sexual intercourse provides the commonest exposure to this combination of circumstances; *i.e.*, a concealed or unsuspected syphilitic ulceration in the vagina or the urethra on the one hand, and the possibility of an abrasion on the other. As a matter of fact, syphilis is not inevitably contagious, as is constantly shown by the fact that, of several men cohabiting with a single syphilitic woman, not all—perhaps less than half—acquire the disease. But, when the disease is once acquired, no therapeutic measure can guarantee its eradication from the system. Thus, in a number of instances, patients have recognized abrasions upon the genitals, and have, within twelve hours of a suspected intercourse, consulted a physician and submitted to thorough cauterization of the abrasion, without preventing the disease or in any way modifying its ravages. A chancre develops at the point of inoculation in due time, quite as certainly as though cauterization had not been performed. Similar results have followed excision of chancre. Although a few syphilologists continue to practise this operation under the impression that the subsequent course of the disease may thereby be somewhat modified, a long array of clinical records to the contrary has led most clinicians to the conclusion that such a practice, though theoretically admirable, is practically futile. From these observations it follows that the syphilitic virus is never confined to the chancre, that by the time this appears the virus has spread throughout the system, and can no more be aborted by excision of the chancre than it can be at a later period by excision of a gumma.

Syphilis, however, is never a venereal disease except in its method of acquisition, and often not in this. Surgeons constantly acquire digital chancre in the vaginal examination of syphilitic women, and it is unhappily not uncommon for the innocent girl betrothed to a syphilitic young man to acquire from the virulent mucous patches in his mouth a chancre upon her lip, tongue, or tonsil.

Moreover, apart from these direct modes of infection, the disease may be conveyed by contact with any article upon which remain the moist secretions deposited from a syphilitic lesion. Thus, forks and spoons and drinking-cups have often carried contagion. Washerwomen have been infected from soiled linen, and the careless use of a dirty Eustachian catheter or dental instrument

has set up little epidemics among the unfortunate patients of the negligent practitioner.

With such widespread possibilities for the dissemination of infection, it is only wonderful that the conveyance of syphilis to the innocent is not more general. Happily, however, it would seem that the lapse of a few hours suffices to destroy the potency of the virus. We commonly see patients, whose mouths are filled with virulent mucous patches, eat and drink among their fellows without spreading the disease, simply because the utensils that enter their mouths are washed and dried before being used by some one else at a subsequent meal.

In this very important question of the limits of mediate contagion, we are again baffled by our ignorance of the cause of the disease, as well as by the impracticability of making inoculation experiments to define these limits accurately.

Although syphilis has apparently been transmitted to the ape and perhaps to other animals, the results of animal inoculation have been always confusing and usually entirely negative. Syphilis, like laughter, would seem to be the prerogative of man.

Another reason why syphilis is not more widespread is that the normal secretions from the body of the most virulent syphilitic patients are entirely innocuous, unless contaminated by the secretions of a syphilitic sore. Thus, inoculation has proven the innocuousness of the tears, the milk, and even the seminal fluid.

It is doubtful, however, whether any one has an absolute immunity from syphilis. Possibly the large pox, like the smallpox, is not universally noxious; but no evidence has been adduced to prove this, and it is unlikely that such evidence will be procurable in the future.

In the days when the unity or the duality of chancre and chancroid was a subject of hot contention, it was believed by some that artificial immunity to syphilis might be acquired by repeated inoculations with chancroid. Under the spell of this delusion many futile inoculations were performed, of which the cases of Lindmann, Warner, and Danielssen are still remembered. The two former succeeded in giving themselves syphilis after many inoculations with chancroid, while the last, more circumspect, produced the same result upon another man.

A much more recent delusion is that first enunciated by Profeta and known as his law; namely, that the healthy child born of syphilitic parents is immune to syphilis. A number of indisputable cases—many of them showing post-natal infections from the kiss or the fondling of either parent—prove the fallacy of this so-called law.

Yet there is one way to be immune to syphilis, and that is by being syphilitic. After all, it is only fair that, since the man who once acquires syphilis can never be absolutely assured that he has seen the last of it, he may at least receive the very mild consolation that he cannot acquire it a second time. It is true there are some thirty recorded and apparently authentic cases of a second attack of syphilis; but these, in view of the grave possibility of error in such a

diagnosis, and in view also of the close scrutiny to which so many patients are annually subjected in the vain hope of discovering such an exception to the general rule, must be regarded as the most exceptional freaks of fortune.

The inheritance of syphilis, so obvious as a fact, has evoked an extraordinary number of conflicting theories. Certain clinical facts concerning hereditary syphilis may be easily determined by any one. Thus, the disease in the child is obviously the same as the disease in the parent; its manifestations are truly syphilitic and truly infectious. The child, however, shows no chancre, and the course of his disease is intensified by the well-known vulnerability of embryonic tissue to infection. It is the rule that, when a man in the active primary and secondary stages of syphilis marries, he infects his wife with the disease and their children are born syphilitic. Yet the wife may escape infection; and, even though husband and wife be both infected, the child may escape—an unusual but brilliantly demonstrative example of this exception being the birth of twins, of whom one is syphilitic, the other not.

On the other hand, in about twenty or thirty per cent of cases the mother of the syphilitic child is apparently not diseased. Yet, even in these cases, the mother may nurse her child, even though it have mucous patches in its mouth, without becoming infected; although, if the child be put to the breast of a non-syphilitic wet-nurse, she exhibits a chancre of the nipple in due time.

This rule, that the syphilitic child cannot infect its own mother, is known as Colles' law. The few alleged exceptions to it have been recently shown by Matzenauer to be without foundation.

Finally, it is generally recognized that the apparently uninfected but immune mother of syphilitic children may herself in after years develop the characteristic lesions of tertiary syphilis.

Here, then, is a beautiful combination of facts to set one thinking; and, unfortunately, the first German to apply to this subject the machinery of modern Teutonic precision and research was Kassowitz, who, from an exhaustive investigation, concluded that syphilis could be inherited from the father alone without infection of the mother. This doctrine, fortified by much clinical evidence, is generally accepted, but has involved its adherents in many difficulties.

In order to explain the immunity of the mother many beautiful theories were evolved, of which the most ingenious is that of Finger, who asserts that maternal immunity is due to the transmission of toxins from the infected foetus, and that the subsequent development of tertiary lesions, noted so frequently, is caused by the action of these toxins.

The French school has preferred to apply to the maternal condition the term "*choc en retour*." Instead of accrediting foetal syphilis to syphilis of the mother, they believe that the father can infect the child, and the child in turn infect the mother. But new light has been shed upon this subject by Matzenauer's work, " Die Vererbung der Syphilis." By reviewing *de novo* all the original docu-

ments, he has apparently been able to show that the constant maternal im-
munity, according to Colles' law, depends upon nothing less than the fact that
the mother of a syphilitic child is herself always infected, that infection from
the father alone cannot occur, and that infection of the child from the mother
occurs by the transmission of the disease through the placenta.

The confusing fact most difficult to reconcile with this theory is the apparent
health of so many mothers of syphilitic children. In this regard, however, two
facts must be borne in mind: First, that all women are relatively immune to
syphilis: they suffer comparatively less from the disease than men do. This rela-
tive immunity cannot be wholly explained by the fact that women suffer less
from nervous strain or physical dissipation than the stronger sex. For the nerves
of syphilitic women are certainly quite as racked as those of men, and they often
equal in dissipation their male compeers. Yet the fact remains—women usually
suffer little from the disease. In the second place, while it has frequently been
noted that women who bear syphilitic children themselves show no evidence of
syphilis, it has been noted in an almost equal number of cases that in later years
these mothers showed tertiary lesions. This is the so-called *choc en retour*—a
hypothetical infection of the mother by the syphilitic child.

Matzenauer has shown that, while the general estimate of syphilis inherited
from the father without maternal taint is about twenty-eight per cent, the esti-
mate of *choc en retour* is about twenty-three per cent: whereas many authors
state flatly that every mother of a syphilitic child is infected by it if she escapes
infection from the father—a theory which merely goes to show how far around
the bush one will reach to explain an accepted theory.

INHERITED SYPHILIS.

Inasmuch as inherited syphilis interests a surgeon but little, it demands only
a brief description here.

The transmissibility of the disease from mother to fœtus seems to extend to
a much later period than does its transmissibility from one adult to another.
It is thus a rule, with few if any exceptions, that the disease ceases to be trans-
missible by contact after the first four or five years, or even earlier: whereas the
only lesions from which such transmission is possible seem to be the early, super-
ficial, so-called secondary lesions.

On the other hand, there are numerous instances of the transmission of syph-
ilis from mother to fœtus years after the beginning of the disease, years after
all other signs of the disease have disappeared from the mother. If it be sup-
posed, however, that conceptions follow fast upon inoculation, one upon another,
the general rule is, that the product of the first one or more fecundations is de-
stroyed by the disease within a few months, and the mother aborts a dead fœtus.
With the lapse of time the disease seems to affect the fœtus less and less, so that

we see the abortion of a macerated three or four months' foetus, followed by abortions at six or seven months, and these again by the appearance at full term of syphilitic children which die of the disease soon after birth, to be in turn followed by children still syphilitic, but which survive; until finally—perhaps not until ten or fifteen years after the beginning of the disease—the mother produces healthy, non-syphilitic children.

Such a condition, though typical, is apparently exceptional. The syphilitic mother, though not treated, may never bear a syphilitic child; may bear healthy children either before or immediately after others gravely infected. As a rule, of course, the mother submits to treatment, and the further production of syphilitic children is thus promptly cut short.

It is interesting to note, by the way, that Matzenauer suggests the only adequate explanation of the progressively diminishing virulence of infection in successive offspring: not, as has been commonly supposed, the diminished virulence of the syphilitic virus in the parent, but the diminished intensity of placental inflammation.
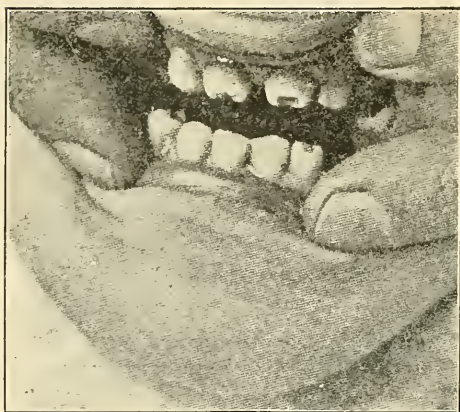
Fig. 24.—Characteristic Dental Malformation in Hereditary Syphilis. (" Hutchinson's teeth.")

When a child infected with syphilis comes to term, it usually shows evidences of the disease either at the time of birth or within a few months thereafter. It then manifests symptoms characteristic of the secondary stage of syphilis, but shows cachexia much more marked than that habitually seen in the adult. The infant is wizened and marasmic. The first characteristic evidences of the disease to show themselves are usually mucous patches in the nose and mouth and about the genitals and in all other natural folds, and more or less generalized secondary eruptions over the skin. Exceptionally, the disease may appear in a mild and misleading form. Thus, osteochondritis and osteophytic changes may dominate the picture and simulate surgical disease. These bone conditions are not essentially hereditary, but due only to the fact that the disease is acquired at an early age, while bone formation is still actively progressive; hence the discussion of them had best be taken up in the consideration of bone syphilis in general.

If the child escapes these early manifestations, he is likely to develop with a typical facies—a square countenance, prominent cheek-bones, bulging forehead, and sunken nose-bones, while the teeth are irregular and of defective quality. The two upper permanent incisors are likely to be notched and small in all their diameters, and to have crescentic indentations in their cutting edges.

Such teeth (Fig. 24) are spoken of as "Hutchinson's" teeth. Interstitial keratitis is also common in inherited syphilis.

In those exceptional cases in which the disease does not develop until later in life—sometimes not until the child is eight or ten years old—the lesions then manifested are those of tertiary syphilis.

The French school is inclined to attribute all sorts of deformities to hereditary syphilis. Indeed, almost every congenital abnormality, from hydrocephalus to a supernumerary toe, has been attributed to this cause; but, so far as one can see, without any adequate reason other than an inordinate horror for this disease. By the same token, there is no evidence that inherited syphilis is transmissible in any way, shape, or form to the third generation.

PATHOLOGY.

Syphilis is the Proteus among diseases in its pathological as well as in its clinical manifestations. It can scarcely be said to be a distinct, pathological entity, inasmuch as the pathologist, examining a piece of syphilitic tissue, concludes that it is syphilitic as much from the absence of evidence of any other disease as from the presence of characteristic syphilitic changes.

The general morbid tendencies of syphilis may be roughly classed under certain heads:

1. It tends to the production of localized inflammations, centring about a single capillary vessel or group of vessels.

2. The arteries, and to a less degree the veins, and to a less degree still the lymphatics, are peculiarly subject to syphilitic change.

3. In mild or beginning syphiloma the inflammation is exudative.

4. In graver types there follows upon this exudative inflammation a productive one, which terminates by absorption, caseation, or suppuration.

5. Certain (gummatous) types of syphiloma follow a malignant course, extending to adjacent tissues regardless of their nature. There is, however, a tendency to central caseation or cicatrization as the disease extends peripherally.

6. In the early stages of the disease the blood changes are those of an acute infection, while in its later stages it may lead to cachexia, with the chronic, arterial, and visceral sclerosis or amyloid degeneration associated with chronic toxæmia.

The characteristic product of syphilis—the syphiloma,—whether it be the primary chancre, the secondary papule, or the tertiary gumma, is characterized by its localization about some arteriole or group of arterioles. Even the lightest of all syphilitic manifestations, the macular syphilide, is a perivascular process; it consists of a disseminated dilatation of the arterioles of the skin, with very slight exudation about these dilated vessels.

The papular syphilide exhibits the same process a little more advanced. Each papule consists of an infiltration of all the layers of the skin with small, round cells, and centres upon an arteriole, itself infiltrated, its walls thickened, and its lumen compressed or obliterated. This exudative inflammation represents the syphilitic process·in its mildest form, and leads to the presumption that the virus acts first upon the vessel walls and then upon the surrounding tissues.

The syphilitic tubercle of the skin and the primary chancre show much the same general conditions in a little more advanced stage. There is exudation both within and around the vessel, but there is also a tendency to proliferation of plasma cells, and occasionally to production of giant cells. This proliferation may take on excessive growth under certain favorable conditions, especially in the moist regions of the skin folds, and is then known as a condyloma—a soft, cauliflower-like growth, composed of practically nothing but embryonic tissue. The result of this combination of newly formed tissue and obstructed or obliterated blood-vessels is a natural tendency toward necrosis. In its mildest form this is shown by the scaly, syphilitic papule or tubercle, which constantly throws off scales of epithelium. The rupial patch represents the same condition further advanced. Instead of a slight shaling off, there is a prodigious piling up of dead epithelium upon the affected spot.

In many instances, however, the tendency to necrosis is much more marked, and consequently in the skin we find ulceration and in syphiloma of the other tissues central degeneration and caseation. Thus the gumma—the perfect type, as one may call it, of all syphilitic lesions—consists, generally speaking, of a mass of plasma cells, with an occasional giant cell and a marked tendency to central caseation.

Suppuration in the syphiloma is due to secondary infection by pyogenic microbes, and is singularly rare when we consider the apparent lack of resistance of the embryonic tissue of which the syphiloma is formed. Indeed, the only common suppurating syphiloma is the pustular syphilide of the skin, and this is unusual. except among the poor and filthy.

The tendency to involve the surrounding tissues without any regard to their diverse structures is manifested by all chronic productive syphilomata. Thus a gumma, starting in the periosteum of the tibia, extends on the one side through connective tissue and skin, and in the opposite direction into the bone; so that, if neglected, it bursts and discloses a ragged, unhealthy, pulpy, or cheesy cavity, at the bottom of which lies bare, loose bone. In a similar way an obstinate or neglected or ulcerated tubercular skin syphilide tends to spread excentrically in every direction, and thus forms a large, inflamed area, the possible extension of which is absolutely unlimited and whose edge forms a circle or segments of a circle.

In these skin syphilides there is, however, a singular tendency to healing at the centre; so that, though the centre may remain ulcerated—even though the

scalloped, serpiginous border has extended far from it—it is rather the rule that the centre should heal, leaving a livid, pigmented scar, which, surrounded by a livid, serpiginous rim, is characteristic of syphilis. Pigmentation, the tendency to which varies so much with the individual, is, generally speaking, a characteristic of healed lesions of skin syphilis, and even the active, unhealed syphilide bears a certain quasi-pigmented ham color, which is very suggestive of its nature.

Since the product of syphilis is, usually speaking, a granuloma, a sort of neoplasm, its healing always leaves a scar, unless it be one of the light, superficial, exudative forms common in the early stages of the disease, which do not destroy enough tissue to leave a noticeable scar. The scar of the syphilide is thin, pigmented, and has a rounded or scalloped border; so that this scar remains an indelible evidence of the nature of the inflammation which has caused it.

So much for the syphiloma. Besides this characteristic product, the virus of syphilis always causes certain, general toxic manifestations. In its early stages syphilis behaves as an acute, infectious disease. It begins with the production of a typical syphiloma (chancre) at the point of inoculation. The walls of the vessels extending from this syphiloma are infiltrated—they may even be palpable—and the infection travels by the perivascular lymph channels to the adjoining nodes, which become characteristically enlarged.

At about this time the evidences of general, systemic intoxication appear. There are a decrease in the number of red blood cells and in the percentage of hæmoglobin, and a slight leucocytosis. These blood changes are accompanied by more or less elevation of temperature and various febrile symptoms, such as bone aches, which are especially likely to be severe at night, and exceptionally by jaundice from congestion of the liver, albuminuria from congestion of the kidneys, or a palpably enlarged spleen. With the appearance of the first eruption these febrile symptoms commonly abate, and do not reappear unless evoked by suppuration.

There is another form of syphilitic toxæmia, however—a chronic cachexia, caused by unusual severity or neglect of the disease. Among the better class of patients one therefore seldom sees this syphilitic cachexia except in infants, while among the poorer classes it is fairly common. As characteristically shown by the infant with inherited syphilis, syphilitic cachexia seems completely to overwhelm the system. The marasmic, wizened child, unable to eat or sleep, very likely covered with the skin manifestations that brand it indelibly, is overcome by the intensity of the infection. In adults the process shows itself less gravely by keeping the patient anæmic, thin, and listless; while the tertiary lesions present upon the patient show cause for his cachexia. Such a condition is commonly met with only in alcoholics, though exceptionally it may be encountered in the poorly nourished or in those debilitated from other diseases or excesses.

It may not be amiss to add here that a very severe cachexia of a neurasthenic type may be produced by the prolonged and excessive use of iodides. This condition is frequently encountered among the victims of the delusion so rife in this country, that the excessive and prolonged use of iodides can accomplish what a short, sharp course is unequal to. Thus, the patient goes on month after month, saturating himself with mixed treatment, until his digestion is ruined, his nervous force impaired, and his liver or kidneys chronically diseased. Such patients, while they bear witness to the popular delusion of the dangers associated with the use of these remedies, prove by contrast the harmlessness of mercury and the iodides when taken in reasonable doses.

Finally, syphilis acts as a chronic cachexia by encouraging chronic, interstitial proliferation in the blood-vessels and in the viscera, with a special tendency to affect the arteries and spinal cord; while in severe, neglected cases of long standing—especially if the patient be alcoholic—amyloid degeneration of the viscera may be looked for.

PROGNOSIS.

The general prognosis of syphilis, under proper care, as we see it in the United States, is that the patient will for a year or two be liable to more or less annoyance from his disease. It is highly probable that during this time he will not in any way be prevented from attending to his occupation or associating with his friends, while the chances are probably even that he will never suffer any lesion, except chancre, which will leave a permanent scar upon his body, and that he will suffer little, if at all, after the first six months of the disease. Such a prognosis implies only a general condition of good health, a previous history free from grave, alcoholic excess, and a willingness to obey instructions.

Syphilis has a fearful name and is a terror to its victims for many reasons. It is pre-eminently the unexpected disease, and breaks out sometimes years after it had seemed to disappear entirely. Unfortunately, it has also been associated in the public mind with those two most obvious of all conditions—skin disease and locomotor ataxia; so that the public regards every case of acne or eczema with suspicion, and psoriasis, lupus, and epithelioma pass as certain proofs of syphilis; while this impression is capped by the tottering ataxic, who, known and pitied for many miles around, makes a greater impression than a dozen maniacs carried off and immured in an asylum.

Add to this the constant efforts of charlatans and the unfortunate predilection of so large a proportion of the profession to treat pretty much everything for syphilis which is not obviously anything else, and it is small wonder that syphilis is, in the mind of the public, such a dread disease. Yet no syphilologist will endorse such a pessimistic view. It is universally conceded that seven or eight out of every ten well-treated syphilitics never have any symptoms after

they have passed the first two or three years of their disease, and the proportion who suffer from grave tertiary or nervous lesions is surely very small.

Practically speaking, it is those men who cannot stop drinking that suffer severely from syphilis. Other causes have a secondary bearing, to be sure. A man who smokes all day may well be unable to get rid of an ulcer on his tongue. A man of a nervous type, who feeds his soul upon his own troubles and lives an intense, high-strung life, is very likely a candidate for locomotor ataxia. But such conditions are rare, indeed, as compared with the supreme influence of alcohol in modifying the prognosis of syphilis.

I have at present under my care two men who were saturated with drink for at least a year or two before being infected with syphilis. Each of them is in the first year of his disease, and each has been markedly cachectic, has suffered grave and destructive gummatous inflammation, and has reacted badly to every form of treatment except the most energetic; and yet each of these men has stopped drinking and is suffering only from the effects of previous debauch. In a similar way severe and constant recurrences of the disease are seen almost exclusively in those who drink to excess.

On the other hand, I feel justified in telling all syphilitics who come to me in the early stages of their disease, with fair health and without a history of marked alcoholism, that they probably will suffer from their disease for not more than a year, and that they may expect—though they may not be guaranteed—to hear no more from it thereafter, on condition of abstaining from alcohol and submitting to treatment.

The prognosis as regards infectiousness is a most important one, and, inasmuch as the tertiary lesions appear not to be infectious, and the primary and secondary lesions usually disappear within two or three years and often much sooner, it is customary to keep the patient on his guard against infecting his fellows during the first three years, and especially if he has any known lesions upon him. It has happened time and again, however, that a patient has transmitted infection from an unsuspected lesion, especially if this lesion be in the mouth or in the genital tract. In the former case kissing, in the latter sexual intercourse, is the means of transmitting the disease. In order to prevent any possible infection, therefore, it is necessary that the patient be most circumspect, especially with regard to these two acts, during the first three years of his disease. Indeed, in order to insure absolute safety, it is customary to urge a syphilitic not to marry until five years have passed, during the last two of which he has had no symptoms. It must be understood, however, that this implies no guaranty as to relapses in the patient himself. We constantly see patients suffering from tertiary lesions, who nevertheless propagate healthy children and do not infect their offspring. Men, on the other hand, even though they suffer but little from the disease, seem to carry the possibility of infecting their offspring throughout the "secondary period."

Syphilitic children have been born to women whose infection dates back ten years or even longer, and who may have had no symptoms of the disease for many years in the interim. How to explain this peculiar and especial recrudescence of virulence we do not know; but the practical inference is that a woman who has had syphilis, and especially if she has borne syphilitic children on previous occasions, should be treated for the disease during the first six months of every pregnancy for many years thereafter. During the last two months of pregnancy it is doubtful whether syphilis can be transmitted to the fœtus.

Inasmuch as the syphilitic's blood probably ceases to be infectious after the end of eighteen months or two years from the onset of the disease, the surgeon who operates upon a syphilitic will take precautions accordingly.

The prognosis as to the individual manifestations of syphilis depends upon the lesion.

Chancre heals spontaneously. Many of the light, general, secondary manifestations of the disease disappear of themselves, though some have a marked tendency to continue and grow worse unless controlled by treatment. Generally speaking, all tertiary lesions fail to show any tendency to spontaneous healing, and, even after a lesion has healed, there seems to be a special liability for the disease to show itself again in the same place in which some previous outbreak has occurred. Of this, the most important example is the so-called chancre redux, a gummatous infiltration at the site of the primary sore. I have only recently seen such a gumma come on at the site of inoculation twenty years thereafter. It would have passed perfectly for a second attack of syphilis, but for the fact that it was not preceded by exposure to infection nor followed by secondary symptoms.

An important element in the prognosis of syphilis is adherence to type. Thus, if a patient shows a tendency to dry, scaly lesions of the skin in the first years of his disease, that tendency is likely to remain dominant throughout; if to mucous patches and condylomata, these are likely to predominate; whereas, if tertiary manifestations appear first in the periosteum or in the nervous system, they are likely to relapse, if at all, in the same department. This, of course, is only a general rule with many exceptions, and represents the fact that the constitution of a given person reacts to the syphilitic virus along certain definite lines,—that in him a certain tissue is the point of least resistance.

THE PRIMARY STAGE.

When a patient is inoculated with syphilis, he shows no symptoms whatever of the disease until after the lapse of from two to six weeks. Then, usually in the third week after inoculation, the primary syphiloma appears at the site of inoculation. This lesion usually begins as an insignificant, red papule, which, within a few days, assumes a definite shape. It is not profitable to discuss here

the great number of subvarieties of chancre recognized by various authors. Suffice it to say that chancre is a moist papule with a tendency to ulceration. It is more or less elevated above the surrounding integument. Its base has a leathery hardness, much denser and more compact than that which would be caused by a simple inflammation of a similar area. Its color is dark red rather than the scarlet of inflammation. Its top may be flat. If ulcerated by necrosis of its centre, as is so often the case, this secondary process may be so extensive as to preponderate and make the lesion an ulcer rather than a tumor; yet close inspection may still show that the base is indurated and dark red, while the ulceration is simply a necrosis of the centre of the lesion, and obviously not a vigorous, progressive, primary infection, eating into the tissues at the edge, and so undermining them (as is the case in the chancroid).

Thus, chancre is in a small way a neoplasm. And this characteristic distinguishes it most clearly from the other venereal sores with which it is most likely to be confused. It is true that the induration may be but slight, producing the so-called parchment chancre—a thin, flat, red, indurated area, dry or scaly upon its surface; or it may be a little, hard nodule apparently of no great importance and readily overlooked. Indeed, these insignificant lesions are characteristic of chancre occurring upon a dry, thick-skinned surface, as, for instance, the thigh. On such a surface the chancre is likely to be a small, hard papule. On the glans penis or on the vaginal wall it is again likely to be small and relatively insignificant, but ulcerated from contact with the natural secretions. On such loose tissue, however, as the prepuce, the labia, or the lip or tonsil, the chancre is likely to be large and ulcerated.

The characteristic appearance of chancre may, unfortunately, be quite overshadowed by the presence of chancroidal infection. Thus, it is very common to treat a patient for chancroids for several weeks without seriously suspecting any syphilitic lesion, until, lo and behold! the secondary eruption appears; and even then it may be impossible to identify the chancroid which concealed within it the virus of syphilis.

Thus, *it is often possible to feel morally certain that a patient has true chancre and syphilis; it is rarely possible to feel morally certain that he has not true chancre.* Yet in either case there is a grave possibility of error, and the best diagnosticians have certainly erred occasionally in drawing inferences from the sore alone, either because the chancre was so insignificant as to appear innocent or because the chancroids were so widespread as to overshadow the chancre.

A great aid in diagnosis is the characteristic group (or pleiad) of syphilitic nodes in the groin. When the chancre is upon the genitals, there is noticed in about ten days after its appearance a swelling in the inguinal nodes, usually of the side upon which the chancre is, perhaps on the opposite side, or perhaps on both sides. The group of enlarged lymph nodes is made up usually of a single node, which feels as though it were half an inch in diameter, surrounded by a group

of nodes enlarged to about half that size. These nodes are all painless and singularly hard. But the most striking characteristic about them is the absence of periadenitis. Each node is separately enlarged, and they are not adherent one to another or to the surrounding tissues. If the chancre appears in other parts of the body than the genitals, the associated nodes are enlarged accordingly; and with chancre about the mouth the involvement of the lymph nodes is considerable, because there is usually some mixed infection. Indeed, there may be mixed infection in chancre of the genitals, and this may produce periadenitis.

It is most exceptional for the pleiad of enlarged nodes not to appear. Fournier failed to find it in only three out of five thousand cases.

To the surgeon the great interest of chancre lies in its diagnosis, not only from chancroid, but also from epithelioma and from inflamed herpes. Since this differential diagnosis often requires the keenest observation, we spare it a few paragraphs.

But it must be remembered that, after all, the fundamental tests of diagnosis are three: The chancroid can be transferred by autoinoculation; the chancre is followed in due course by secondary syphilis; and epithelioma, besides following a far more indolent course than the other two, may be diagnosed absolutely by a snipping taken from the growth. Bearing in mind these three facts, and applying them appropriately in each case, will surely lead to a diagnosis in the end, though a more rapid diagnosis may often be reached by the aid of the following descriptions:

Differential Diagnosis of Inflamed Herpes, Chancroid, Chancre, Gumma, and Epithelioma.

The five maladies enumerated in this title form ulcerations upon the penis, which under certain conditions may require a nice diagnostic acumen to distinguish one from another. Characteristic lesions of any one of them strike the eye in an instant, and are not to be mistaken. Thus, it would be absolutely absurd to erect a table of differential diagnosis between the simple, superficial, herpetic ulcer that lasts but a week or so, and the full-blown, vegetating carcinoma that has perhaps devoured the whole head of the glans penis. Yet an irritated, herpetic spot may be not so very unlike a beginning carcinoma.

To distinguish these conditions one from another, there are certain guides of great importance and other minor suggestions which, to speak truly, are significant only to the experienced eye. Therefore, while an elaborate table of differential diagnosis may look as though it meant a great deal, it is my impression that an incisive paragraph descriptive of each of these ulcers will carry more weight by impressing a picture than can be conveyed by a table of data more or less important, but to whose relative significance it is impossible to draw attention; hence the plan adopted.

Inflamed Herpes.—Simple herpes, beginning as a vesicle or as a group of vesicles surrounded by an area of acute erythema, and running a course of a few days, during which the vesicles break, scab, and heal, forms such a characteristic type that it is quite unmistakable. Even when the vesicles are confluent and form a large scab, one can recognize the irregular, scalloped edge, showing where each little vesicle has contributed its part to the whole. But, if some investigating physician has been before you and has carefully cauterized the herpetic eruption, it may be so inflamed as to form a large, irritated ulcer. To distinguish this from the more important and lasting ulcerations to be described in the succeeding paragraph, one must apply the treatment of cleanliness and antisepsis—a treatment which should be applied to every form of ulceration that has previously been tampered with—until it acquires some characteristics sufficient to form a basis for diagnosis. Such a treatment—*e.g.*, the application of equal parts of aromatic wine and water, followed by a dusting with aristol or with nosophen twice a day—will cause quick subsidence of the herpetic lesion and leave no doubt as to its innocence.

Chancroid.—Chancroid is the venereal ulcer *par excellence*, appearing in from one to ten days after sexual contact, usually multiple, beginning as a papule, which within twenty-four hours becomes vesicular, ulcerates, and forms a little, cup-shaped ulcer, surrounded by a broad, inflammatory base. At this stage it may be impossible to distinguish chancroid from herpes, except by the inoculation test. But the ulcer rapidly grows, and, if at first single, it soon performs its own autoinoculation and other ulcers appear, their site of appearance being usually the apposed layer of foreskin or glans (as the case may be), with an especial predilection for the little pocket on each side of the frenum. By this time the original ulcer is covered by a yellowish, thick pellicle, and has begun to erode the surrounding tissues, eating under the edges of the epithelium, so that the ulcer edge is undermined and sharp. In a few days the ulcers at the edge of the frenum cut through this: an inflammatory adenitis, tender, perhaps going on to suppuration, with the formation of chancroidal ulceration, appears in one or both groins: all of this process going on rapidly and making slight advance from day to day. Such a condition is quite characteristic and usually unmistakable; but, when partially checked without being cured,—whether by antisepsis or by simple cleanliness,—chancroidal ulcers may settle down into a sluggish state, in which the bacterial poison has been completely destroyed or greatly attenuated, so that there is left a sluggish ulceration covered with foul granulations, which may cover a considerable area and show little or no tendency to heal. On account of its chronic nature, and perhaps on account of the repeated cauterizations to which it has been subjected, such an ulcer may be surrounded by a more or less indurated base, and may be mistaken for chancre or epithelioma. Under these conditions, as in all the earlier stages, autoinoculation is the test for chancroid.

With the sharp point of a bistoury some of the secretion is carefully wiped

from the surface of the ulcer, and then wiped off again upon the outer surface of the thigh; whereupon the point of the bistoury is pushed a little into the skin—just deep enough to draw a little serum—and twirled around, so that this serum is thoroughly mixed with the secretion of the ulcer. The patient should be seen three or four days later, the point of inoculation having been protected by a vaccination shield; and, if the original sore was a chancroid, a new chancroid will have appeared at the point of inoculation. This may be destroyed by nitric acid after anæsthetizing with pure carbolic acid, so that no harm is done and the diagnosis made.

It must not be forgotten, however, that the patient may well be infected at the same time with both chancroid and syphilis; in which case early and prompt treatment may effectually rid him of his chancroids, with the exception of one, which will remain a sluggish ulceration, in reality a chancre, whose characteristics have been modified by the efflorescence of the chancroidal infection. From such an ulcer autoinoculations may or may not take, but in due time secondary symptoms will follow. Moreover, chancroid may be the site of gummatous recrudescence; so that, generally speaking, if the chancroid does not get well after six or eight weeks of treatment, we may consider the advisability of a sharp course of antisyphilitic treatment, on the possibility that it has changed into a syphilitic lesion.

Chancre.—Chancre occurs, as we have already seen, from two to six weeks after contact; lasts, generally speaking, from one to three months; is characteristically a moist papule upon an indurated base; is subject to secondary infections, which may make it ulcerate and suppurate, or become chancroidal or phagedænic; and is followed in about forty days after its first appearance by secondary syphilitic lesions of the skin and mucous membranes, and meanwhile, some ten days after its appearance, sets up the typical inguinal adenitis already described.

These characteristics are often obscured by coexisting chancroid or by a tight foreskin. For the latter complication the only treatment is prompt incision, in order that the ulcer may be gotten at and properly diagnosed and treated. But for the diagnosis of chancre, whatever its complications, we await the characteristic enlarged nodes in the groin, and, if these are obscured by mixed infection, we must await the secondary syphilitic eruption.

Gumma.—Gumma of the penis is rare, except as the so-called chancre redux; which is to say that, while gumma may occur anywhere in the body without any apparent reason, it is likely to strike a place of least resistance; and such a place may be formed by the scar of chancre, even though many years have elapsed since the chancre has disappeared.

Gumma imitates as nearly as may be the original chancre. It begins as a hard tubercle, breaks down in the centre, and, as it progresses, shows a much more destructive tendency than does uncomplicated chancre. It spreads in all directions, exudes a purulent fluid, and excavates the tissues quite deeply. The

absence of sexual exposure and of subsequent secondary syphilis, the history of previous chancre upon the same site, and the prompt effects of antisyphilitic treatment make the diagnosis.

Epithelioma.—The warty variety of epithelioma does not interest us here. But epithelioma may begin as an ulcer—and a seemingly innocent ulcer at that. It may be surrounded by a very slight induration and may resemble chancre rather closely. Although having no connection with venereal disease, it may first be noted at a short interval after sexual contact, and so put the physician upon the wrong track. Although epithelioma is rare before the age of forty-five, it is occasionally encountered in the fourth decade of life.

Kaufmann collected one hundred and thirty cases, of which three occurred between the ages of twenty-one and thirty. The great predisposing cause, however, of epithelioma is the retention of smegma due to phimosis; hence the circumcised Jew is exempt.

The characteristics of the beginning epitheliomatous ulcer are an indurated, nodular border, a tendency always to spread, whatever the treatment employed, and the exudation of a sanious discharge. The only one of these characteristics that can be depended upon, however, is the constant progress of the disease, whatever local treatment is applied to stop it. If, therefore, in a doubtful case, a small ulcer progresses viciously in spite of all treatment and shows an indurated edge, if there is question of its being a venereal sore, a clipping should be taken from it for microscopical examination; or, if there is obviously no venereal history and gumma has been excluded by a course of antisyphilitic treatment, the sore may be looked upon as epitheliomatous and destroyed by cauterization if it is very small; otherwise it demands prompt amputation of the penis, with excision of the inguinal nodes.

THE SECONDARY STAGE.

Chancre, after lasting about ten days, gives rise to a syphilitic pleiad in the adjacent lymph nodes. Then follows a period which is termed "the secondary period of incubation." It should rather be called "the period of general toxæmia without localized symptoms." If the patient is robust and the infection slight, there may be practically no symptom during this time; perhaps a little headache at night, perhaps a general sense of malaise or debility.

In the severer cases, however, the patient is racked by excessive pains in his bones, intense headaches, or high fever. He may be jaundiced; his urine may contain albumin; his spleen may be enlarged. Such an intense toxæmia is, however, most uncommon. As a rule, there is little or no disturbance, until, in the sixth or seventh week after the appearance of the chancre, the first eruption comes out upon the skin. This eruption is usually either macular or papular. The macular eruption consists of a faint mottling, almost entirely confined to the

trunk and most marked on the sides and loins. So faint is it that the patient, as a rule, does not notice it until it is pointed out to him, even though he has been warned that it will appear. Yet blushing or the application of heat, *i.e.*, a hot bath, makes it stand out quite prominently. It does not appear upon the face. It vanishes in from three to fifteen days.

The papular syphilide is even more widespread, may cover the whole body, and is much more disfiguring; for the thick crop of little papules covers the patient from top to toe and cannot be overlooked, although I have known an ingenious physician to mistake it for measles.

The size of the papules varies considerably in different cases. If not attacked, the eruption lasts for from three to eight weeks, and may come out in successive crops for an indefinite time. It disappears with slight desquamation, as does the macular syphilide.

At the time these eruptions appear the chancre is usually still present. A careful investigation of the subcutaneous lymphatics discloses in some part of the body a characteristic, syphilitic pleiad, and a minute examination of the area from which these nodes are fed leads to the discovery of the slight induration remaining even when the chancre has almost disappeared.

Investigation of the patient's general health at this same period discloses a marked chloro-anæmia, with diminished red blood cells and hæmoglobin, and a slight leucocytosis. By the time the eruption is in full blast one may look for a general enlargement of the lymph nodes. These nodes are not very large, but are hard and shotty and freely movable under the skin; there is no periadenitis. The epitrochlear and posterior cervical nodes can often, but not always, be made out. This enlargement of the lymph nodes, like the original pleiad, may remain when the eruption has disappeared—a witness to the storm that has burst.

Such are the general characteristics of secondary syphilis—a period of apparent calm followed by a macular or papular eruption. It is the rarest thing in the world for these general early syphilides to be skipped, but beyond them there is no rule. They may be followed by other typical manifestations of the disease, but in no order and with no regularity. Or they may be followed by a long interval—perhaps many years—during which there are no symptoms.

In our day, whatever natural tendency to systematic development syphilis has (and it is extremely doubtful if it has any) is so completely shrouded by the effects of treatment that all we can say is that there are various manifestations which we recognize as syphilitic, any or all or none of which may appear upon the syphilitic patient.

The secondary, or infectious, period of syphilis is generally estimated at from one to four years. During part or all of this period, and especially during the first year, the skin and mucous membranes are likely to show certain characteristic, disseminated lesions. These are commonly known as the secondary syphilides. Of these the macular and the papular syphilides have already been de-

scribed. If the patient is filthy or much depleted, the papular syphilide may promptly develop into a pustular inflammation; rarely, it becomes vesicular (varicelloid). Bullous and pigmentary syphilides have also been described, but are extremely rare. If the papules grow large, flattened, and copper-colored, the eruption is spoken of as a tubercular syphilide. If these tubercles constantly desquamate, the eruption is called tuberculo-squamous. The commonest syphilide of palms and soles, after the first general eruption, is a squamous (desquamating) lesion, occurring in round patches or in ring-wormy, circinate convolutions about a centre of healthy skin. With this may be associated almost imperceptible papules, from which the epithelium has desquamated, leaving them set in a crater of desquamation.

The loss of hair from syphilis (syphilitic alopecia) is of psychologic rather than pathologic interest, for there is a widespread delusion that syphilis commonly causes baldness—a delusion with no other foundation than the claim of quackery and the fact that syphilis is habitually contracted at the time of life when senile baldness begins—the age of twenty-five, alas! As a matter of fact, there are two varieties of syphilitic alopecia, neither of any great importance. A slight, general, temporary falling of the hair occurs in the first flush of the secondary period, but is usually very slight and rarely as severe as that of typhoid. Alopecia occurs also over any syphilitic lesion of the scalp. Thus, a neglectful patient may suffer a seborrhœal papulo-squamous syphilide of the scalp which destroys the hair in an incomplete, irregular fashion, leaving a motheaten poll. But it is astounding how rapidly the hair returns after the subsidence even of a severe type of syphilide.

With the first outbreak of the skin syphilide, there is often a mottled erythema, a macular syphilide of the mucous membrane of the mouth and throat. This is very often followed by the appearance of ulcers or mucous patches. The syphilitic ulcer is a rounded, shallow erosion, superficial at first; but it gradually deepens, with a thickened border, and a dirty-white pellicle covering its base. It is sensitive, very rarely painful. It may exactly imitate the aphthous spot. It occurs on any mucous membrane and on any part of the skin constantly kept moist by irritative secretions.

The Mucous Membranes.—The mucous patch is a lesion peculiar to syphilis. It is rounded in outline, pale or rosy in color, usually a little elevated upon the mucous membrane, although it may be depressed below it. The surface of the mucous patch, when it occurs within the mouth, is often covered with a white pellicle. Such a spot, upon whatever mucous membranes it occurs, is characteristic of syphilis, inasmuch as it is not an ulceration and cannot occur from any of the many causes of erosion. It may, however, become ulcerated, and then cannot be distinguished from the aphthous spot—the so-called canker sore.

Mucous patches may also occur upon the moist portions of the skin, such as the soft skin of the scrotum or about the anus or the female genitalia. They are

subject to constant friction and to irritative discharges, so that, if neglected, they very frequently proliferate freely and spread out into cauliflower-like growths, called condylomata, the surface of which is fissured and fungating, perhaps ulcerated or scabbed. The discharge from such a growth is foul-smelling and viscid. Mucous patches and condylomata may occur between the toes, on the genitals, or in any wrinkled, sweaty spot. In the better classes of the community, mucous patches occur only on the mucous membranes.

The Nails.—Syphilis affects the nails as it does the rest of the skin. Thus, mucous patches may appear under the free border of the nail, and syphilitic papules or ulcers may surround the nail with an irregular, sluggish, suppurative condition, very much like suppurative onychia or run-round, but always chronic, never acute.

Dry, syphilitic onychia attacks the matrix and causes the nails to grow out in an irregular, thickened manner very similar to eczematous onychia. In the early stages of the secondary period the nails may be thinned, lustreless, and cracked from the systemic intoxication.

Such are, briefly, the common skin and mucous-membrane lesions likely to occur during the secondary, or infectious, period of syphilis. In the first six months of this period the more superficial and disseminated lesions predominate, but, as the months roll by, the recurring lesions (if they do recur) show a tendency to segregate themselves more and more into patches and to become deeper, more destructive, and more difficult to heal.

Occasionally, one may follow a case which responds ill to treatment—either on account of the carelessness of the patient or the obstinacy of the disease— from the superficial, general, papular syphilide through various eruptions more and more grouped, more and more intense, until, finally, the patient is seen with a true destructive, tertiary condition; and yet, on looking back, one cannot exactly say where secondary lesions stopped or where tertiary lesions began. Such a case illustrates most plainly the fact that, pathologically speaking, there is no essential difference between secondary and tertiary syphilis; the difference is one of degree and usually one of time. Secondary syphilides always appear early in the disease; tertiary syphilides usually late in the disease; yet it is a common experience to see the two existing side by side, and one may even see a characteristic, gummatous, tertiary ulceration followed by some secondary manifestations.

TERTIARY SKIN LESIONS.

The tertiary lesions of the skin, the tertiary syphilides, are chiefly of that circumscribed, destructive character which constitutes gumma. Gumma of the skin is more often multiple than single. It begins as a tubercle, which breaks

down, ulcerates, and invades the surrounding skin, but has no great tendency to involve the subcutaneous tissue. The gumma may remain as a little tubercle or ulcer, but it usually assumes one of three clinical types, viz.:

1. Syphilitic ulcer (leg ulcer).
2. The serpiginous ulcerative syphilide.
3. Rupia.

Syphilitic Ulcer (Leg Ulcer).—So common is this lesion that in attempting to diagnose an old case of syphilis we always inspect the patient's shins, in the hope of finding the characteristic scar of syphilitic ulcer.

Tertiary ulceration of the skin is by no means confined to the leg, and syphi-
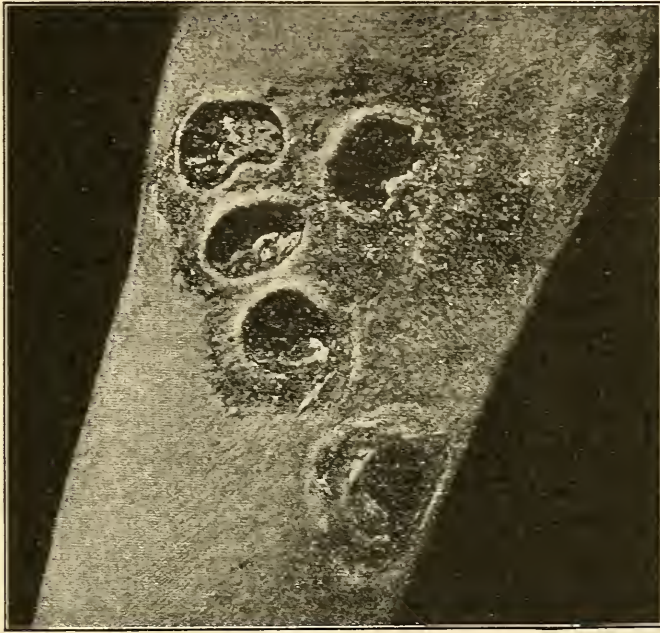
FIG. 25.—A Group of Syphilitic Leg Ulcers.

litic leg ulcers may be due to subcutaneous or subperiosteal gumma as well as to gumma of the skin; yet syphilitic leg ulcer is so pre-eminently the type of all syphilitic skin ulcerations that its description may suffice for our purpose.

The lesions, for they are usually multiple, may be grouped or scattered, but their distribution is characteristic. They may occur *anywhere in the upper part of the leg, but when near the ankle they generally occur on the external (fibular) aspect*, not on the internal (tibial) aspect, of the leg. This is the first striking feature to distinguish them from *varicose ulcers*, which *always occur on the lower third of the leg and are most marked on its inner (tibial) side*.

The lesion, beginning as a tubercle or as a group of tubercles, rapidly becomes an ulcer—circular, if arising from a single lesion; or with a border made up of a series of segments of circles if, as is the rule, it is formed by the coalescence of a

number of lesions. This ulcer is sluggish in character; its secretion sero-sanious; its base sloughing; its scab dark brown, brownish-green, or black; its edges sharp; its areola insensitive, rather indurated, and of a coppery or ham red. But when seen by the physician it may be implicated by secondary pyogenic infection, so that its secretion is purulent, its borders œdematous, scarlet, and tender. Its characteristic position, however, often distinguishes it from varicose ulcer, while it may be differentiated from eczematous leg ulcer by its circular or scalloped border, by the history of syphilis or evidences of it elsewhere on the body, by the effect of antisyphilitic treatment, and, moreover, by the absence of the itching, œdematous, scaly area that surrounds the eczematous ulcer.

The Serpiginous, Ulcerative Syphilide.—This tertiary lesion may occur on the leg, but shows no special predilection for that region. It may begin as a single ulcer, which heals at the centre as the ulceration progresses peripherally; or it may begin as a group of tubercles distributed in a circle or in a conjoined series of segments of circles, and which break down rapidly and thus form a ring ulcer, which spreads by peripheral extension of the ulceration while it heals centrally. Thus, in either case is formed a composite lesion, consisting of a central scar surrounded by an irregular line of active ulceration. Here, again, the ulceration is sluggish, the borders coppery, the distribution in characteristic segments of circles.

Rupia.—This form of tertiary syphilide is especially liable to occur in debilitated persons. The ulcer, instead of extending peripherally, seems to expend its energy in the formation of a scab, under which suppuration and ulceration continue and build up other layers of scab, each successive layer uniting with its predecessors and elevating them from the surface as a dark brownish or greenish crust that resembles a horn. These great, irregular, dirty, oyster-shell crusts, quite firmly attached to the subjacent gummatous ulcer, are absolutely pathognomonic of syphilis.

The Scars.—The scars left by the healing of any form of gumma of the skin are absolutely typical (*vid. infra*).

THE GENERAL CHARACTERISTICS OF SYPHILITIC LESIONS OF THE SKIN.

Divers as are the skin eruptions caused by syphilis, there are certain general characteristics by which they may usually be identified without any doubt. Thus, it is perfectly possible for one not versed in the nomenclature of syphilis to infer correctly that a given skin lesion is syphilitic, even though he has not the technical ability to determine the exact type of the syphilide in question.

Some of these characteristics are common to practically all syphilides, others are restricted to a few, and any of them may, of course, be modified by the simultaneous eruption of lesions due to some other cause.

1. Polymorphism.—Syphilis is the only disease which produces at the same time several different types of eruption. Indeed, one almost always finds this characteristic polymorphism in the early, general eruptions. Thus, a syphilide is often maculo-papular, papulo-pustular, tuberculo-squamous, and so on through all the possible combinations.

This polymorphism is generally due to the fact that the papular syphilide, the type of secondary syphilis, may come out in successive crops; and these successive crops, coexisting upon the patient, show papules in various stages of their development toward pustules, tubercles, or gummata. Polymorphism is rarely seen in the later lesions of syphilis.

2. Rounded Outline and Grouping.—The skin lesions of syphilis show a general tendency to rounded outline, whether of a single lesion or of a group of lesions. Thus the papule or gumma is primarily a rounded lesion centring about an arteriole. If this lesion grows larger, it does so by direct extension to the surrounding parts, and thus its edge always advances in a circinate manner; so that the border of a syphilide, if irregular, is made up of crescentic lines, of circles, or of parts of circles.

In the same way a patch of syphilitic eruptions is usually distributed in a generally spherical manner about a centre, which itself may be unaffected. This is very well illustrated by the squamous palmar and plantar syphilide; and one also often sees groups upon the trunk or upon the extremities which, although made up of entirely distinct papules or tubercles, have a rounded or crescentic distribution.

3. Copper Color.—With the exception of the very earliest macules and papules, the syphilide is of a dull, rusty ham or copper red, quite distinctly different from the brilliant scarlet of inflammatory skin lesions. Psoriasis, lichen planus, and certain gouty eczemata share this dull color in some degree, however.

Inasmuch as pigmentation is a frequent secondary process in old syphilitic lesions, however situated, this often adds a darker hue to the lesion.

4. Absence of Pain and Itching.—Excepting that the early pustulo-crustaceous syphilide of the scalp usually itches, and secondary suppuration in any syphilide may cause pain, these two symptoms are conspicuous by their absence from all syphilides. Yet urticaria, eczema, or pediculi may coexist with syphilis and may cause itching in syphilides.

5. Symmetry.—The earlier generalized syphilides are symmetrically distributed on the right and left sides of the body. The earlier grouped lesions show a similar bilateral tendency, while, as a general rule, the later the lesion the less its symmetry.

6. Scales, Crusts, and Ulcerations.—Scales from a squamous syphilide are thin, dirty-white, non-adherent; very different from the thick, glistening, adherent scales of psoriasis.

Syphilitic crusts or scabs are usually dark brown or green in color, laminated

(made up of superimposed layers), and often floating on a mush of pus. The deep, laminated, conical rupial scab is the extreme and pathognomonic type.

The syphilitic ulcer (chancre apart) is rounded or circinate in form. The edges are abrupt, but not undermined, indurated, fading off into the surrounding tissue, and surrounded by a ham-colored or pigmented area. The base is dull red or bluish, indolent, indurated, secreting a sanious or purulent ichor. The ulcer is painful only when it overlies inflamed periosteum.

The location of ulcers in the upper third of the leg and the simultaneous existence of active, peripheral ulceration, with central cicatrization, are very common and characteristic.

7. Pigmentation and Cicatrices.—A knowledge of the traces left by a syphilitic eruption is often of more help to the surgeon striving to make a diagnosis than a knowledge of these lesions themselves; for the scar remains an indelible witness, whereas the actual eruption may have long since disappeared.

Papular and squamous syphilides destroy no tissue and leave no scars, though exceptionally they may be followed by pigmentation. But tubercular, pustular, ulcerative, and gummatous lesions destroy tissue, and, consequently, leave characteristic scars. These scars bear the rounded or circinate imprint of the lesion that caused them. They are punched-out, their bases thin, smooth, and shining, quite different from the puckered, irregular scars of tuberculosis.

Moreover, a deep, coppery pigmentation usually covers the scar and the surrounding tissue for several months after its formation. Pigmentation is deeper and more lasting in dark than in fair persons, and in certain portions of the body, notably the shins, it may remain permanently a brownish or yellowish, mottled discoloration. As a rule, however, it fades in the course of a few months to a dull yellow, and then disappears, leaving the thin, smooth scar but little different in color from the surrounding skin.

SYPHILIS OF THE EYE AND EAR.

Syphilis of the eye, the common, secondary iritis, as well as the rarer lesions of cornea and retina, interest the surgeon so little as not to merit any more space than is given them in the chapter devoted to that organ.

Syphilis of the ear may also be dismissed with casual mention.

SYPHILIS OF THE VISCERA.

The viscera are attacked by syphilis in its secondary as well as in its tertiary stages. Secondary visceral syphilis, acute congestion during the first few months of the disease, does not concern the surgeon. Even tertiary syphilis of the viscera is rarely enough diagnosed during life, and although instances of syphilis of almost all the abdominal and thoracic viscera have been recorded, the liver, the kidney, and the rectum are the only organs in which syphilis interests the surgeon.

Liver Syphilis.—Tertiary syphilis causes in the liver either interstitial hepatitis (cirrhosis) or gummatous hepatitis. These two forms usually occur together, and they may be associated with amyloid degeneration.

Syphilitic cirrhosis of the liver is in no way distinguishable from other varieties of cirrhosis, except that it is caused by syphilis and is in some degree amenable to antisyphilitic treatment. It is not a surgical malady.

Gummatous hepatitis is not very uncommon, but it usually causes no symptoms and is discovered only at autopsy. The gumma consists of a mass of embryonic cells surrounding a cheesy centre, while from it radiate bands of fibrous tissue, both inter- and intra-lobular. There are usually several gummata.

If, however, the gummata are many or large, they may give rise to symptoms, rarely by obstructing the biliary ducts and causing jaundice, usually by involving Glisson's capsule and setting up a perihepatitis. There may even be extensive perihepatic adhesions.

Thus the symptoms vary from a mere sense of weakness and depression, with anorexia and perhaps diarrhœa, to a condition of ascites and jaundice with intense localized pain over the gumma and a palpable tumor. In the former case, disease of the liver may not even be suspected; in the latter, it is manifest that the liver is the seat of a new growth, though it requires a careful inquiry to infer, and a sharp course of antisyphilitic treatment to prove, that the new growth is a gumma.

Since gummatous hepatitis rarely occurs within five years of the beginning of the disease, and since there is nothing in its symptoms to differentiate it clinically from other neoplasms, the diagnosis is often difficult, and many exploratory laparotomies for supposed tumor or inflammation about the liver have revealed gumma. Dr. Cumston (*Ann. Surg.*, 1903, xxxii., 725) has related several such cases which merit quotation:

Case I.—Male, 41 years old, father of four children, of whom the first two died at birth; the other two are alive and well. Denies syphilis and alcoholism.

"About three months before the patient came under observation he had become suddenly jaundiced, and soon after he complained of pain in the right hypochondriac region, as well as in the right shoulder blade. Palpation showed that the border of the liver extended about four fingers' breadth below the costal margin and extended toward the median line. A slight amount of ascites was present, and the patient had lost some ten pounds in weight since the commencement of his illness. Œdema of the lower extremities was wanting, and there was entire absence of any history pointing to melæna or hæmatemesis. A detailed examination of the other abdominal and thoracic viscera was negative, and there was complete absence of enlarged lymphatic glands."

Diagnosis: Carcinoma of liver or gall-bladder.

Laparotomy revealed numerous tough adhesions between liver and parietes. "The liver felt hard, and two nodules, the size of English walnuts, projected from the anterior surface of the right lobe near its border; their contour was regular and their surface somewhat nodular; in color they were light yellow." The nodules were

incised, their cheesy centres scraped out, and the cavities packed.   Healing un-
eventful.

Under potassium iodide, 4 gm. daily, the patient was cured in three months, and
has remained well two years.

CASE II.—Female, 39 years old, has had three miscarriages, followed by the
birth of two healthy children.

She complains of chronic, dull pain in the right hypochondriac region, and nausea.

Tongue furred; pulse, 76; temperature and respiration normal.   Slight leucocy-
tosis.   Examination of thorax negative.   No enlarged lymph nodes.   "Palpation
of the abdomen revealed a somewhat nodular tumor, lying in the epigastric region
and nearly reaching to the middle line, and extending about five fingers' breadth
below the tip of the sternum.   Both liver and tumor moved with respiration, and by
percussion the growth appeared to be directly connected with the liver."

Diagnosis: Tumor of the liver, either syphilitic or malignant.

Laparotomy revealed slight ascites and a liver the left lobe of which "was studded
with numerous tumors, varying in size from an almond to a walnut."   A small one
was excised for examination, and proved to be a typical gumma.

A treatment of mercurial inunctions and potassium iodide, 4 gm. a day, cured
her in four months.   She has remained well three years.

CASE III.—Male, 49 years old; no children.   He denies ever having had syphilis.

In the last eighteen months he had dropped in weight from 190 to 167 pounds,
and had felt a fulness, but no pain, in the upper abdomen.   Latterly, the fulness had
begun to impede respiration and digestion.

Heart, lungs, temperature, and pulse normal.   Urine contains a trace of albumin,
but no casts.   "Liver dulness extended to about three fingers' breadth below the
costal border, and from there toward the epigastrium and downward to within three
fingers' breadth of the umbilicus.

"By palpation an ill-defined mass could be made out in this region; its surface
was irregular and it was somewhat tender.   It appeared to be connected with the
liver and was fairly movable transversely," but not vertically.

Diagnosis: Malignant neoplasm.

Laparotomy revealed an adherent pedunculated tumor, about the size of an
orange, and with a pedicle about 4 cm. long, growing from the under surface of the
left lobe of the liver.

The tumor was removed and proved to be a gumma.

These three cases are happily descriptive of three types of gumma that sim-
ulate neoplasm.   Similar cases have been reported by many surgeons.   It will
be observed that Dr. Cumston shows a surgeon's partiality for excision or for
curettage of hepatic gummata.   Yet, entirely apart from the fact that the great
majority of such gummata cannot be excised, the surgeon must remember that
a thorough antisyphilitic course is essential to a cure, which course will remove
the gummata far more effectively than he can hope to do, and without incurring
any of the risk from hemorrhage or shock, so grave an element in liver surgery.
It is proper, however, to excise a piece of tissue for examination, and but few

surgeons could be expected to resist the temptation afforded by Case III., although this by no means proves that the case did any better for the excision. The plea that, where antisyphilitic treatment failed to reduce an old, fibrous gumma, surgery might succeed has no evidence to back it and is not *a priori* convincing in view of the brilliant successes of antisyphilitic treatment and the uncertainties of liver surgery.

But there is another clinical type of gummatous liver, one in which the symptoms of perihepatitis predominate. The following case (Cumston) is an excellent example:

CASE IV.—Male, about 40 years old. For several months he suffered pain in the right hypochondrium, and has been slightly jaundiced. Tongue furred; temperature normal; pulse, 80. "A large, somewhat nodulated mass in the region of the gall-bladder; the border of the liver extending about three fingers' breadth below the costal margin."

Diagnosis: Tumor of liver or biliary passages.

Laparotomy revealed slight ascites, a large liver, and a gall-bladder surrounded by adhesions, but which when freed proved normal and empty. A diagnosis of ulcer of the duodenum was therefore made, but the adhesions were so dense it was deemed inadvisable to interfere further.

After operation it was learned that the patient had had syphilis, and he was therefore treated by large doses of potassium iodide. Cure in three months, persisting two years.

Dr. Lilienthal has reported a similar case, in which a suppurating gumma could not be distinguished from suppurating cholecystitis except by exploratory incision.

Indeed, in a doubtful case exploratory laparotomy is a proper and prompt method of obtaining a diagnosis, but a short, sharp antisyphilitic course is harmless, and, if applied indiscriminately to all cases of supposed tumor of the liver, would not hurt any of them, but would save a certain small percentage from the dangers of operation.

Kidney Syphilis.—Kidney syphilis is extremely rare. Indeed, apart from the various forms of nephritis of a medical character which may be due to syphilis, there is scarcely any information to be obtained upon gumma of the kidney, beyond the fact that it does occur and may show itself clinically as a tumor of the loin. Hence it may not be amiss to record two cases reported by Israel— the one mistaken for tumor, the other for tuberculosis.

CASE I.—In October, 1888, I was consulted by a woman, 23 years old, on account of a tumor of the right kidney. She had been married four years and had borne three children, of whom the first died in twenty-three days and the second in one year.

In March, 1888, she had bilateral, syphilitic iritis. In June she was delivered of a healthy child. For four weeks she had suffered from frequent urination and ab-

dominal and pelvic pains, and, for two weeks, from a sharp pain in the right side, without cough. The urine was normal. The right kidney was large, hard, sensitive, and immovable. The urine was increased in volume, of low specific gravity, and contained a few leucocytes and bacteria, once a hyaline cast, and sometimes albumin and sometimes not. Continued pressure on the kidney markedly increased the epithelial sediment and caused slight bleeding. Repeated experiments of this kind produced a slight but definite decrease in the volume of the tumor.

A course of iodides proved futile, and on January 22d nephrectomy was performed. The fatty capsule was found œdematous, scarred, and adherent. The kidney was found apparently normal in its upper two-thirds, while the lower end was occupied by a hard growth. It was therefore removed. Section of the kidney showed syphilitic and interstitial nephritis and hyperplastic perinephritis. After operation the patient gained forty pounds, and bore a healthy child within a year, while the urine continued to show albumin from time to time for five years in spite of iodides. Since then the patient has been well and has borne several children.

CASE II.—The patient, a man, 30 years old, had lost two brothers of phthisis. He had had a chancre many years before, and had been treated with mercury. In May, 1889, he began to have continuous pain in the left side. Six months later, he began to have short, sharp pains every hour or so. Then a redness appeared over the tenth rib in the axillary line, and three weeks later a supposed abscess of the spleen was incised. Fourteen months later, in December, 1890, the patient consulted Israel, who found a diffuse, adherent growth in the region of the kidney, in front of which the spleen could be made out, distinct and movable, while a fistula led between the eleventh and twelfth ribs into the tumor. The urine was purulent and albuminous; tubercle bacilli could not be found in it.

January 3, 1890: *Nephrectomy for Tuberculous Kidney.*—The fistula was followed down after resection of the eleventh and twelfth ribs, and the kidney isolated with great difficulty from the dense, perinephritic scar. The wound healed extremely slowly, but the patient gained weight and was apparently well in 1900. Investigation showed gummatous degeneration of the kidney.

Syphilis of the Blood-vessels.—Syphilis has long been recognized as one of the possible contributing causes in arteriosclerosis, whether that be diffuse or localized. Hyaline degeneration and amyloid changes in the vessel wall also occur as late results of syphilis, while specific, obliterating endarteritis, with whose occurrence in the brain arteries the researches of Huebner have made us familiar, is known to occur exceptionally in other parts of the body. Most exceptionally, gummatous changes are found in the vessel walls, doubtless due to disease of the vasa vasorum; but the only vascular lesion of syphilis that interests surgical practice is aneurism.

Until very recently syphilis has been regarded as the chief cause of arteriosclerosis and of aneurism. But recent research, whether because of its greater accuracy or because syphilis is so much better controlled nowadays that its later manifestations are relatively less frequent, seems to show that syphilis assumes a relatively unimportant rôle in the production of aneurism. But whether this be so or not (and, indeed, the question is not yet decided), the clinical fact of

greatest importance is that the time-honored treatment of aneurism by rest in bed and iodide of potassium does good by dilating the capillaries and reducing pressure in the aneurismal sac rather than by direct antisyphilitic influence.

Syphilis of the Rectum.—Syphilis of the rectum is an extremely rare disease. It has long been an accepted theory that rectal strictures are commonly caused by syphilis, but such is by no means the case. The great majority of rectal strictures are certainly not caused by syphilis. Indeed, so great is the disparity between vague assumptions of the accepted theory, on the one hand, and proven facts, on the other, that one is almost tempted to deny the existence of syphilis of the rectum; and, therapeutically at least, such denial is quite warranted; for, although there are a few reported cases of gumma of the rectal wall (most of which have been collected by Taylor in his book on venereal diseases), this condition is certainly most exceptional, and the ordinary, so-called syphilitic stricture of the rectum is nothing more than an inflammatory stricture. It does not yield to antisyphilitic treatment, and must be attacked by the ordinary surgical means.

Gumma of the rectum apparently shows itself as an elevated, ovoidal, granulating mass upon the rectal wall; it may be entirely within the rectum or may extend upward from the anus (ano-rectal syphiloma). Mucous patches, condylomata, chancre, and chancroid occur about the anus and in the lowest portion of the rectum. But the most important feature to be remembered, first and last, is that syphilis of the rectum is extremely rare, and that rectal stricture is to be treated as an inflammatory, cicatricial, and ulcerative condition, not as a syphilitic lesion.

SYPHILIS OF THE NERVOUS SYSTEM.

Syphilis may attack the nervous system in any or all of its constituents. The bones of the spine and cranium, the dura, the pia, the blood-vessels, or the neuroglia, may be affected by the disease. Consequently, syphilis imitates every nervous disease more or less accurately. Syphilitic hemiplegia and paraplegia are common. Syphilitic epilepsy is rare. The fact that locomotor ataxia is almost always, and general paresis only less frequently, associated with antecedent syphilis is known to all.

But these various lesions belong to the domain of internal medicine. The surgeon's special interest is in gumma of the brain simulating neoplasm. Not all brain gummata simulate neoplasm, by any means. On the contrary, in most instances they do not. But when a patient shows symptoms of brain tumor the surgeon must carefully exclude syphilis before operating. This may be no simple matter, for the symptoms of gummatous growth may be precisely those of neoplasm (see the article on Surgery of the Head, in a later volume). The

gumma may, it is true, show a certain suggestive irregularity of symptoms, such as irregular paralyses, which baffle accurate localization; but such a sign cannot be depended upon. Hence the only safe rule, the one which should always be followed, is to subject every case of supposed brain tumor to a searching inquisition and examination for syphilis, hereditary or acquired; and, *even though this prove futile*, to subject him to a brief and vigorous course of mixed treatment —the only safe test whereby to exclude syphilis (see below).

Unfortunately, however, this treatment may apparently help the patient somewhat, even though he have a true neoplasm of the brain. Thus, I have seen a miserable creature go to the Hot Springs of Arkansas, again and again to be saturated with iodide and salivated with mercury, all the while almost blind from optic neuritis and racked by the most excruciating headaches, yet adding the sufferings of violent treatment because of fancied remission in his symptoms; until, finally, the surgeon's knife disclosed a sarcoma, which eventually killed the patient.

In syphilis of the nervous system this mistake of over-treatment is likely to be carried to its most unwarrantable excesses. And here of all places it is necessary to make the test course of antisyphilitic treatment a short and sharp one in order that whatever doubt exists may be promptly wiped away; and, if this short, sharp course fails to effect a marked improvement, the patient may be immediately consigned to operation—if this is feasible.

Generally speaking, the characteristics of disease of the brain which arouse the suspicion of syphilis are the irregular and fleeting character of the first attack and the occurrence of paralysis, especially of hemiplegia, in a patient under forty. It is a rule, almost without exception, that syphilitic hemiplegia is preceded by ephemeral attacks of aphasia, paralysis, or unconsciousness; while the general rule that all hemiplegias in patients under forty should be looked upon as syphilitic is of immense help in the diagnosis.

Locomotor ataxia and paresis, which have been grouped by Fournier among the parasyphilides, *i.e.*, the diseases to which syphilis often bears an etiological relation of a vague character, are sometimes truly syphilitic—that is, caused by gummatous deposits in the cord or the brain, and are, therefore, eminently amenable to antisyphilitic treatment. Such syphilitic pseudo-ataxia or paresis is rare.

True ataxia and paresis, in which the pathological lesion is a progressive sclerosis, but not a deposit of syphilitic tissue, may apparently sometimes be benefited in the early stages by a vigorous course of iodides; but they are, generally speaking, not amenable to antisyphilitic treatment.

The greatest surgical interest attached to ataxia relates to the so-called Charcot knee joint, a dystrophic degeneration of the ligaments of the joint, permitting abnormal mobility and exciting synovitis and traumatic irritation of the tissues about the knee, which thus swells and takes on an appearance somewhat re-

sembling that of a tuberculous knee. Indeed, I have seen a patient who was brought into the hospital upon a stretcher, so that his gait did not attract attention, and who would have submitted to resection of the joint for supposed tuberculosis had not a searching examination at the last moment revealed evidences of previous syphilis and present ataxia.

The diagnosis of such a case is, of course, obscured by the fact that the diseased knee may prevent the patient from walking and exhibiting the characteristic gait. But the history of syphilis, of gastric or intestinal crises, of lightning girdle pains, of difficulties with urination and defecation, of impaired locomotion before the occurrence of the knee implication, should always make the diagnosis clear; whereas confirmatory signs may be obtained by absence of knee-jerk and abnormality of pupillary reaction.

SYPHILIS OF THE UPPER AIR PASSAGES.

Syphilis of the nose, mouth, and throat is quite as common in its occurrence and as diversified in its manifestations as is syphilis of the skin. The various types of secondary syphilides—erythema, mucous patch, condyloma, ulceration—have already been briefly described. They interest the surgeon only indirectly, for they are not amenable to surgical treatment nor can they be confused with truly surgical diseases.

The two extremes of syphilis, however, *i.e.*, chancre and gumma, imitate surgical maladies and require closer consideration.

Chancre.—Chancre of the lip is common; of the tongue, tonsil, or palate, rare. In whichever of these regions it occurs, it bears the common characteristics of chancre. It is a growth, dull red in color and ulcerated superficially, of a wooden hardness to the touch. Its size is often much greater than that of genital chancre. Its growth is rapid.

The two distinguishing characteristics of buccal chancre are painlessness and the rapid and considerable submaxillary adenitis.

The growth must be distinguished from Vincent's angina and epithelioma. With the former it is commonly confused. A smear taken from the surface of the ulcer shows the thick bacillus and the long spirochæta of Vincent's angina or the treponema of syphilis. The anginous ulcer looks more like a chancroid than a chancre and is exquisitely sensitive; but in the past two years I have seen four or five cases in which the diagnosis was possible only by means of the microscope.

Epithelioma, on account of its slow growth and the slight early glandular enlargement, is much more likely to be mistaken for gumma.

Gumma.—To distinguish gumma from neoplasm is no such easy matter. The history of previous syphilis, the absence of pain and of any marked involvement of the lymph nodes speak in favor of gumma; while the characteristic pain of

a malignant growth and the presence of hard, regional adenitis plead for neoplasm. Finally, the diagnosis often rests with the excision of a piece of tissue or the effects of antisyphilitic treatment. Although either of these diagnostic measures may in some degree fail—mixed treatment giving promise of some result at first in certain neoplasms, and the excised piece of tissue being sometimes nondescript in character—yet, generally speaking, these are the tests to which all neoplasms of doubtful character must be put.

Certain characteristics of gumma in different parts of the upper air passages are sufficiently important, however, to merit special notice.

Gumma of the Lip.—So rare is gumma of the lip that it is, one might say, always mistaken for epithelioma and excised as such. The only sure criterion is the test of treatment or of the microscope, as mentioned above; an apparent epithelioma of the lip occurring in a man not yet forty years of age is open to grave suspicion.

Gumma of the Tongue.—Chronic neoplastic lesions of the tongue, like those of the lips, are always suspected of being malignant. Yet gumma of this organ is not very uncommon, and has certain characteristics which should distinguish it in most cases at a glance from epithelioma (common) or tuberculosis (very rare).

Gummata are usually multiple and occur upon the dorsum of the tongue, beginning as hard nodules, which enlarge quite rapidly and painlessly and then ulcerate and suppurate. The ulcer is excavated, with underlying sharp edges and a sloughing base surrounded by an inflammatory area. It gives rise to little or no enlargement of the lymph nodes, does not bleed readily, and responds to antisyphilitic treatment.

Epithelioma, on the other hand, is never multiple, is almost always upon the edge of the tongue, and often begins as a wart or in a spot of old leucoplakia. It forms a more definite tumor than does gumma; it is surrounded by a thick and elevated border. It bleeds readily and suppurates much less freely than gumma, its discharge being sero-sanguineous and often foul. The submaxillary lymph nodes become enlarged, and a snipping from the growth shows the characteristic cell nests and heaped-up layers of squamous epithelium. Epithelioma, of course, occurs late in life and is not affected by drugs.

Finally, tuberculosis causes a relatively insignificant, shallow, slow-growing, tender ulcer, usually upon the tip of the tongue. There is generally at the same time tuberculosis elsewhere in the body, and bacilli may be found in the secretion of the growth.

Gumma of the Palate and of the Nasal Bones.—Perforating gumma of the palate and of the septum, less frequently of the turbinated bones, is one of the commonest bone lesions of syphilis, and, while in some cases the gumma may grow but slowly, it is characteristic of the lesion that it progresses rapidly, ulcerates through the superficial tissues, either into the nose or into the mouth,

almost before the patient knows the lesion is there, and within a very few weeks so infiltrates the subjacent bone—be it palate or vomer—that the circulation is cut off, necrosis of the bone occurs, and a perforation is formed, extending from one nostril to the other or from mouth to nostril, as the case may be: which perforation remains a permanent evidence of its specific cause. Indeed, if the gumma is not soon recognized and vigorously attacked, it may eat away great areas of bone, and may even, in exceptional cases, extend its infection up through the sphenoidal cells into the meninges, and so cause death.

Chronic ulceration of the palate or of the nasal cavities is thus immediately suggestive of syphilis, especially if there is bare bone at its base and if from it arises a foul, disgusting odor. Sometimes the nasal bones may be made to crackle under lateral pressure, and ancient destruction of these bones is familiar in the saddle-backed, bridgeless, pug nose which it produces. In the one case of epithelioma of the hard palate which I have seen, there could be no question of the diagnosis; the hard, lumpy growth, set firmly upon the bone, but not yet involving it, though it was many weeks old, did not suggest the destructive ulceration of gumma in any way. Gumma of the soft palate behaves, if anything, more virulently than gumma of the hard palate.

Gumma of the Larynx.—While it is no doubt true, as Mackenzie asserts, that, if complete case histories were to be obtained, "few syphilitics would be found who had not, at some period or other of the disease, suffered from some form of laryngeal affection," this statement covers a great many mild, secondary lesions, such as erythema, mucous patch, condyloma, which do not interest the surgeon. Gummata are not very common. They usually start from the epiglottis, but may appear on any part of the larynx. They may be single or multiple; they rapidly ulcerate and, destroy the cartilage. The healing of such ulcers under treatment leaves characteristic scars about the epiglottis, or perhaps around the whole larynx and trachea, and may result in atresia of the larynx.

Gumma of the epiglottis is usually painful on account of the motions of deglutition, but tuberculous ulcerations are much more painful and always exquisitely sensitive. The multiple, slow-growing, tuberculous ulceration, usually occurring in a young, tuberculous subject, may as a rule be readily distinguished from the rapidly growing, more malignant, syphilitic ulcers, which ordinarily occur at a rather later age; while malignant neoplasms, here as elsewhere, are more dense, more truly tumors, occur in older people still, and produce a watery discharge, the odor of which is not so foul as the "peculiar, sickening stench" of syphilitic ulceration.

Interstitial, Syphilitic Inflammation.—Besides the inflammations already mentioned, the throat and tongue are subject to diffuse, interstitial changes which especially interest us in the case of the tongue. Leucoplakia of the tongue—a white, shining patch upon the dorsum of the tongue—may or may not be syphilitic. It is common in smokers, and equally so in syphilitics; but it rarely,

if ever, occurs in syphilitics who are not smokers. On the other hand, syphilitics who do smoke acquire a diffuse, thick, irregular leucoplakia, the patches of which are interspersed with deep fissures and perhaps with gummatous ulcerations, thus producing a virulent condition never due to tobacco alone, and characteristic of the combination of syphilis and tobacco. To improve such a condition, the first requisite is entire abstinence from tobacco, alcohol, and all hot and spicy foods; second, syphilitic treatment; and, third, the application of vigorous cauterization. Nitrate of silver is often not strong enough; the *liquor hydrargyri nitratis* is better, and in some stubborn cases it is necessary to cocainize the tongue and then to apply the actual cautery; but, inasmuch as some severe cases resist even this vigorous treatment, and as the scars resulting from such cauterization may be quite as inconvenient as the original malady, and may even set up points of ulceration for new gummata, it is wise to be circumspect in the employment of the actual cautery.

SYPHILIS OF VARIOUS ORGANS AND STRUCTURES.

Syphilis of the Testicle.—The testicle and epididymis are the only portions of the genito-urinary tract in which syphilitic lesions are at all common (except, of course, lesions of the skin of the genitals), and, although clinical records do not show the occurrence of testicular syphilis in any large proportion of cases, so common is it, nevertheless, that many pathologists seek for evidence of diffuse, interstitial orchitis in doing a post-mortem, and consider this, when found, conclusive evidence of the existence of syphilis. Yet, as far as the clinician is concerned, this diffuse, interstitial orchitis was doubtless never noted during life.

Syphilis affects the testicle in its secondary as well as in its tertiary stage. Slight temporary congestion (a secondary epididymitis) has been occasionally noted; it is of no especial clinical importance. The tertiary lesions consist in diffuse, interstitial orchitis—pathologically common, clinically rare—and gummatous, epididymo-orchitis, clinically quite common. This latter condition calls so loudly for treatment that it is usually cured and does not appear at autopsy.

Gummatous orchitis rarely occurs until several years have passed from the date of chancre; but, although its growth is painless, it may increase the size of the testicle to twice or three times the normal in the course of six or eight months, and usually attracts attention in this way. Examination of the enlarged gland reveals an irregular, lumpy condition, which may or may not be shrouded by an associated hydrocele. Careful palpation shows that the lumps, if in the testicle, are hard and rounded, unless the case has been long neglected, when they may have gone on to softening and may even have broken through the skin, leaving a sluggish, suppurating, sloughing tract.

In many instances, however, the epididymis is affected with the testicle, and in a fair proportion of cases it is the only part of the organ involved. In the epi-

didymis the changes are, to a practised finger, absolutely characteristic. The head, or the tail, or both, may be enlarged. This enlargement is insensitive, of a wooden hardness, and, generally speaking, diffuse, though one may feel certain nodules or irregularities in it. Its most striking characteristic, however, is a sharp edge, which projects above the testicle when the globus major is diseased, below it when the globus minor is involved, and, by its sharp edge and position with reference to the testicle, suggests the title "clam-shell epididymis," which very well describes the sensation imparted; for the testicle feels as though it were a stone lying loosely in a clam-shell. This characteristic epididymal change once recognized can scarcely be mistaken for anything else, although it may be simulated by chronic epididymitis or by tuberculosis. Yet the characteristic form of this latter malady—a rounded swelling or series of swellings chiefly confined to the epididymis—does not in any way suggest the sharp-edged syphilitic epididymis.

Rarely the vas deferens as well as the epididymis is gummatous.

An important point in the prognosis was established by Gosselin, when he found spermatozoa in the urine of a patient cured of double syphilitic orchitis. If, however, the process is allowed to involve the whole testicle, atrophy and sterility are likely to follow the arrest of the active disease.

The differential diagnosis of the various tumors of the testicle is, I think, sufficiently detailed in the following table, which I constructed some years ago from another work:

DIAGNOSTIC TABLE.

	Simple Chronic Epididymitis.	Tuberculosis.	Syphilis.	Tumor.
History.	Gonorrhœa, stricture, or hypertrophy of the prostate.	Tuberculosis, family or personal.	Syphilis, inherited or acquired.	Perhaps trauma.
Frequency	Uncommon	Frequent.	Frequent	Rare.
Size	Small between attacks.	Does not reach any great size.	Does not reach any great size.	May reach any size.
Sensitive.	Yes.	Yes	No.	No.
Shape	Between attacks testis normal, epididymis nodular.	Epididymis nodular. Testis not involved unless acute or ancient.	Testis evenly enlarged, slightly nodular. "Clam-shell epididymis."	Testis considerably enlarged. No characteristic involvement of epididymis.
Cord	May be slightly thickened.	Usually enlarged and nodular.	Free	Free. Veins dilate in later stages.
Seminal vesicles. . .	Usually distended	Tubercular.	Uninfluenced. . . .	Uninfluenced.
Prostate	Posterior urethra congested or inflamed.	Congested. May be tubercular.	Uninfluenced. . . .	Uninfluenced.
Urine.	Cloudy.	Cloudy. May contain bacilli.	Clear	Clear.
Hydrocele.	Unusual	Often	Nearly always. . .	Unusual.
Onset.	Usually acute.	Usually chronic. . .	Chronic.	Chronic.
Course.	Recurrent acute attacks.	Usually chronic. . .	Chronic.	Fairly rapid.
Opposite testicle . .	Often involved simultaneously.	Usually involved subsequently.	Free	Free.
Abscess.	Unusual	Common	Rare.	None.
Potency	Unimpaired.	Somewhat impaired.	Somewhat impaired.	Unimpaired.
Atrophy of testis. .	Rare	Rare	Common	Never.

In case of doubt, the aspirating needle should eliminate the possibility of hydrocele, spermatocele, or hæmatocele; and the diagnostic test of antisyphilitic treatment should never be forgotten before surgical measures are attempted.

Syphilis of Bone.—Surgical syphilis is bone syphilis, for syphilis of bone is extremely common, closely resembles other bone diseases the differential diagnosis from which requires surgical experience, and often causes destruction and sequestration of bone, the treatment of which demands surgical skill.   For this reason a special article has been dedicated to this subject in one of the later volumes.

Syphilis of the Bursæ and Tendon Sheaths.—Secondary subacute bursitis and tenosynovitis are rare and surgically unimportant.

Gummatous tenosynovitis is extremely rare.

Gummatous bursitis, while rare, is readily confused with other forms of chronic bursitis, and is therefore surgically important.   It usually attacks the prepatellar bursæ, doubtless because they are the most subject to predisposing trauma.   The inflammation is gummatous and progresses rapidly.   At first it forms a hard, diffuse swelling.   This soon softens, implicates the integument, and bursts, leaving a characteristic syphilitic ulcer.   Periosteum and bone may be invaded secondarily.

Syphilis of the Muscles.—The secondary manifestations of syphilis in the muscles are myositis and contracture.   The former, an acute or subacute inflammation of the muscle, is one of the rarest manifestations of syphilis.   The latter, a simple contracture of the muscle, doubtless due to subacute myositis, usually occurs in the brachial biceps.   This muscle contracts suddenly or progressively, drawing the elbow to a right angle and so fixing it.   Attempts to overcome this flexion are intensely painful and violently resisted.   Otherwise there is no pain.   Electrical reaction is lost.   The contracted muscle feels a little harder than its fellow.   This condition yields slowly to antisyphilitic treatment.

Tertiary syphilis may cause interstitial myositis or gumma.   Both are rare.

Syphilitic interstitial myositis is a chronic process, causing swelling and contracture of the affected muscle.   Pain is slight unless excited by attempted motion.   The absence of redness, œdema, leucocytosis, and fever excludes acute, inflammatory myositis.   If the condition is neglected the muscle becomes permanently contracted and atrophied.   Ossification is exceptional.

Gummatous myositis is characterized by the appearance of a large, hard, circumscribed, intramuscular tumor.   It is scarcely tender or painful.   It softens very slowly, and then, simulating tuberculous abscess, gradually ulcerates through the skin, forming a syphilitic ulcer.   The sterno-mastoid is the muscle most frequently attacked.

Syphilis of the Lymph Nodes.—Apart from the familiar, generalized, secondary syphilitic adenitis already described, the lymph nodes not infrequently undergo gummatous degeneration.

Three cases I happen to have seen recently will elucidate the surgical characteristics and differential diagnosis of these and allied processes.

The first patient, a man 48 years of age, with no previous history of syphilis, complained of a hard, irregular tumor of the cervical lymph nodes below and behind the angle of the jaw. Examination revealed an enlarged, ulcerated tonsil directly connected with the growth. A few weeks of vigorous, antisyphilitic treatment failing to have any effect, it was promptly removed, and proved to be a mixed-celled sarcoma of the tonsil.

A few weeks later I saw a patient in the third year of his syphilis, who had been quite constantly under treatment and had, upon the left side of his neck, a swelling of the lymph nodes, at first sight almost identical with that of the previous case. Neither was particularly painful, and their degree of hardness was about the same. But in this latter case there was no involvement of the tonsil; there was a large submental lymph node which rapidly broke down and discharged a watery pus, and on the opposite side of the neck there was slight enlargement of the corresponding node. The history of syphilis, the bilateral lesion, the rapid growth and ulceration of the submental lymph node made the diagnosis of syphilis, which was confirmed by the success of treatment.

At the time when I was treating this latter case I had under my care a third man, an alcoholic, who, although in the first year of his syphilis, had very rebellious, diffuse, tubercular syphilides. While these were disappearing under treatment, there suddenly appeared a large, tender swelling of the inguinal lymph nodes, most marked upon the left side. Examination of the preputial cavity revealed a number of mucous patches and a disgusting state of filth. Cleanliness and a little nosophen powder, together with the general treatment of syphilis, which was being vigorously pushed, promptly cured the mucous patches, and the swollen nodes in due time subsided.

The chain of causes in this instance was characteristic. First, the dirt under the prepuce caused the mucous patches by its irritation; then the mucous patches emitted an acrid secretion, which caused balanitis, of which the secondary, glandular infection in the groin was the first sign; and, finally, cleansing of the dirt and a little antisepsis were the means of cure, the mercurial treatment not being changed in any way.

THE DIAGNOSIS OF SYPHILIS.

In order to make a diagnosis of syphilis, it is not sufficient to determine that a given lesion, from which the patient is at present suffering, is syphilitic. The diagnosis must go deeper than this. It must answer sundry questions: How long has the patient had syphilis? How severe and of what nature have been its previous manifestations? Has the treatment of the early stages been appropriate and adequate?

To illustrate the need of this searching investigation, let us suppose a patient sent to consult a surgeon concerning a growth in the upper part of his tibia. Examination reveals that it is—doubtless, but not certainly—a gumma. A searching investigation of the patient's history reveals the fact that the primary and secondary stages of the disease occurred some eighteen months previously. This certifies the diagnosis. But the treatment thus far has been desultory and directed solely against existing symptoms. Here, then, is a neglected case, requiring a systematic and prolonged course of mercury to cure the disease, quite as much as a short, sharp course of iodides to heal the existing lesion.

It is necessary, therefore, for certainty of diagnosis, for accuracy of prognosis, and for intelligence of treatment, to diagnose not only the syphilide, but also the syphilis. The examination had best be undertaken systematically by the following routine method, viz.:

1. Examination of the lesion.
2. Examination of the patient.
3. Investigation of the patient's history.

And, if a certain conclusion cannot be reached by these means, we add:

4. Observation of the progress of the lesion—the test of time.
5. The test of antisyphilitic treatment.

Let us consider each of these methods in detail.

1. Examination of the Lesion.—The safest method to pursue in a case of suspected syphilis is to examine the lesion and the patient before making any allusion or venturing any question about the previous history, for thus alone can the surgeon keep his mind uninfluenced by that perennial and omnipresent symptom of venereal disease—lying.

Little need be added concerning the examination of the lesion beyond what has been already reviewed in the preceding pages. *Inspection* reveals the number, the grouping, the configuration, the color of the suspected lesions; while *palpation* reveals their sensitiveness, density, and extent.

Aspiration may exceptionally be employed, and sometimes *biopsy*—snipping off a bit of the suspected tissue for microscopic examination—is necessary for a prompt differential diagnosis between gumma and malignant neoplasm.

2. Examination of the Patient.—Inasmuch as the surgeon's diagnosis is concerned almost exclusively with the tertiary lesions of syphilis, the patient's person should be examined, chiefly with reference to the scars left by previous lesions.

First examine the *skin, especially the shins*, for here are most likely to be found those round, pigmented, parchment-like scars already described—the indelible evidences of previous ulcers. *Palpation of the tibiæ* and other bones may reveal tenderness, exostoses or the cavities left by gummata. In going over the rest of the body, do not fail to *palpate the various subcutaneous lymph nodes*, on the chance that a group of enlarged nodes may lead to the discovery of some

lesion you might otherwise overlook, or that a general enlargement of the lymph nodes may be present to prove the disease a recent acquisition. At the same time a general physical examination of the *thoracic and abdominal viscera* may throw some light on the negative side of the question—the existence of other diseases than syphilis.

Finally, the *mouth, nose, and throat* should be carefully examined for mucous patches, ulcerations, perforations of palate or of septum; and the *tongue,* especially if the patient is a constant smoker, may be expected to show leucoplakia, interstitial glossitis, or ulceration if the syphilis is old and severe.

The *genitals* in tertiary syphilis may still bear the scar of the chancre, while in the earlier stages of the disease they are peculiarly likely to harbor mucous patches or condylomata.

3. Investigation of the Patient's History.—The patient should be questioned, first, in relation to the duration, course, pain, or itching of his present lesion; then as to his past history, the number and duration of his genital sores, their period of incubation, the condition of his health thereafter, especially as to eruptions upon skin or mucous membranes, and headache or other pains, *with severe nocturnal exacerbations.* Finally, he should be closely questioned as to medication—what, and how much, and for how long a time.

The patient's statements upon all subjects must be accepted with a certain reserve. He may be ignorant or he may be lying. But upon two subjects his testimony is next to valueless. Ask him if he has lost much hair, and, if he thinks he has syphilis, he will describe with poetic fervor the departed glory of his flowing locks, whether he has lost any hair or not. His answer reflects the condition of the inside of his head, not that of its exterior.

The other subject upon which the patient's opinion is all but valueless is the interpretation of his case by the physicians who have previously had him in charge; for here the possibility of error is twofold. The physician may err and the patient may misinterpret the physician's opinion. On this point, therefore, little credence may be placed.

As a result of these investigations one can usually make a definite diagnosis: the patient has or has not syphilis. It is true, a certain number of individuals reach tertiary syphilis without any recollection of having passed through the earlier stages. Yet in men this is very rare (3.7 per cent, according to Fournier); and, if it is more frequent (17.9 per cent) in women, they nevertheless usually give a characteristic history of miscarriages and infant mortality; while among the ignorant classes, whose history is of little value, one may expect to find plenty of scars of previous neglected lesions.

But, supposing the patient has had syphilis, the question still remains: Is the present lesion syphilitic?

Here is a distinction many practitioners never make. If a patient be confessedly syphilitic,—nay, let him be suspected on grounds however inadequate,—

and if ever after he suffer from anything more mysterious than a toothache, they pour in iodides on general principles (such men always use iodides, never mercury), without ever a thought that syphilis is no preventive of other diseases, and, bad as it is, it has no power to tinge every disease from which the patient may subsequently suffer. In short, although it is advisable not only to prove the lesion syphilitic, but also to prove that the patient has syphilis, it is essential, even if the patient be syphilitic, to prove the lesion syphilitic too.

4. The Test of Time.—Yet this proof may not be readily attainable. An ulcer in the upper third of the leg, a mushy or fluctuating tumor arising from bone in a healthy adult—such lesions are obviously syphilitic. But, to take a common example, a small, hard growth on the tibia may be either neoplastic or syphilitic. How shall we decide? We may wait and watch the growth until it develops definite characteristics of syphilis or of neoplasm. Sooner or later the diagnosis will be clear—and if the growth prove malignant the patient will die! It is in just such cases that delay is criminal; and, since almost every tumor of bone *might* be syphilis or *might* be malignant disease, we require an immediate, accurate, differential test. Such is:

5. The Test of Treatment.—When in doubt, treat for syphilis. A short, sharp course will decide in two weeks whether the lesion is syphilitic or not. This method of diagnosis is a confession of weakness, to be sure, but such frank confession of weakness is an exhibition of strength.

THE TREATMENT OF SYPHILIS.

The treatment of syphilis is twofold: A routine course, covering the first three years or so of the disease, by which we hope to rid the patient of his malady; and beyond this, perhaps simultaneously, perhaps subsequently, the treatment required to conquer the symptoms from which the patient happens to suffer.

The Routine Treatment.—Without delaying to dispute the pros and cons involved, we may state briefly certain rules concerning the routine treatment of syphilis. As this subject does not directly concern the surgeon, it were a waste of time to enter into detail here.

1. The routine treatment of syphilis should be instituted as soon as the diagnosis is assured. But, since the unwarranted accusation of syphilis is, morally and physically, no less ruinous than the neglect of an actual existing syphilis; and since in spite of many sincere and searching investigations no one has ever been able to show that treatment during the first months in any way mitigated the subsequent course of the disease, *treatment should never be instituted until the diagnosis is absolutely assured.* Now even the specialist—*a fortiori,* the surgeon or the general practitioner—can rarely be certain in his diagnosis of what he believes to be a true chancre, or of what he believes to be a syphilitic pleiad, until this belief is confirmed by an unmistakable secondary eruption. Hence it is a

general rule, with very few exceptions, that treatment should not be begun until a characteristic, general, secondary eruption has made its appearance.

2. The treatment should be continued for at least two and a half years. If, during the last year of that time, the patient shows no symptoms of syphilis, he should be watched six months longer, without treatment; and if he remains clean and sound, he may then be discharged as cured, with the assurance that medicine has done all it can to cure him, and that he has eight chances out of ten of never hearing from the disease again, but with the proviso that it is impossible by any system of treatment to assure him absolutely against the possibility of relapse.

If, on the other hand, the disease is not so easily conquered, if symptoms continue to appear after the first eighteen months of treatment, the period of treatment should be extended until a year shall have elapsed since the appearance of the last symptom, and six months of confirmatory observation should always follow the cessation of treatment.

3. The patient may marry at the end of five years from the beginning of his disease, if he has had no symptom of syphilis for eighteen months previously and if he has submitted to proper treatment. Exceptionally, but only after obtaining the consent of a specialist, the patient may marry earlier.

Lack of thorough routine treatment may result in the transmission of syphilis from an apparently healthy mother to her child, even though many years have passed since she acquired the disease.

If, for social reasons, a man is forced to marry early in the disease, he should not be permitted to have sexual intercourse, unless covered, until six months after the appearance of his last symptom; and if his wife should become pregnant at any time within the limits prescribed above, she should undergo the routine treatment for syphilis throughout her pregnancy.

4. In order to minimize the severity of the disease, the patient should avoid every excess likely to impair his physical or nervous strength. He should, as far as practicable, "go into training."

Above all else, he should *avoid alcohol*. No man who studies syphilis in the clinic can doubt that, whatever the ordinary mortal may suffer from alcoholism, the syphilitic who suffers the later complications of the disease is pre-eminently the syphilitic who drinks. While it is, of course, impossible to make a strict rule, I believe that the man who takes no more than two or three drinks a day definitely reduces his power of resisting syphilis. Every syphilitic should be earnestly urged to become a total abstainer. The effort may be futile, but it is worth the making, for syphilis without alcohol and syphilis with alcohol are almost different diseases.

Tobacco is harmful only as a local irritant. The common lesions of mouth and throat are induced and aggravated by tobacco, leucoplakia is due to syphilis plus tobacco, and mercurial salivation may be induced in a susceptible sub-

ject by the irritating smoke. Hence, if the patient has no trouble with his mouth, he may smoke, but he must smoke moderately to avoid inducing irritation; and if the mouth is sore he may not smoke at all.

For the same reason, a thorough dental overhauling is part of the preparation for a mercurial cure.

5. In order to protect others, the patient must be instructed that, during the infectious period, he may have sexual intercourse only with a condom; he may kiss no one on the mouth; he must use individual table utensils; he must himself wash from his garments any secretion from syphilitic sores that may cling to them.

6. And the cure itself? Mercury. Whether given by mouth, by skin, or by the hypodermic syringe, the patient should be kept under the influence of mercury two and a half years or more.

The ideal of treatment is that the patient shall take enough mercury to inhibit the symptoms of syphilis, and not enough to exhibit poisoning by the drug. In other words, not only should the patient not be salivated, but he should be given his mercury in such a form that it will perfectly agree with him, that he will feel, not depressed and run down, but fortified and robust under its use. This end may often be achieved by any of the routine methods of treatment, yet occasionally, with a susceptible patient, the physician may be at his wits' ends to get the mercury into the patient and yet to keep him in good health.

Another ideal, and one often overlooked, is that the patient should take his cure as directed. Put yourself in his place, and think what it must mean to drag through month after month in constant terror of new symptoms and new drugs. When practicable, therefore, the system of giving mercury by the mouth, and giving it regularly every day of the year, at the same time and in the same dose, is the best, in that it relieves the patient of all responsibility except the postprandial pill. And this soon becomes such a habit that when he gives it up he almost feels lonely. Unhappily, many patients cannot bear this form of medication, or the irruption of some symptom requires severer methods for its control; but when this so-called "tonic" system works, it is the best for the patient, though the least profitable for the physician.

The actual detail of the routine treatment of syphilis (whether by the tonic system or no) belongs to medicine, not to surgery.

The Cure of Symptoms.—Here is where the surgeon, like every other specialist, must be proficient, if only for purposes of diagnosis. It is true, as Osler says, that he who knows syphilis knows all internal medicine; but it is equally true that he who does not know how to treat syphilis is incompetent to practise any branch of the healing art.

The generally accepted formula of treatment is: "Mercury for the earlier symptoms; iodides for the later ones." This formula is both incorrect and misleading. While it must be granted that many of the later lesions of syphilis are

cured by iodides without mercury, they may be cured more rapidly by iodides with mercury; and in many instances the mercury is clearly the more important element of the cure, inasmuch as mercury alone will often cure old lesions upon which the iodides, even in heroic doses, make no impression.

The correct formula, therefore, is: For the earlier symptoms of syphilis, mercury alone; for the later symptoms, mercury and the iodides.

Though recognizing that this formula savors of heresy in this country, where iodides are used more frequently and more freely than anywhere else in the world, I am nevertheless convinced that it is the correct one. In 1876 a world bathed in iodides was startled by the announcement from the lips of my father that mercury is no poison when properly administered, and that iodides are not appropriate to the cure of the early symptoms of syphilis. Yet, in 1906, America, where this truth first saw light, still clings to a heroic system of iodization which Europe has largely replaced by the employment of mercurial hypodermic injections. Thirty years hence we may hope that the "Hot Springs' System" will be employed only when it is required, not as a cure for all phases of syphilis.

The Use of Mercury.—In the routine treatment of syphilis we aim at controlling the disease with the least possible amount of mercury. But in the treatment of symptoms our aim is altogether different. We want prompt results, whatever amount of mercury be required to obtain them. The disfiguring and incriminating lesion must be cured at the earliest possible moment, not only to save the patient from disgrace among his friends, but also, and this pre-eminently in surgical syphilis, to check the destruction of tissue and to minimize the resultant scar.

Now the old system of solving this problem was: Mercury by mouth or inunction; if these fail, iodides or mercury by the hypodermic method. Such a system does not really attack the problem. Neglecting the physical destruction, the mental despair that the slightest delay may entail, and placing pre-eminent the fancied comfort of the patient under treatment by mouth or by skin, it relegates to last that method of treatment which should be first.

Mercury by hypodermic injections is the surest, swiftest, safest treatment of the symptoms of syphilis. At the appearance of the first rash of the secondary stage, a couple of injections clear the patient's skin. A palmar syphilide, rebellious to all other forms of treatment, shows improvement after the second or third injection. The diagnosis of a doubtful bone lesion is determined by a course of injections (with the assistance of iodides) lasting but two weeks.

Rarely, injections cannot be employed. If the injector is clumsy or the injectee nervous, they may be unbearably painful. An innocent syphilitic wife may very well be persuaded to take pills for a theoretical anæmia, but she can scarcely be asked to expose her person to the arrow of adversity in the shape of a hypodermic needle without an explanation of the true nature of her malady. Yet, take it by and large, such cases are rare. Almost all syphilitics heal quicker

under hypodermic medication than under any other treatment, and for the great majority the inconvenience and danger of such treatment in no way diminish its utility.

Hypodermic Injections of Mercury.—Without enumerating the virtues and faults of the various salts of mercury, we may say briefly that the insoluble preparations are preferable to the soluble ones, on the score of greater efficiency, equal painlessness, and less frequent administration.

Of the insoluble salts the three best are salicylate of mercury, calomel, and gray oil.

Calomel, though very active, is too painful to be much used.

Gray oil divides the honors with the salicylate. It is perhaps less active than the salicylate, and apparently it is also rather less painful. It is best employed as made by some standard drug house. In case of need it may be made according to Vigier's formula:

> ℞ Hydrarg. bidestillat., ... 19.50
>   Ung. hydrargyri, ... 1.
>   Vaselin, ... 2.50
>
> Mix well until all the free mercury is taken up.   Then add:
>   Vaselin, ... 7.
>   Liquid vaselin (alboline), ... 20.
>
> S. Shake and warm.   Inject 4 to 7 cgm. (5 to 10 minims) once or twice a week.

Each cubic centimetre of the mixture contains 50 cgm. of mercury.

Salicylate of Mercury.—My own preference lies with the salicylate. My experiments with other salts have always led me back to this one, and of the various formulæ I prefer the simplest, viz.:

> ℞ Hydrarg. salicylat., ... 3 (gr. xlviij.).
>   Alboline (or benzoinol), ... 30 (℥ i.).
>
> M. S. Shake. Inject 5 to 10 cgm. (9 to 16 minims) once or twice a week.

The Technique.—The *instrument* required is a hypodermic syringe made of glass or metal (sterilizable), fitted with a needle, $1\frac{1}{2}$ to 2 inches long, and of a sufficiently large calibre not to choke with the oily solution.

Syringe and needle are prepared by *boiling*, the surgeon's hands by scrubbing, the patient's skin by a sharp rub with alcohol and ether.

The injection is made preferably near "*Galliot's point*," at the intersection of a horizontal line passing two fingers' breadth above the great trochanters and a perpendicular line dividing the outer third from the inner two-thirds of the buttocks.

For a woman it may be more convenient to employ the interscapulo-vertebral region (Lang). The injections are made in the dorsal region, on a line 4 cm. (2 finger-breadths) from the median line. In a fat subject Dr. Sinclair has made the injections into the pectoralis major.

The injection must be made into the muscles. If the mercury is deposited in the subcutaneous tissue, it will certainly produce a sharp inflammatory reaction, probably a slough.

The *technique* is, therefore, the following: With the patient lying prone and the region about Galliot's point sterilized, the needle (loosely screwed to the syringe) is jabbed directly into the buttock to a depth of from one to two inches (depending on the depth of the superficial fat). The syringe is then unscrewed and loaded. Before reapplying the syringe, pinch the tissues about the needle and note whether any blood is forced into it. If so, withdraw it halfway and plunge it in again until no blood can be squeezed into it. Thus you ascertain that its point is not in a vein. Now reapply the loaded syringe, aspirate into it the minute drop of air in the top of the needle, and slowly inject the determined amount of mercury. Quickly withdraw the needle, rub the skin briskly for a moment to prevent leakage of the injection, and, if any blood exudes, clap on a piece of adhesive plaster, with instructions that it be removed the following morning.

Injections are repeated on alternate sides of the body. No two should be placed at an interval of less than one inch apart.

The *result* of such an injection is usually a slight uneasiness, beginning an hour or so after the injection and lasting for a day or so. Exceptionally, the pain is intense and may simulate sciatica. The first injection is habitually the most distressing.

The *accidents* that may follow injection are: 1. Suppuration, which, in an experience of ten years, I have never seen. 2. Lumps of induration, showing that the injection has set up considerable local reaction. (These occur rarely with gray oil or salicylate if it is injected aseptically and into the muscle.) 3. Embolism. This I have seen but once, but others have frequently met with it. It usually occurs within a few moments of the injection, beginning with a severe, irritative cough, which lasts a few hours and is followed by a very localized bronchitis or broncho-pneumonia, rarely severe enough to detain the patient in bed. The preliminary irritative coughing may not occur. I have never heard of a fatal case.

4. Mercurial poisoning may occur under treatment by the hypodermic method as well as under any other form of mercurial medication. Indeed, unless there is urgent need of immediate and thorough mercurialization, it is safer to test the patient on light doses (0.5 gm.), for the first injection may be followed by a sharp purging and light salivation. On the other hand, a subject whose stomach is totally intolerant of mercury often does extremely well on injections.

When there is grave destruction of bone, however, or some equally severe lesion, then prudence must be thrown to the winds and the full dose given, not once a week or twice a week, but every other day until the first sign of salivation appears. But *with the first sign of mercurialization the injections must stop,*

for the salivation will not reach its maximum for several days, and to pile on more injections would be but to add unnecessary suffering, for grave salivation is debilitating and no more calculated to cure syphilis than any other poisoning would be. Moreover, caution is encouraged by remembering that if we once put in an injection we cannot get it out again.

Other Methods of Administering Mercury.—The administration of mercury by fumigation, inunction, and by the mouth requires no especial mention here. Usually inferior to injections in efficacy, they are, nevertheless, applicable to the treatment of many of the milder manifestations of the disease, while exceptionally they succeed where injections fail.

The Use of Iodides.—Until the introduction of hypodermic mercurial medication, the good old rule, "Mercury for secondary syphilis, iodides for tertiary syphilis," was generally accepted, in spite of the fact that occasionally a case of tertiary syphilis resisted iodic treatment; or, what was more striking, a doubtful case that had been treated freely by iodides without benefit was submitted to operation, and the excised growth pronounced syphilitic by the pathologist.

Such accidents still happen, but the general use of mercury by hypodermic has made them much less frequent. With our present knowledge we may divide tertiary syphilides into five classes:

1. Cases that do well under the ordinary "mixed treatment."
2. Cases that require mercury by the hypodermic method.
3. Cases that require heroic doses of iodides.
4. Cases that require tonics and hygiene.
5. Parasyphilides.

1. The great majority of tertiary syphilides fall under the first category. They may be promptly cured by one of the familiar formulæ given below.

2. A certain small proportion of cases, including especially palmar syphilides, orchitis, chronic sclerotic glossitis and laryngitis, and sclerotic visceral lesions, often resist iodides in any dose, yet yield to mercury by the hypodermic method, without iodides.

3. Bone syphilis sometimes, and cerebro-spinal syphilis always, demand high doses of iodides. Cerebro-spinal syphilis in whatever form is the source of the greatest concern. In order to prevent permanent damage, its lesions must be cured promptly before secondary degenerative changes have occurred. Moreover, these lesions do not usually yield except to very high doses of iodides, the effect of which appears to be heightened by mercurial hypodermics. Hence, iodides to the point of poisoning and mercury to the point of salivation constitute the rule. It is in such cases that the "Hot Springs treatment" and the Hot Springs of Arkansas themselves are useful.

4. Anæmic, scrofulous, and debilitated subjects require hygienic and tonic treatment in addition to the specific course. Rupial syphilides, however rebellious to specific remedies, often yield to general hygiene.

5. The parasyphilides, ataxia and paresis, though sometimes amenable to specific treatment in their early stages, are generally more benefited by hygiene, exercise, electricity, and strychnine.

Potassium iodide is the salt that has the confidence of the profession, and, despite its obvious defects, its disgusting taste, and the poisonous effects to which some persons are so peculiarly susceptible, it is yet the best we have—with sodium iodide a poor second.

The dose is 5 grains (0.7 gm.) thrice a day to begin with, and the full dose is 10 to 20 grains. In severe cases one may have to push the dose up to 100 or 200 grains a day, even in face of pretty severe poisoning (see above); but in nine cases out of ten the lower doses are quite adequate, and those vicarious heroes who hurl gallons of iodide into every syphilitic they meet ruin more stomachs than they cure syphilitics.

The so-called saturated solution (equal parts of iodide and water) is the usual and most convenient form of administration. The beginning dose is thus five minims, and, by adding a minim a day, the proper maximum is attained. *But the iodide must always be administered greatly diluted*, each dose in a tumblerful of fluid. Milk, vichy, tea, coffee, any excipient that proves grateful to the patient, may be employed. The dose is best digested if taken an hour before meals or two hours after meals.

There is no need to relate the symptoms of iodine-poisoning. Suffice it to say that a certain number of patients cannot take iodides in any form. For them we must depend upon mercury.

An attempt has recently been made to produce an iodized oil suitable for injection. Iodipin has not been well received. Lafay's forty-per-cent oil (lipiodol) is said to be better.

Mixed Treatment.—The two familiar formulæ for mixed treatment (I hesitate to choose between them) are:

> ℞ Hydrarg. chlorid. corrosiv., ...   gr. i.–ij.
> Potass. iodid., ...   ℥ ij.–iv.
> Aq. aurant. cort. (or syr. sarsaparillæ co. or aq. menth. pip. etc.), ad   ℥ iv.
>
> M. S. Teaspoonful well diluted an hour or two after each meal.

Or:

> ℞ Hydrarg. biniodid., ...   gr. i.–iss.
> The rest as above.

By using such a mixture in connection with a saturated iodic solution, the daily dose may be varied as required.

If, however, the mercury is given by injection or by inunction, the simple iodic solution is all that need be taken by mouth.

The Test Course.—In speaking of diagnosis, we had occasion to refer to the test course by which a syphilitic lesion might be promptly recognized. Such a

course consists in the injection of 15 minims of the salicylate-of-mercury mixture twice a week,* and the administration of from 10 to 15 grains of potassium iodide thrice a day for two weeks. Before the end of that time a syphilitic lesion previously untreated may be expected to show marked improvement. Exceptionally, however, higher doses of the iodide are required.

* The more familiar daily inunction of a drachm of blue ointment is less effective and, in my experience, more repugnant to the patient.

PART VIII.

SURGICAL DISEASES OF VARIOUS
WIDELY DISTRIBUTED STRUCTURES
OF THE BODY.

ABSCESS.

By AUGUST F. JONAS, M.D., Omaha, Nebraska.

Definition.—An abscess means a swelling whose contents consist of pus—a circumscribed collection of pus, in contradistinction to an infiltration of the cellular connective tissues with pus. It is also incorrect to use the term abscess, instead of that of diffuse phlegmon, when speaking of an organ or a tissue—*e.g.*, the musculature or a fascia—which is extensively infiltrated with pus. It has become customary in practice to consider only circumscribed collections of pus abscesses.

The practitioner always has in mind the idea that every collection of pus has formed at the expense of the connective or membranous tissues. Consequently, the word empyema has been applied to pus collections which occur in physiological cavities and which, therefore, have not formed at the expense of the membranes lining such cavities. Thus, for example, we speak of empyema of the pleura, of the pericardium, of joint cavities, and of synovial sacs. At the same time the term abscess is quite as frequently used to designate the presence of pus in these cavities, and by many practitioners it is so used by preference in the belief that they are not so likely to be misunderstood.

One finds pus collections in all organs and tissues: in the brain and in the spleen; in the liver and in the kidneys; in the cornea and in the medullary canals and the lymphatics; between the media and the intima of a vein, as well as between the layers of bladder wall; in the substance of a muscle and also in that of a periarticular fungous mass; in an ovarian cyst or a hydatid sac.

Abscesses are commonly found in the connective tissue.

Classification.—We may classify abscesses, as they are commonly encountered in practice, as follows: (1) According to their location, as (*a*) superficial or subcutaneous, and as (*b*) deep-seated or subfascial; (2) according to their clinical characteristics, as (*a*) acute or hot, and as (*b*) chronic or cold.

The quantity of pus they contain varies according to their location, the character of the structure that forms their walls, the nature of the infection, the length of time they have existed, and the kind of tissue in which they are located.

Pus usually spreads in the direction of least resistance, and thus an abscess may become very large and may burrow extensively; very little resist-

ance being offered by the loose connective tissues. On the other hand, fascia usually presents a most effective barrier, and pus extends only along its course. Superficial abscesses extend for considerable distances in horizontal directions.

Subfascial abscesses find their way along the sheaths of muscles and blood-vessels, sometimes passing beneath the periosteum and separating it from the bone for a considerable distance. The route of an abscess can often be determined when we take into consideration the extent of a fascia and the direction in which it runs. As an example, we may refer to psoas abscess, which begins in a vertebral body, burrows downward in the psoas fascia behind the peritoneum, and finally appears in the groin.

Etiology.—Abscesses are due to two causes: first, an infection with micro-organisms of different kinds; second, an irritation dependent upon the introduction of various chemical substances. The first cause is almost exclusively operative in the cases of abscess which we encounter in practice. The second cause rarely comes into play outside the laboratories. It has been shown experimentally, for example, that the introduction, aseptically, of such substances as turpentine, zinc chloride, nitrate of silver, and many other chemicals is competent to set up suppuration in the tissues into which one of these substances has been introduced. In practice, the surgeon has little or nothing to do with chemical abscesses; consequently we will confine ourselves to the consideration of pyogenic bacteria. Ogsten first demonstrated these organisms in 1881, and later (1884) they were also demonstrated by Rosenbach. These observers established the fact that the organisms with which we have chiefly to deal in suppuration are the Staphylococcus pyogenes aureus, citreus, and albus and the Streptococcus pyogenes. While they are more or less constantly present in abscesses, still suppuration is not entirely due to their agency. The most common pus-producer, after the ordinary pus cocci, is the Micrococcus lanceolatus. It may produce pus in peritonitis, synovitis, otitis media, and osteomyelitis, and in inflammation of the soft parts. The Bacillus coli communis may be found in all suppurative conditions affecting the abdomen and its contained organs, as in suppurative cholangitis, abscess of the liver, and appendiceal abscesses. The typhoid bacillus of Eberth may, after the lapse of a considerable period of time, cause suppuration of the biliary tracts and of the soft parts, empyema, and osteomyelitis.

Besides those already mentioned there are other micro-organisms which are known as pus-producers. They are the following:

The Staphylococcus epidermidis albus, which has been shown by Welch to inhabit the skin and to be the most common cause of "stitch abscess."

The Bacillus pyocyaneus, which has been found in blue pus and has been shown to be the cause of suppurative pericarditis, otitis media, ovarian and hepatic abscesses, and ascending ureteritis.

The Micrococcus gonorrhœæ, which has been shown to be pyogenetic.

The Bacillus pyogenes fœtidus, which has been isolated in a number of fœtid abscesses. This bacillus seems to have a close relationship to the colon bacillus.

The Bacillus prodigiosus and the Micrococcus intracellularis are known to cause abscess.

Finally, some varieties of fungi are classed among the pus-producers—*e.g.*, the ray fungus of actinomycosis, the Oïdium albicans, and many forms of blastomycetes. The Tricophyton tonsurans may also be the cause of cutaneous abscesses. The Bacillus tuberculosis of Koch is the cause of chronic or cold abscesses.

Man is more predisposed to suppuration than are any other members of the warm-blooded class. The common pus microbes exist normally on the skin and in the mouth and the vaginal secretions, and they gain entrance to the deeper structures when the epidermal or epithelial covering is injured. Such diseases as scarlatina, variola, diphtheria, influenza, measles, typhoid fever, dysentery, gonorrhœa, etc., predispose to pyogenic infection. Such infections are of a mixed character. The abscesses thus produced contain the microbes of the primary disease as well as pyogenic organisms.

Microbes in chronic abscesses lose their virulency, but they may regain it by being passed through several susceptible animals.

Origin of Pus.—When an abscess is located in an organ or in one of the tissues the question arises, Is the pus derived from the connective tissues of that particular organ or from the parenchyma, or are other elements, derived from some other source, constantly present? According to the views of Cohnheim, that which is ordinarily called pus is nothing more nor less than a fluid containing chiefly a mass of white blood corpuscles, which, by a process of diapedesis, have emigrated from the blood-vessels. It was assumed that, through the influence of the inflammatory irritants, the permeability of the blood-vessel walls was increased, and that in this way the emigration of enormous quantities of white corpuscles was rendered possible. This, however, does not explain the destruction of an organ—the liquefaction of the parenchyma and connective tissues. It might be imagined that these immigrated leucocytes collect in large masses and crowd away the surrounding tissues. This theory assumes that the liquefying tissues suffer destruction in a passive way. Stricker, who defended Virchow's cellular theory, took the ground that where pus formation had taken place, there the parenchyma had undergone destruction; this destruction being due to a disintegration of cellular tissue. It is fair to assume that disintegration is an active process, an accelerated vital process. It is preceded by a swelling of the cells. Then follows a disorganization of the normal cellular arrangement by a liquefaction of connective-tissue fibres, so that the component cellular elements float freely in the serum of the pus. According to this view an abscess will develop if the cells in any inflammatory centre resolve themselves into a mass of free cells—designated pus corpuscles—and float

in the serum of the pus. If this be true, then we must assume that the tenseness of the skin, in skin abscesses, is due to the hyperæmia and infiltration of the connective tissues, and is an expression of cell swelling. The subsequent central softening, the so-called purulent softening of the infiltrate, is a manifestation of disintegration and liquefaction—a change to pus.

Pus is a non-coagulable albuminous fluid containing a wealth of cells. Unlike blood and lymph serum it is non-coagulable. Pus is made up of a liquefaction of the fibres and cells of connective tissue, of dead and living leucocytes, of inflammatory exudates, and of micro-organisms. This liquefaction is brought about by digestive ferments, which have originated from the bacteria or from the cells or from both. The microbes first enter the tissues, and then their products bring about all the well-known inflammatory conditions, leading to leucocytic emigration and to the exudation of serum. The cells are destroyed by the bacterial products. The blood and tissue cells accumulate at the seat of primary infection; bacterial ferments, extra- and intracellular, are produced; the fixed tissue cells multiply; the immigrated cells increase in numbers. The resulting mass has a firm consistence. The toxic substances, the ferments, cause death of the cells and dissolve them, as well as the connective tissues.

Human pus is an alkaline, somewhat mucoid, thick creamy fluid, yellowish and sometimes green in color, and of a slightly sweet odor. It has a specific gravity of 1.030–1.033. Often the specific gravity is much lower. When pus is placed in a vessel and allowed to stand, it separates into two strata, the upper one being clear and of a yellowish color, not unlike blood serum and lymph. The lower layer is opaque and is composed of cells and other elements, formed and in a broken-up state. The chemical constituents of the upper stratum consist of albumoses, globulin, leucin, tyrosin, cholesterin, and fats; further, of magnesium phosphate, sodium chloride, and calcium chloride. The lower stratum contains various ferments and toxic elements.

Pus formed near the intestines usually has a fetid odor. Abscesses of the middle ear or the brain are frequently fetid—a condition which is due to putrefactive changes.

The color of pus may undergo a change when there is an admixture of blood. Under these conditions it may vary from a bright red to a deep chocolate. The Bacillus pyocyaneus may produce a green pus. The colon bacillus, the Proteus vulgaris, and the Bacillus aërogenes capsulatus may each be responsible for the formation of gas in an abscess.

Foreign bodies, parasites, shreds of tissue, caseous and calcareous masses are sometimes found in abscess cavities.

The formed elements of pus are composed chiefly of leucocytes of the granular polymorphonuclear type; there are also found eosinophiles and different kinds of hyaline cells with round and oval nuclei. In addition, there are found cellular detritus and the pus-producing micro-organisms.

Clinical Features.—When we consider the clinical course of an abscess we find, above all, two principal types: the hot or acute abscess, and the cold or chronic abscess.

Acute Abscess.—The acute or hot abscess—also the phlegmonous abscess —forms rapidly under severe inflammatory manifestations. In cases where the abscess is superficial, where its development can be closely followed, it will be observed that at first there is a red, smooth, hot, tense, and painful swelling due to an inflammatory infiltration, and that with this are associated disturbances of function which vary according to the anatomical situation of the swelling. The older surgeons gave to these characteristic changes the names *rubor, calor, dolor, tumor, et functio læsa.* After the lapse of a few days the swelling undergoes some softening in its most prominent part, but the connective-tissue spaces continue to be infiltrated with a serous fluid. Still later, it will be found that the infiltration is extending peripherally along the course of least resistance, which, as a rule, is toward the outer surface of the skin. Another phenomenon, which belongs to this stage of the disease, is the appearance of a maculated redness of the skin in the most prominent part of the swelling. By this time, too, the patient will generally be found to have an elevated temperature and he sometimes complains of chilly sensations. The process of softening at or near the centre of the swelling continues, and often on the third or fourth day a distinct elasticity can be felt. The skin, which has a glistening surface and a livid reddish hue, appears more tense. The pain, which in the beginning was of a throbbing character, becomes less as the softening increases and the skin becomes more attenuated. The fever, however, continues at about the same height. The skin over the most prominent part of the swelling steadily diminishes in thickness until it finally becomes as thin as paper, while at the periphery of the fluctuating swelling there can be felt a hard infiltrated zone, sometimes called the inflammatory wall. Finally, the deeper layers of the skin at the highest point of the swelling become liquefied and there remains at the surface only the epidermis, through which the pus is plainly visible. When this yellow spot or area appears, the layman will say, "The abscess is ripe." The rupture of this thin epidermal cover and the discharge of the imprisoned pus occur soon afterward. The pain and the fever then often disappear immediately. The abscess cavity becomes lined with granulation tissue which continues to develop until it completely fills the unoccupied space up to the level of the skin. This granulation tissue undergoes a change into completely organized connective tissue, and the process of repair is completed by epidermization and a gradual diminution of the size of the cavity by reason of the contraction which always takes place in newly formed connective tissue. Sometimes the abscess walls, after the escape of the pus, come immediately into complete contact. Union then quickly follows, and there remains, though only for a day or two, a small, crater-like surface at the point of rupture. The mode

of union which we have just described is analogous to the so-called "union by second intention."

If we inspect the interior of a hot abscess that has been widely incised, we shall observe—after its contents have been evacuated and the cavity thoroughly irrigated—that thickened, purulent, fragile, ragged masses and irregularly shaped débris are attached to and cover the floor and walls of the cavity. At certain points in this purulent, membrane-like coating there appear to be gaps through which buds and areas of granulations may sometimes be seen to push their way. The old idea that every abscess is lined by a distinct pyogenic membrane which secretes pus must be abandoned.

In the early stage of subfascial and deep-seated abscesses the symptoms are subjective. The patient complains of localized, deep-seated pain, and there are tenderness on pressure and elevation of the body temperature. As the pathologic process advances toward the surface the symptoms increase in intensity. And yet days or even weeks may elapse before the pus arrives so near the surface that we may recognize its presence by palpation, as well as by the usual signs of redness, tenderness, and heat of the overlying skin, by the change in the natural outlines of the part, and by the œdema of the surrounding region.

The form and contour, the nature of the contents, and the character of the walls of an abscess depend largely on its location. For example, in purulent osteomyelitis the form of the abscess is limited to the form of the medullary canal; in the case of an abscess of the liver, its walls may be lined with a bile-stained coating; in central bone abscesses, the inner walls often present small spicula of bone.

The *form* of some abscesses is limited by the fact that they occupy preformed cavities. In solid organs the abscess is separated from the surroundings by a zone of granulation tissue which has been termed abscess membrane, in the belief that the pus is secreted by this membrane. This so-called membrane, however, is an attempt on the part of Nature to limit the action of the pus-forming elements.

In abscesses located near the rectum or the peritoneal cavity, there are sometimes found intestinal gases which possibly passed through the intestinal wall; finally, in rare cases free gases develop in abscess cavities. In abscesses that have perforated into secretory or excretory organs, the pus is usually mixed with the secretions or excretions of these organs. For example, if the abscess communicates with the intestinal canal, the fecal matter and intestinal gases are likely to form a part of the contents. Abscesses often develop about a foreign body, and at times there is found in their contents some object like a piece of necrotic bone, a bullet, a silk ligature, etc. Such abscesses have been called *eliminating abscesses*, because the foreign bodies are surrounded by pus which progressively softens the tissues as the object gravitates downward or follows the course of least resistance until it is expelled.

Abscesses following a trauma or an erosion of a blood-vessel may contain blood and pus. In some cases there may be primarily a hæmatoma, and then at some later date a pyogenic infection may occur in this hæmatoma, as a result of which infection a collection of pus may form. If the abscess is incised before the entire hæmatoma has undergone liquefaction, pus and blood will be found —i.e., the conditions presented will be those of the so-called *hemorrhagic abscess*.

Follicular and retention cysts may suppurate and form abscesses, the cyst contents becoming mixed with pus.

Abscesses differ widely in regard to their size. If we insist, as we must, that all abscesses are composed of a collection of immigrated leucocytes and liberated connective-tissue and parenchyma cells, serum, and micro-organisms, we find some of these collections so small that they are microscopical and may be termed *microscopical abscesses*. On the other hand, the abscess may contain a litre or more of pus. Between these two extremes we may have every possible size. The largest dimensions are attained by the cold abscesses. The hot abscesses, as a rule, perforate spontaneously before an enormous size is attained.

The increase of the size of an abscess is due to a continual involvement of new tissue, extending in all directions from the primary centre unless prevented by anatomical limitations, or to a coalescence of several neighboring centres; the intervening walls becoming entirely liquefied.

Nearly all abscesses eventually perforate spontaneously, when left to themselves, either through the external skin or into a hollow viscus; occasionally the contents of an abscess may become absorbed or may undergo calcification. Absorption must be preceded by a fatty degeneration of the pus corpuscles. Calcification follows only after the individual pus corpuscles have undergone atrophy and the pus as a whole has been rendered more solid by the loss of water. The subsequent steps of the process are these: the thickened mass becomes cheesy, sometimes cholesterin crystals make their appearance in it, and lime salts are absorbed to a greater or less degree; finally, the entire mass is changed into a formless calcareous substance.

Diagnosis.—Not only is it necessary to determine if an abscess is developing or has already formed, but it is also imperative to fix its topographical location, its origin, and its nature. The existence of an abscess can be determined by observing certain cardinal points. The presence of fluctuation in a given swelling is one of the first of these points. This condition, it is true, only indicates the existence of the fluid. In hot abscesses fluctuation, when associated with acute inflammatory signs, is usually sufficient to establish the presence of pus. If it has been possible to observe from the beginning a gradual softening of an inflammatory infiltrate, the diagnosis is certain. It is frequently difficult to elicit fluctuation when an abscess is deeply located. Occasionally swellings, like neoplasms or even hypertrophied structures, may simulate fluctuation so

perfectly that even surgeons of experience may be misled. Sometimes the presence of pus can be determined only by exploration—for example, by means of a subcutaneous puncture with a large-sized aspirating needle connected with an exploring syringe, or by a carefully made valvular or free incision.

The existence of pain, in the case of an acute abscess, is another cardinal point which one may always expect to find. It is apt to be throbbing in character, particularly when the abscess is located near a large blood-vessel, and the intensity of the pain is in direct proportion to the firmness of the abscess walls. Pain is usually relieved when the abscess cavity discharges its contents. A cold abscess may attain immense proportions with an entire absence of pain. When the swelling can be reached with the finger, tenderness or actual pain will usually be produced by pressure.

Swelling is another manifestation which is always present in the case of an abscess that is located in a soft structure. If the abscess is situated near the surface and is accessible to palpation, there is usually no difficulty in determining the existence of swelling. On the other hand, if the abscess is protected by bony structures or by a great mass of soft tissue, it is not always possible to obtain the desired evidence.

Sometimes we are obliged to base our diagnosis upon the existence of a well-defined, localized, severe, and continued pain in a locality where abscesses are known often to develop, and upon the fact that the pain is associated with more or less fever. But if the seat of the lesion is palpable we may always expect to find tenderness. As examples of abscesses which it may be difficult and sometimes even impossible to diagnose with certainty without operative means, we may mention the following: abscess of the brain, abscess of the liver, perinephritic abscess, and abscesses in the right iliac fossa, in the gluteal region, in the muscles of the thigh, etc.

All acute or hot abscesses present more or less redness on the surface, most intense at the centre of the swelling and gradually fading toward its periphery, where it blends with the normal color of the skin.

Cold or chronic abscesses maintain a normal color of the overlying skin until the latter becomes attenuated at some point, which finally becomes the seat of a spontaneous perforation.

It is sometimes difficult to determine that a given fluctuation is really due to the presence of pus. A diagnosis can be reached only by a process of exclusion. Thus, for example, the swelling under consideration might be due to the presence of a fairly large quantity of blood, in which case fluctuation would sometimes be distinct.

In order to determine, however, whether the fluctuation is, or is not, dependent upon the presence of blood we should have to adopt some such reasoning as the following. Every swelling that is made up of blood is either vascular or extravascular. If it be vascular, it must either be an arterial

aneurism or a varix. If it be an aneurism, pulsation will be felt; if it be a varix, there will be no difficulty in compressing the swelling until all the blood shall have disappeared—only to appear again quickly after the pressure shall have been withdrawn. Again, if the swelling be due to the presence of an extravascular mass of blood, we should expect to obtain the history of a trauma which was not followed by any inflammatory reaction. It will also be noted that the swelling gradually diminishes in size. Serous and synovial exudates are found only where there are serous and synovial structures. In a given case it might be necessary to differentiate between an empyema and a serous or sero-synovial exudation. When suppuration occurs in a synovial sac, it can be differentiated from a sero-synovial exudation by the following circumstances: The suppurative process is associated with throbbing pain and œdema; there is evidence of a circumscribed inflammation; the skin of the affected part is immovable over the underlying tissues; and the appearances indicate that a perforation is imminent.

Fluctuation felt by palpation of muscular tissue (i.e., by tapping upon it) may simulate an accumulation of pus, but the two conditions may be differentiated by noting the direction in which the muscular fibres run and remembering that muscular fluctuation is present only with transverse palpation of the organ.

It is sometimes difficult to ascertain positively in which particular fascial plane, in different parts of the body, an abscess may be located. As a rule, the following considerations will enable us to make a diagnosis: Abscesses which are immediately under the skin are plainly prominent and rise above the skin level. An abscess under a fascia may exhibit no external evidence. An abscess located under a muscular plane elevates to a perceptible degree the entire muscle group, and often suspends the function of the muscles involved. An abscess beginning in a bone presents no external signs. An abscess lying behind or in contact with a special organ sometimes crowds it out of its normal relations. Examples: the eye may be crowded forward or laterally by an orbital abscess; the liver may be crowded downward by an empyema; the uterus may be crowded to one side by a pelvic abscess.

Pain is not always confined to the immediate region of the abscess. In subfascial pelvic abscess, the pain radiates downward into the thigh; or, in an abscess of the hip joint, the pain is referred to the knee joint.

An abscess may cause deformities of the extremities. Thus, for example, a pelvic abscess produces flexion of the thigh on the abdomen; an abscess in the popliteal space produces flexure of the leg on the thigh.

It is often difficult to state in which organ an abscess originates, because the visible abscess may have extended along muscular and fascial planes, having burrowed its way to a considerable distance from its starting point. To locate the primary seat we must take into account the existence of other pathologic

processes and ascertain if any legitimate connection between the two points can be established. Usually, however, the abscess is immediately over the primary focus. If an abscess exists over the tibia, it usually indicates that the seat of infection is immediately underneath, and that the abscess has originated in the periosteum or the bone. If the pus is found in a lymph node, we may be assured that it originated at some point in the area whose lymphatics are directly related to this particular lymph node.

In a *gravitation abscess* the question is not so simple. Examples: a psoas abscess may have had its origin in a tuberculous spondylitis; an abscess beginning in or about the hip joint may appear near the knee. Many facts must be taken into consideration.

An abscess may threaten life on account of its location. Retropharyngeal, brain, and lung abscesses belong in this category. In such abscesses the pus burrows a way for itself to some important structure, or breaks through into a neighboring cavity, inhibiting and suspending the function of special organs. Sometimes a blood-vessel is eroded and a hemorrhage then results. Then, again, a meningitis or an infective phlebitis may be set up by an extension of the inflammatory process from a brain abscess (either a cerebral or an extra-dural abscess); and, similarly, a general peritonitis may develop from an appendiceal abscess. Finally, abscesses in the neighborhood of large articulations may perforate into and destroy the joint cavities. As a rule, however, they remain extra-articular and are followed by no serious consequences. Acute abscesses in healthy and vigorous individuals usually heal rapidly and seldom become a menace to life.

When infection is transferred from the primary seat of invasion to some other region, and an abscess develops, we speak of this as a *metastatic abscess*. Metastatic abscesses develop at a greater or less distance from the primary seat of infection. They are of embolic origin, the infective material being transferred from the primary abscess by means of the blood current. The emboli are usually infected with staphylococcus and streptococcus pyogenes, and they originate from a thrombus in a blood-vessel located in the immediate neighborhood of the initial abscess. They are often multiple and small. Such abscesses may be exceedingly grave. When the metastases are few and superficial, complete repair may take place. If, on the other hand, the secondary invasions affect important organs, especially if the metastases are ushered in by a violent chill, the prognosis becomes grave. Often each new infection is ushered in by a distinct chill followed by a decided elevation of the body temperature, sometimes terminating in a profound sweat and lessened fever, only to be followed by a more or less decided exacerbation of the febrile state.

The *constitutional disturbance,* in the average case of acute abscess, is by no means small throughout the entire course of the disease. On alternate days there may be a rise and a fall in temperature that suggest malaria, from which

disease the differential diagnosis has frequently to be made by means of the microscope. When suppuration takes place, there is either a chill or a rapid rise of body temperature. Just before "pointing" takes place, the pain and febrile disturbance are sometimes very great, the temperature rising to 104° F. or higher. The rupture of the abscess is followed by a subsidence of both the local and the constitutional symptoms. Before rupture takes place, the abscess cavity is tensely filled and the pus is therefore under considerable pressure — a condition which favors absorption of the toxins into the circulation. As soon as the pus cavity is opened and its contents evacuated absorption ceases, because the direction of elimination is outward.

Abscesses are sometimes *absorbed*; they do not discharge their contents. The pyogenic agent becomes neutralized by some process or other, and as a result the inflammation subsides. The fluid is absorbed, the leucocytes and wandering cells disappear, and the dead cells undergo disorganization through the aid of ferments. Such absorption processes sometimes take place in abscesses which are provided with a connective-tissue capsule. In those cases in which the contents of the abscess are absorbed nothing may remain except a small scar. In other cases, however, a cyst may form or an included calcareous mass may persist.

Treatment.—The advances made in modern pathology have completely changed the methods of treating abscesses. Guided by our knowledge of the bacteriology and of a more advanced pathology, we can readily understand that treatment, to be effective, must not be delayed until the typical signs of an abscess have fully developed. The old dictum that an abscess must be "ripe" before it is radically treated cannot stand. We must deal with an abscess in its incipient stage, before the surrounding tissues have been invaded, or, at all events, before destruction has become extensive. We must attack the primary focus before a circumscribed collection of pus has formed. An extensive experience has demonstrated the fact that an early interference is not only justifiable, but is demanded. The adoption of this course has had the effect of greatly lessening the destruction of tissue, of preventing many grave infections, and often of saving life.

From a clinical standpoint abscesses are designated according to their situation, or according to the particular organs or structures involved, or according to the nature of the infection and the predisposing causes. Whatever may be the location or nature of an abscess, there is only one underlying principle in the management of all, viz.: as soon as the objective or subjective signs point to the existence of a localized infection with a tendency to suppuration, it must be attacked through the establishment of a free opening. The old practice of waiting until "pointing" occurs is not justifiable. The early incision prevents the extensive damage which so often results from an abscess being allowed to burrow and destroy important structures. A prolonged, deep-seated, local-

ized pain and tenderness associated with fever, with or without swelling and fluctuation, are usually sufficient evidence to justify an exploratory incision. Often the integrity of an organ depends on early interference. Such incisions should, when possible, be so made as to insure free drainage of the entire cavity. The drainage opening should enter the most dependent part of the abscess cavity. When necessary to insure free drainage, larger drain openings should be made; and in many cases through-and-through and counter-drainage must be employed in order to secure and maintain perfect evacuation of the abscess cavity. When, from the situation of the abscess, it is impossible to secure drainage through its floor, the surgeon may sometimes apply pressure in such a manner as to compress the walls of the abscess and thus shut off pockets in which pus might accumulate. In other cases like those of retro-sternal abscess, and in some pelvic abscesses, the injection of glycerin into the abscess cavity has proven useful. This may be effected by means of a rubber tube, which is to be pushed down to the bottom of the cavity. The glycerin, owing to its greater specific gravity, sinks to the bottom, raises the pus, and causes it to escape. This plan, however, should be carried out with great caution, to prevent rupture and extravasation.

When the pus has been evacuated, the abscess cavity should be explored, preferably under the guidance of the eye, and, when this is not possible, by the finger, which should be protected by a rubber cot or a glove. When the relations of the abscess to other organs have been determined and it has been found that no important structures such as vessels or organs form a part of its web, the cavity may be carefully curetted, to remove granulations or a limiting membrane if one exists. All sloughs and loose shreds must be removed. All infected tissues must be eliminated, when possible. When all diseased structures have been removed, the cavity may be irrigated with an antiseptic solution of from 1 to 1000 to 1 to 5000 mercury bichloride, or with a carbolic-acid solution of a strength of 1 or 2 per cent. The chief purpose of such irrigation is to wash away any particles of the infected tissues that may still be loose in the wound. The antiseptic solutions do not remain in contact with the infected tissues sufficiently long to produce a germicide effect; consequently the beneficial effect which results from their employment is rather to be attributed to the washing away of infection than to an actual destruction of the infective organisms. When the irrigation is finished we may make an attempt to disinfect the cavity. After thoroughly drying it with a swab, the cavity, if not too large and if it is in an accessible locality, may be filled with carbolic acid (95 per cent) with the aid of a medicine dropper or a glass syringe. If the cavity is large a gauze mop saturated with the acid may be used to swab the walls throughout. As soon as the tissues thus treated have assumed a characteristic white or grayish color remove the excess of carbolic acid with a mop and immediately fill the cavity with absolute alcohol, which at once neutralizes the carbolic acid and permits

the tissues to reassume their natural color. The action of the acid is prompt in destroying all micro-organisms with which it comes in contact. There is no danger of absorption of the acid nor of too great destruction of tissue, because the action of the former can be absolutely limited by the alcohol. The cavity should then be loosely filled with antiseptic gauze, and over this should be placed a moist antiseptic dressing covered with oiled silk. This dressing may be repeated daily until the secretion of pus ceases. If the cavity be deep and if it extend into the tissues to a considerable distance, a tube or tubular cigarette drain should be introduced instead of the gauze, in order that drainage may be facilitated and that a reaccumulation of pus in the depths of the cavity may be prevented. The tubular cigarette drain consists of rubber tubing wrapped first with several layers of gauze and then with gauze-rubber protective. The tube should be of sufficient length to reach the bottom of the cavity, and its calibre should be large enough freely to convey all secretions to the surface. It is not possible to render an acute abscess cavity strictly aseptic, even with the carbolic-alcohol treatment. Consequently, the partial compression of such a cavity, as recommended by some, with the expectation that it may bring about primary union, cannot be relied on.

Occasionally it happens that the lymph channels which course through or near an abscess become infected and the neighboring lymph nodes become swollen. Or the infection thus conveyed may do more than this; it may cause the swollen nodes to suppurate. In some cases the original wound may even heal before the surgeon's attention is directed to the infected node. As soon as the characteristic red streaks, which indicate the development of lymphangitis, appear on the skin, moist antiseptic poultices should be used. Such a poultice is made up of large masses of absorbent cotton saturated with a 2-per-cent carbolic-acid solution, and it should be large enough to extend beyond the margins of the inflamed area. Over the cotton must be placed a still larger sheet of oiled silk, for the purpose of preventing evaporation of the solution. The dressing must be freshly moistened every six hours.

In mild and uncomplicated abscesses, a simple incision followed by an antiseptic poultice (cotton saturated with a strong solution of carbolic acid) is all the treatment that is required. When the infection is severe, and especially if it is associated with many suppurating points, it will be found necessary to make several free incisions and to apply the antiseptic poultices faithfully. The latter should be frequently changed, and in some severe instances, when a hand or a foot is involved, it may be found more effective to place the inflamed part in an antiseptic bath. If, in spite of these measures, the infection spreads, amputation may become a necessity as a life-saving measure. When the suppuration affects a part of the body that cannot be immersed in an antiseptic bath, and when the disease has not yielded to extensive incision and moist antiseptic dressings, continuous irrigation with antiseptic

solutions may be used. In some instances the patient will succumb, no matter how heroically we may carry out the treatment.

We may briefly state that the essential points in the management of abscesses are these: free incisions; thorough evacuation of pus and débris; careful irrigation of the abscess cavity with an antiseptic solution or a disinfection of the same with carbolic acid and alcohol; free drainage; and moist antiseptic dressings.

When the abscess is large and when it has burrowed extensively, it may become necessary to make a second or even a third opening, in order to provide an outlet for the abscess at its most dependent part and to facilitate complete irrigation. Such counter-openings are safely made by introducing through the first incision a closed pair of hæmostatic forceps and pushing them to the farthest end of the cavity, and into the connective tissue, until the point of the forceps appears beneath the skin. An incision made at this point will permit the forceps to be pushed completely through. A perforated drainage tube is now grasped by the open blades of the forceps and drawn completely through the abscess cavity. The tube is cut off near the skin openings, and a safety pin is fastened in each end.

Cutaneous abscesses result from an infection of sweat glands and hair follicles. They are known as pustules, furuncles, boils, and carbuncles. They should be promptly treated by incision and antiseptic dressing.

Furuncles or *boils* affect not only the corium, but also the subcutaneous connective tissue; they vary in size from a pea to a hen's egg. As the tissues become liquefied, as the result of the action of microbic products, the boil becomes sore and tender on pressure and presents a small fluctuating point at which soon afterward a spontaneous rupture occurs. Through the opening thus established there will be evacuated, first, the pus and then a central slough known as a core.

Furunculosis is a condition in which boils develop, one after the other, in a regular series. Dozens of furuncles sometimes follow one another throughout a period of several months. They may vary in size from that of a pin's head to that of an English walnut. They develop as the result of a series of infections, the infective material being transported directly from the original furuncle by scratching with the finger nails, or indirectly by the friction of the pus-stained clothing upon the skin. The treatment of furuncles should be active and preventive. Early incision and moist antiseptic dressings prove, as a rule, entirely satisfactory. Avoid touching the affected areas with the fingers, as the nails may become the carriers of infection. The finger nails should be carefully attended to by keeping them trimmed closely and carefully scrubbed with a soft brush. Avoid scratching and friction of the skin. Frequent antiseptic baths (sublimate solution 1:4000) and frequent change of under clothing are desirable measures. Internal remedies are useless, except in so far as they may

influence beneficially a gouty condition of the system, which is believed by some authorities distinctly to predispose to furunculosis.

Carbuncles find their most frequent location on the back of the neck, back, and buttocks. The disease manifests itself by a firm, brawny swelling and an attenuated skin which is perforated by many small openings, from which escapes a thin pus that is derived from multiple foci. Such a swelling varies in size from that of a silver dime to that of a saucer, and its base often rests upon one of the muscular fascias. It is an exceedingly painful disease. The connective tissue and skin involved undergo necrosis, and after the slough separates and is cast off there remains a deep ulcer with an irregular margin. The sloughing process is a slow one, sometimes requiring weeks. It should never be left to itself but should be hastened by an early destruction or complete removal of all affected tissues. The constitutional symptoms are very marked. The temperature is often high, septic intoxication is sometimes profound. Elderly people, diabetics, those with Bright's disease, and others broken-down in health and feeble, are often attacked with a carbuncle. In such cases the disease frequently proves fatal. As regards the treatment it is important that very free crucial incisions should be made, with the aid of either local or general anæsthesia. Afterward, thorough curetting and clipping away of necrotic structures, and the free use of the actual cautery thoroughly to destroy all infected tissues, are the measures which should be employed. The most thorough method of dealing with a carbuncle is to administer a general anæsthetic to the patient and then to extirpate the entire infected mass with the knife; after which the walls of the resulting excavation are to be disinfected with carbolic acid and alcohol, and a moist antiseptic dressing is to be applied. Until the wound becomes covered with granulations the dressings should be changed two or three times daily; but afterward dry antiseptic dressings will answer.

The terms *felon*, *panaritium*, and *whitlow* are commonly applied to abscesses of the finger, and such abscesses are either *subcutaneous*, *tendinous*, or *subperiosteal*. They vary in severity. Their importance lies in the fact that they may endanger the function of the hand and fingers, and consequently they should receive early attention. The subperiosteal felon may destroy the phalanx and one or more joints. When the disease affects the tendons, it may spread along the tendon sheaths and may end in necrosis of the tendon. The cutaneous felon sometimes involves, as may all the other forms, the lymphatic channels, and it is then likely to cause suppuration of the lymph nodes at the elbow and in the armpit.

Palmar abscess usually affects a flexor tendon sheath and is known as tenosynovitis. It exhibits much the same symptoms as those which are observed in felons, but they are, as a rule, more severe, on account of the process being more extensive. The patient cannot flex his finger owing to the extreme pain which results from the involvement of the tendon. The swelling is marked

and often extends to the dorsum of the hand. If we remember that the flexor sheaths communicate with the common palmar sheath only in the little finger and sometimes with the thumb, and not in the other fingers, we shall understand why suppuration does not extend beyond the heads of the metacarpal bones in the index, middle, and ring fingers; and it is only occasionally, in very severe infections, that these bounds are overstepped and the palm invaded in very much the same manner as happens when an infection begins in the thumb or in the little finger. It is important that an infection of a tendon or a tendon sheath be recognized very early on account of the danger that adhesions may form between the tendon and its sheath, and also on account of the tendency of the infective inflammation to extend upward into the palm, the wrist, or even the forearm. The greater and more extensive the suppurative process, the greater the probability of permanent limitations of function. Tendons may become fixed to such a degree as to abolish flexion, thus rendering the fingers stiff and sometimes distorted.

Incisions should be made early; i.e., as soon as a local infection can be recognized. To wait for undoubted fluctuation is usually to wait until irreparable damage has been done. Do not wait for pus to form. It is safer to anticipate an extension of the inflammation by making an early and free incision. In the neglected cases—such, for example, as have received only the supposititious benefits of a bread poultice or a flaxseed poultice or some other domestic remedy—the pus has often burrowed as far as to the dorsum of the fingers and throughout the greater part of the palm, producing extensive sloughing. In this way tendons, and sometimes even phalangeal joints, have been destroyed. When the dorsal surfaces are involved, free counter-openings must be made and through-and-through drainage established. When incising the palm avoid the palmar arches. This can be easily done by recalling the linear guides of these vessels, and by continuing to advance, after the skin has been incised, by means of a careful dissection of the tissues, aided by the employment of a Halsted hæmostat. The incisions should be made directly over the affected metacarpal bones and not above the centre of the palm. If the suppuration extends toward the wrist joint, an incision should be made over its middle, and by careful blunt dissection a communication should be established with the primary suppurative process in the palm. At each subsequent dressing one must be on the watch for new centres of suppuration. They are not uncommon and should be promptly incised. The subsequent dressings should comprise: a thorough irrigation with sublimate solution (1 : 4000) or with a solution of iodine and potassium iodide (one per cent), and the application of a moist antiseptic dressing, once daily. The writer has observed many cases in which complete restoration of function was effected by early incisions and by careful attention to details, as stated above.

In certain situations—e.g., the triangle of the neck—where important blood-

vessels and nerves are located, and where consequently a bold incision might endanger important structures, an incision should be made only through the skin, superficial fascia and platysma, and then the further dissection may be carried out with a pair of hæmostatic forceps. The structures should be separated by insinuating the closed forceps into the tissues and then, with the blades separated, continuing this blunt dissection of the tissues until the abscess is reached. After the blades have been introduced closed into the abscess cavity it will often be found practicable, by forcibly separating them, to break down pockets and septa. Before withdrawing the forceps the surgeon would do well to introduce a probe alongside the instrument, so as to insure maintaining a direct route into the cavity. The openings made through the fascias, for the purpose of reaching the abscess, are not always in a direct line, and consequently, without the aid of the probe as a guide, the true route might be missed when an effort is made to introduce the drainage tube. The tubular drain, held in the grasp of the hæmostat forceps, may easily be pushed along beside the probe (Hilton's method).

Cold Abscesses.

Under this head we must include all abscesses that originate in a structure affected with tuberculosis, whether the abscess be located in a joint, a bone, or a lymph node, or be confined by a fascia. These abscesses sometimes serve as a starting-point for an extensive invasion unaccompanied by constitutional disturbance. Occasionally, however, there may be more or less fever, and not infrequently a gradual diminution of bodily weight and strength takes place. If the abscess attains a large size, the patient exhibits pallor, general weakness, loss of appetite, and disturbed nutrition. These abscesses may undergo spontaneous absorption; a perforation may also develop and the contents of the abscess thus be evacuated.

Cold abscesses are very often found to be located at a considerable distance from their original seat of formation. Thus, for example, an abscess may appear at the knee, although the starting-point of the pus was in a tuberculous focus in or about the hip joint. Then, again, it sometimes takes the form of a dissecting abscess, because it has separated muscular planes and has traversed the sheaths of muscles. Finally, an abscess which originates in one of the dorsal vertebræ may present itself in the lumbar or in the inguinal region, the pus having forced its way downward behind the peritoneum. While some have applied to such an abscess the term *retroperitoneal*, others have insisted that the starting-point should receive consideration in the selection of a name. Thus, for example, they would use the expression dorsal gravitation abscess if the primary centre be located in a dorsal vertebra, or that of lumbar retroperitoneal abscess when the original causative lesion is located in a lumbar vertebra. These special designations are helpful and necessary for accuracy of description.

When we palpate a cold abscess that has approached the surface, we find at first an infiltration, which, as a rule, is not specially painful or sensitive. The integumentary veins over the swelling may be dilated and there are only slight evidences of local reaction, until the swollen tissues become liquefied and fluctuation can be felt. Most frequently cold abscesses originate from deeply seated organs and are difficult to find in the early stages of their development. If the abscess is fully developed, it declares itself by the following signs: Fluctuation can be plainly felt in all parts of the swelling; at no point can an inflammatory wall be distinguished; no spontaneous pain is felt and the swelling is not sensitive to pressure; the overlying skin is reddened only at a circumscribed point, and that, too, only when the abscess is about to perforate spontaneously. The tissues in which the abscess is located appear to have undergone purulent destruction. The character of the pus differs, as a rule, from that of the hot abscess. The pus of the latter is usually thicker, more creamy, and of a distinctly yellow or green color, and it often has an odor. On the other hand, the pus of the cold abscess is often thin, serous, and flaky. Nevertheless, cold abscesses may present pus of varying degrees of consistency.

Many cold abscesses decrease in size under certain conditions. Thus, for example, it has been observed that when an individual who harbors a large gravitation abscess due to tuberculous softening of a vertebral body, is able to pass a large part of his time out-of-doors, as one generally can during the summer season, his abscess will decrease in size; whereas, during the cold winter season, when he is compelled to live in a more or less vitiated atmosphere, indoors, the abscess generally increases in size, this increase being due, possibly, to an increased transudation of serum into the abscess cavity—the result, doubtless, of decreased general physical vigor.

The extension of a cold abscess depends, in a large measure, upon the density of the cellular connective tissue. If the cellular tissue is loosely constructed, the pus will spread rapidly. On the other hand, if it have a dense character, the spread of the pus will be inhibited. The size of an abscess is a matter of importance, for upon this factor and upon the arrangements of fascia depends largely the formation of the so-called *gravitation abscess*.

A cold abscess may be mistaken for a cyst, and, *vice versa*, a cyst may be mistaken for a cold abscess. The absence of any local signs of inflammation and the circumscribed globular form of the swelling render it an easy matter to make such a mistake. As a rule, the abscesses are softer, the cysts more tense. The length of time required for the development of the swelling is a matter which calls for careful consideration. In the case of a cyst the development of the swelling requires considerable time, while in that of an abscess the development takes place at a relatively more rapid rate. Cold abscesses are gravitation abscesses, and it is therefore possible, if the case under consideration be one of this nature, to determine the locality from which it originated. In

rare cases a cold abscess may be confounded with a solid growth. As examples I will mention the following facts: It is known that small lingual abscesses, on account of their firm, tense character, have been confounded with carcinoma nodules: and again, that cold abscesses of the female breast have been mistaken for medullary cancers. Similar errors are possible in any part of the body where a cold abscess is covered by a strong, firm fascia, owing to which condition fluctuation is very indistinct and may even lead the examiner to believe that he is dealing with a neoplasm (pseudo-fluctuation). It may be difficult, in certain cases, to distinguish between deeply situated, suppurating inguinal lymph nodes and hydrocele or a femoral hernia. As a rule, however, it is not difficult to recognize the presence of an abscess; and yet cases are occasionally seen in which it is found to be very difficult to make a differential diagnosis. There are even cases on record in which an aneurism has been mistaken for an abscess. In doubtful cases an exploratory puncture may be required to establish a diagnosis.

Cold or chronic abscesses are nearly always of tuberculous origin, most frequently having their primary focus in the bones, but also not infrequently in lymph nodes and occasionally in the skin and connective tissues. The contents of the abscess consist of a collection of liquefied tuberculous products. This fluid is purulent only in appearance. It contains very few leucocytes and and other cellular elements; the bulk of the solid material is made up of granular caseous substance, with some granular and fatty cells. The etiological factor is the tubercle bacillus. These abscesses require a long time before they reach their full development.

When a tuberculous abscess is opened, its wall is found to be lined with a distinct, easily detachable, translucent membrane, which may readily be broken. It contains numerous opaque points each of which is a miliary tubercle or a centre of caseation. This membrane is known as a tuberculous pyogenic membrane.

Treatment.—The methods pursued in the management of cold abscesses are the following: (1) The expectant method; (2) tapping, followed immediately by the injection of chemical solutions; (3) free incisions and the removal of the pyogenic membrane.

The *expectant method* has become almost obsolete. It was practised in the preantiseptic period, when a free evacuation of pus by incision was almost regularly followed by a mixed infection with its attendant complications, such as a rapid loss of flesh and strength and frequent death from sepsis and exhaustion. While it is not uncommon to see old abscesses of considerable size entirely disappear, the great majority open spontaneously, sometimes after the most extensive burrowing. Metastatic invasions of the lungs, joints, and other structures are not uncommon. It is plain, therefore, why the expectant plan has almost been abandoned.

Tapping, followed by the immediate injection of antibacterial chemicals, has found great favor with many surgeons. Among this class of remedies, iodoform has enjoyed a foremost place for upward of twenty years. The mode of procedure consists first in tapping the contents of the abscess cavity through a cannula, and then, when the cavity has been emptied as thoroughly as possible, a sterilized emulsion of iodoform in olive oil (15 per cent) is injected through the same cannula, from half an ounce to one ounce of the emulsion being allowed to remain in the abscess cavity. The procedure is to be repeated once every ten to fourteen days until a cure is effected. Under this plan many tuberculous abscesses, provided the primary focus is not located in bone, terminate favorably. In the latter case, the products of such a focus continue to feed the tuberculous cavity with new infective material and thus prevent it from closing. In such cases the primary depot must be removed before one can reasonably expect a recovery. It was Mosetig-Moorhof who first made us familiar with the beneficial effects of iodoform in the treatment of localized tuberculous processes.

Recently Nicholas Senn, who has been for many years an enthusiastic advocate of iodoform in the treatment of cold abscesses, and more particularly when they are located in joints, has abandoned its use, and he now recommends the employment of a one-per-cent aqueous solution of iodine and potassium iodide, to be injected into an abscess cavity in very much the same manner as it is customary to use the iodoform emulsion. He states "that iodine is a much more powerful tissue stimulant than iodoform and consequently has a more pronounced effect in initiating an active process of phagocytosis, a most valuable adjuvant to its antibacillary action." For nearly two years past, the writer has injected into many tuberculous abscesses from four to six ounces of a one- to two-per-cent iodine solution, allowing it to remain. He has obtained such gratifying results that he has made it a matter of routine practice to treat all tuberculous abscesses and ulcers with a solution of iodine and potassium iodide. Sometimes this solution is injected into the cavity through an aspirating needle; at other times the abscess is freely laid open and thoroughly irrigated with the solution.

Free incision, with a complete removal of all tuberculous contents, has become the most frequent practice in all except psoas abscess. Suppurating tuberculous lymph nodes should first be freely incised, thoroughly curetted, and then disinfected with carbolic acid and alcohol. Afterward, the remaining portion of the node should be extirpated by careful dissection. The resultant cavity is to be irrigated with a one-per-cent solution of iodine. If the contents of a tuberculous abscess burrow into cellular structures or between muscular or fascial planes, the entire abscess cavity should be laid open by incision. The membrane lining the cavity, together with all affected tissues, should be removed with a sharp spoon and scissors. This procedure is to be followed by an irrigation with a one-per-cent iodine solution. The cavity is then to be

carefully dried, the skin and other structures sutured, and a tubular drain introduced and carried down to its most dependent part. An antiseptic hygroscopic dressing is to be applied over all, and this dressing is to be changed daily. Irrigation through the drainage tube is to be made with each change of dressing if there is considerable discharge.

If a large abscess is known to take its origin in a bone or joint, the primary focus must be removed, as stated above.

The *general constitutional treatment* of tuberculous abscesses should be as carefully carried out as in cases of lung tuberculosis. The constant sojourn in the open air under the direct influence of sunshine by day, and the sleeping in a room with an open window at night, are among the most effective therapeutic measures. The patient should be clothed by day to suit the varying seasons, and at night he should have sufficient blankets to insure bodily comfort. Surgeons have occupied themselves too exclusively with the local tuberculosis and have given too little heed to depressed vitality, which is one of the most important etiological factors. Good nourishment is as important as the breathing of fresh air. The diet selected should be the best that the patient can bear. Of all medicaments none is superior to cod-liver oil. All forms of emulsion are unreliable on account of the uncertainty of the quantity of cod-liver oil contained in them. In the case of children it has been the custom of the writer to give the oil, at first, in teaspoonful doses, three times daily, and then gradually to increase the dose to a tablespoonful. A good mode of administration is to float the oil on water in a small glass. He gives no other medicines, except for special indications.

ULCER AND ULCERATION.

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Definition and General Description.—The term ulceration is susceptible of a most elastic application, being employed surgically with varying significance, but it should be confined to the process by which an ulcer enlarges or increases in extent. Besides, ulcer and ulceration are histologically identical, and, consequently, we shall adopt this interpretation and employ the two words as representing the same condition.

The wide differences of opinion that existed in the early days of medicine as to the exact nature of an ulcer, which was at that time regarded as a disease entity, have been narrowed down by modern pathology to within comparatively precise limits. But even now the numerous definitions given to ulcer furnish sufficient evidence of the difficulty in so defining the lesion that its chief characteristics shall harmonize with the pathology.

Broadly stated, an ulcer may be defined as a breach or solution in continuity of either a cutaneous or a mucous surface, which has passed on to the stage of granulation, and which manifests a diminished tendency to spontaneous healing. It is the result of the molecular death or cell degeneration of a part; or, in other words, it is a lesion in which the retrograde changes proceed more rapidly than those of organization; and it has been considered as distinct from an open granulating wound in that the latter evinces a normal disposition to cicatrization. In point of fact, however, the differences between a granulating wound and an ulcer undergoing repair are in no wise distinguishable; and it is only necessary in the former that the granulations and edges break down and extension take place, for it to assume all the characters of a true ulcer.

Thus, the essential or distinctive features of an ulcer are necrobiotic changes which are, for the most part, although not invariably, dependent upon a pre-existing inflammation—changes which produce loss of substance, and which are associated with the formation of a defective granulation tissue. The process bears a close relationship to gangrene, differing only in the degree or extensiveness of tissue death.

The process of cellular destruction brought into existence by the usual cause of ulceration, is followed by that of *pathologic regeneration* or *reconstruction by granulation*. Between this and the process of inflammation it is scarcely possible to draw a separating line, and, indeed, regeneration must be considered as being an actual part of inflammation. This complicated histologic phenom-

enon is of vital importance in the repair of ulceration, and represents the means by which loss of substance is restored by new tissue having the same structure as, or, at least, bearing a close resemblance to, the primitive tissue. The first step in the process is the production of new cells by division of the already existing cells, and known as formative embryonal cells, which, after undergoing additional changes through karyokinetic activity, together with the secretion of an intercellular substance, finally form the permanent tissue. It is probable that there exists here an exaggerated stimulus to the formative process—a stimulus that is due, possibly, to the presence of a variety of toxic substances.

Every ulcerated surface is covered with numberless minute red elevations or projections, termed *granulations*, which constitute what is known as *granulation tissue*. This tissue is of temporary formation, being the framework upon which the solid and permanent structure of new tissue is erected. It consists of newly formed vascular loops or sprouts, that spring from the endothelial cells of pre-existing capillaries and are surrounded by masses of actively proliferating cells. These cells are composed of mono- and polynucleated leucocytes, together with round and irregularly shaped connective-tissue cells, and sometimes, at a late stage, giant cells. Primary or early blood-vessel regeneration is necessary for the conveyance of nutriment to the tissues in process of formation. The growth of these vascular off-shoots is very active, and, as a consequence, the newly formed embryonic tissue is abundantly supplied with blood-vessels, which give to granulation tissue its characteristic red color. But, as this tissue is transformed into connective tissue or cicatricial tissue, the vessels, or at least the majority of them, disappear, and the scar gradually becomes paler, losing the bright red hue.

For the most part, the proliferated *formative cells* are connective-tissue cells, and, on account of their resemblance to epithelial cells, they are called *epitheloid cells* and also *fibroblasts* (because, at an advanced stage, they develop connective tissue). They may be regarded also as in some measure *wandering cells*, since they may migrate some distance from the point of their origin. In the formation of connective tissue they assume a variety of shapes, and at certain times they also form polynuclear cells. Their large bright nuclei of oval form do not take deep staining, which serves to distinguish them from leucocytes, whose nuclei, on the contrary, stain quite deeply. The leucocytes of granulation tissue are the cells which have emigrated or wandered from the blood-vessels, and their presence indicates that inflammatory exudation from the vessels is still in progress.

Thus, granulation tissue is at an early stage composed of fibroblasts and leucocytes embedded in a ground substance which is richly supplied with blood-vessels, and in which fibrillation soon makes its appearance. The leucocytes are seen in all cutaneous layers, but principally in the superficial ones, where, embedded in fibrin, they form a covering over the surface of the granulations.

At first, the fibroblasts are round cells, but later they become club-shaped and spindle-shaped, and also send out branched processes which, in manifold ways, unite the cells. About this time the large formative cells multiply greatly, exceeding in number the small round cells, and, when they have increased to a given extent, the formation of the fibrillated intercellular substance takes place—in other words, connective tissue begins to develop. After the formation of fibrillæ has reached a certain stage the process stops, the fibroblasts with their nuclei remain as fixed connective-tissue cells, retain their vitality, and become attached to the surface of the bundles of fibrillæ. Here the process terminates, since the granulation tissue is now transformed into fibrous tissue or cicatricial tissue (Ziegler).

If the formation of granulation tissue is not disturbed by infection or other outside interference it proceeds until the ulcerated area is completely covered by epithelium. This process of epidermization is established by proliferation of the original epithelial cells at the margin of the wound, the epithelium gradually advancing and covering over the granulation tissue. When this is effected the processes of repair have been practically concluded, but the various transforming processes continue to go on in the scar tissue for quite a long period afterward. At first the scar represents a territory only a little less extensive than that of the former ulcerated defect, and it is very vascular and of a red color; but contraction soon begins, and in a short time the scar is reduced to an area decidedly smaller than that of the original ulcer. At the same time the majority of the blood-vessels undergo obliteration and the surface becomes pale. The cicatricial tissue continues surcharged with cells for months, but as time progresses these gradually disappear and the tissue becomes firmer and denser, and elastic fibres are formed.

When the process of epithelial reproduction or surface repair advances more rapidly than the formation of granulations, the resulting cicatrix is depressed below the surrounding surface; but, when the two processes proceed *pari passu*, the scar that ultimately remains will be of an ideal character—that is, the defect will be insignificant.

The surface of the skin in extensive cutaneous scars is permanently smooth and glazed, because the papillary layer is not regenerated, or, at any rate, only partially so; but, if the ulceration is limited in extent and if the skin has not been totally destroyed,—some portion of the Malpighian layer and possibly the sebaceous and sweat glands still remaining *in situ*,—the skin may regain much of its normal appearance and condition. As a rule, granulation tissue, in the process of restoration, stops at its metablastic change into fibro-connective tissue; and it is only under exceptional circumstances that there is a regeneration or restitution of special structures or organs, such as the original muscular, nervous, or glandular tissue. However, when the regeneration involves one of the more common types of connective tissue—the fibrous, the car-

tilaginous, or the osseous—the result shows that the restoration is perfect in degree.

Cicatricial tissue possesses the property of contractility without elasticity, and it is this property that causes scars to contract; the results of such contraction often being very great distortion and disfigurement, especially when the structures of the face in the neighborhood of the eyelids, mouth, and nose are implicated, or when the neck and the arms are the seat of extensive cicatrices.

Etiology.—The general causes of ulcer are essentially those of necrosis. These may be either of local or of constitutional origin, and in some instances both kinds of causes are combined.

As a convenient means of grouping the causes they have been divided into four classes, viz., those which produce local anæmia or ischæmia, the toxæmias, the mechanical causes, and those which partake of the nature of neuropathic or trophic nerve derangements.

1. The *causes which produce local anæmia or ischæmia* result from the disorders of nutrition and disturbances of circulation, and they constitute probably the most prominent class. They cover quite a wide field, and include such conditions as arterio-sclerosis; atheromatous degeneration; thrombosis; infarction or embolism; pressure upon vessels, as by growths; arterial spasm; feebleness of heart action; venous blood stasis, and the stasis of complete obstruction due to certain mechanical causes; possibly certain toxic substances that produce blood coagulation; certain drug intoxications; and, finally, the effects of intense heat and cold.

The *constitutional or systemic disturbances of nutrition* are represented by all cachectic and anæmic disorders; some diseases of metabolism; and the changes of senility.

2. *The toxæmias* occupy an important place in the production of tissue death. The poisonous products or toxins of bacteria cause cell degeneration not only by their direct action but also in an indirect manner, through the medium of the circulation and in connection with some injury, by which means tissue resistance is lowered and bacterial invasion favored. Many chemical substances, especially the metallic salts, acids, and alkalies, may produce direct tissue dissolution, and this is often enhanced by the mechanical and circulatory disturbances which they cause. The alkaloids also possess, in a marked degree, the power of producing necrosis.

3. *The mechanical causes of necrosis* constitute an extensive group. The direct effect of pressure is positive, and is frequently supplemented in an indirect way by the associated disturbances of circulation. The necrotic changes in tissues due to the arrest of the circulation caused by the pressure of inflammatory exudates, are well known to the surgeon. Again, the cases of pressure necrosis resulting from calculi and like concretions, and from foreign bodies, offer further examples of this etiologic class.

4. *Neuropathic or trophic nerve derangements* are decided factors in causing death of tissue. These are seen in acute sloughing decubitus or bed sore, in the ulcerations resulting from inflammation of the trigeminus, and in lesions of the spinal cord. While it is proper that these should be considered a distinct class, it must be acknowledged that they are so often associated with nutritional and circulatory derangements, and with injury, as to make the separation difficult.

Tissue necrosis is influenced decidedly by the vascularity of the part involved in the necrotic changes, by the vital resistance of the tissues, and also by the state of their health at the time. Naturally, also, the process is largely affected by the intensity and severity of the operative cause and by its duration.

Age and sex possess a recognized influence on tissue death. The diminished activity of the circulation and the retrogressive tissue changes characteristic of old age should predispose to surface necrosis, although strangely enough it has been shown by statistics that such lesions are scarcely more frequent in advanced years than they are at other periods of life. In regard to the influence of sex it is known that men are much oftener affected with ulceration than women (in the proportion of three to one)—a fact which undoubtedly is to be attributed to occupation and to a greater exposure to admitted causal agents. Thus, it will be observed that tissue death is due to a diversity of causes and conditions that may operate both singly and, more especially, in combination.

Classification of Ulcers.

Although, in the light of our advanced knowledge with regard to ulcers, infection must be considered as the essential or underlying feature of the ulcerative process, yet it seems advantageous to group ulcers etiologically into two great classes, namely, *the non-infective*, and *the infective*.

I. *The Non-Infective Class of Ulcers.*—In this group should be placed all ulcers that are dependent upon causes not demonstrated to be of bacterial origin, both local and constitutional. These causes comprise, as already indicated, traumatism, extreme heat and cold, disturbances of circulation, disorders of nutrition, and tropho-neurotic derangements. We will consider these *seriatim*.

(1) *Traumatism,* in its broadest sense.—Under this division come ulcers resulting from primary wounds; ulcers from local pressure long maintained, especially over bony prominences, as from badly adjusted splints, faultily applied bandages, and mechanical apparatus; the pressure ulcer or simple bed-sore, due to continued pressure over poorly protected osseous points; ulcers that form about foreign bodies; ulcers produced by pressure necrosis resulting from calculi and other concretions, as seen in the ulceration and perforation caused by fæcal concretions in the vermiform appendix and by biliary stones in the gall-ducts and gall-bladder; and ulcers due to external friction brought about

by constant rubbing of a part—as, for instance, heel ulcer caused by ill-fitting boots, and the excoriations inflicted by the nails in scratching.

(2) *Effects of Extreme Heat and Cold.*—These effects are seen in the deeper degrees of burns and scalds, and in frost bite. Congelation and heat may cause destruction of tissue vitality by direct action, and, again, thermic agents may act indirectly by so altering the blood-vessels of a part as permanently to arrest the circulation. With burns due to thermic agents must be classed Roentgen-ray burns, although it is possible that in these latter the destructive effect is dependent not alone on the heat of the ray, but also, and probably to a greater degree, upon a form of energy that radiates from the platinum terminal, and perhaps to some extent upon the ultra-violet light. These necrotic skin changes that occasionally result from the *x*-ray (designated as *white gangrene*) vary in intensity and are comparable to the several degrees of common burns. The primary injury is believed to take place in the peripheral nerves controlling the nutrition of the skin, thus indirectly producing tissue necrosis, but there are no histologic examinations on record which substantiate this assumption. The process is often slow and quite obstinate, and ultimately there is formed a leathery slough, around which is an area of brawny and indurated swelling.

As a cause which bears some relationship to those which have just been considered may be mentioned the erosive action of chemical agents (acids and alkalies), such as carbolic acid, the mineral acids, and caustic potash.

(3) *Disturbances of Circulation.*—The disorders of the circulation by which the blood supply to a part is diminished or interrupted, thereby producing tissue necrosis and ulcer, are manifold. Possibly the most prominent example is seen in the venous blood stasis of varicose veins, which in time produces ulcer of the leg. This condition is characterized by a continued passive hyperæmia that causes excessive œdema, infiltration, and nutritional changes, and hence inability in the part involved to repair surface injuries which ordinarily would be considered trivial. Another example is afforded by the stasis that results from complete obstruction of the circulation due to certain mechanical causes. Any obstruction to the arterial circulation, either complete or partial,—such, for example, as is caused by the pressure of a neoplasm upon a large vessel; the obstruction caused by embolic plugging of the principal arterial trunk, by infarction or embolism of smaller vessels, and by thrombosis; the obstruction caused by arterio-sclerosis, including atheromatous degeneration; and, possibly, the obstruction produced by certain toxic substances which possess the power of coagulating blood,—is capable of perverting the surface nutrition and of causing local tissue necrosis. And, finally, there should be added to this list the following causes: benign growths in which the circulation has been interrupted, and which may ulcerate, thus diminishing surface resistance to infection; arterial spasm; depressed cardiac action; and certain drug intoxications, as exemplified in chronic ergot poisoning, which leads to tissue death

from anæmia by persistent contraction of the arterioles. As already remarked, the effects of intense heat and cold are not entirely traumatic, but are also largely influenced by disturbance of the circulation.

(4) *Disorders of Nutrition.*—Certain dyscrasic or constitutional diseases, that are characterized by a generally lowered vitality, and that possess a marked tendency to local necrobiotic manifestations—among which may be mentioned the various cachexias and anæmias and the disorders of metabolism—offer special liability to the development of an ulcer. As examples may be mentioned the ulcerations associated with scorbutus, diabetes, gout, and Bright's disease. In scurvy the vitality of the tissues is depreciated by the somewhat frequent occurrence of blood extravasations, which often end in sloughing and ulceration of the skin. In diabetes ulceration results not only from the lessened blood supply, due to the endarteritis which is so frequent an accompaniment of this disease, but also from the heightened susceptibility of the tissues to infection. The ulcers associated with chronic uræmia are particularly observed in young persons, and are chiefly found in the small intestines, although some observers claim that they are oftener situated in the colon and occasionally in the stomach. They are usually seated in the lower portion of the ileum, in a line running longitudinally along the free border of the gut, and they do not show any special preference for the agminated glands. These ulcers are mostly irregular in contour and deep, and occasionally they lead to perforation.

The effects of certain mineral drugs upon the general nutrition is demonstrated in the specific action of phosphorus and mercury, the ulceration dependent upon which being more commonly met with in the mouth, probably at points where resistance to infection is least. Those singular ulcerations of the duodenum which are secondary to extensive cutaneous burns and which are regarded by some pathologists as embolic; and the ulcers resulting from certain diseases of the skin which have not yet been decided to be of germ origin—such, for example, as pemphigus, eczema, ecthyma, etc.—belong to this class of disorders of nutrition.

The diminished vitality dependent upon changes incident to senility predispose to surface necrosis. These are manifest in the frequent skin degenerations and ulcerations of the aged, especially in those individuals who are exposed to the vicissitudes of weather.

(5) *Tropho-neurotic Derangements.*—That an influence favorable to local tissue-death may be transmitted along the nerve paths is an undoubted fact, and, although such disorders are for the most part intimately connected with both nutritional and circulatory disturbances, they should be placed in a distinct and separate group by themselves.

Positive examples of this type of ulcer are seen in certain lesions of the spinal cord, as in the tabetic class of diseases, especially tabes dorsalis. The ulceration resulting from trigeminal neuritis furnishes another instance; and slough-

ing bed-sore, or decubitus, must also be placed in this category, although it is regarded by some writers as belonging to the class of pressure sores, and therefore as traumatic in its origin. In addition, the advanced stage of Raynaud's disease comes legitimately within this scope, and the same obtains of that peculiar, circumscribed, circular ulcer of the plantar surface of the foot, commonly located at the base of the great toe, which is known as perforating ulcer of the foot (and which is often also mentioned as a variety of pressure ulcer).

II. *The Infective Class.*—This embraces all ulcers dependent upon causes, both local and constitutional, of undoubted or at least probable bacterial origin.

(1) Among the *local infections* producing cell degeneration and ulceration chancroid is conspicuous. They include also: the primary lesion of syphilis; secondary infection of normally healing wounds by pyogenic organisms; malignant neoplasms the surface vitality of which is lowered through defective blood supply (as carcinoma and sarcoma, including so-called rodent ulcer); primary tuberculosis of the skin and mucous membrane (which includes lupus and lupoid); and the stings of poisonous insects and bites of serpents and animals, which often cause tissue-death and ulceration.

(2) Under *constitutional infections* come the infective granulomata—tuberculosis in its secondary ulcerous manifestations, the ulcerations of syphilis during the secondary and tertiary periods, the ulcerating nodular growths of glanders, the ulcerating nodules of tubercular leprosy, together with the ulcerations of actinomycosis and rhinoscleroma. This division also includes the various forms of ulcer that accompany typhoid fever, diphtheria, amoebic dysentery, etc.

Pathologic and Anatomic Characters.—The cause and location of an ulcer largely influence its anatomical characters, and therefore the extent, depth, shape, and other general features of an ulcerated area are naturally modified by various conditions.

An ulcer may be quite small or so extensive as to be almost without limit, as is sometimes observed in ulcers that completely encircle a limb or that involve large areas of the surface of the body. The ulceration may be restricted to a superficial denudation—a mere abrasion at first—which does not undergo prompt repair and soon becomes an ulcer through the irritation produced by the air, by chemical changes in the dried secretions covering the part, and by infection.

But the ulcerative process more often extends to the deeper layers of the corium and even to the subcutaneous or submucous tissue, or still deeper—to a depth that includes all structures down to the bone.

Anatomically, an ulcer is composed of two layers: a superficial layer of soft granulations—granulation tissue—and a deeper and dense, pearly white, fibrous layer, which separates the healthy structures from the granulation tissue above, and which defines the limits of the diseased tissue.

In a recent or acute ulcer of the skin the microscope shows, near the margin of the ulcer, the following changes: a decided thickening of the rete mucosum, with enlargement of the papillæ; the connective tissue œdematous and infiltrated with round cells; and the blood-vessels increased in size. As the ulcer grows older the inflammatory products undergo organization, and there is developed a connective tissue which soon condenses into that dense, sclerotic layer of fibrous tissue which surrounds and limits the chronic ulcer.

To enter more minutely into details, we may say that a recent ulcer consists histologically of, first, a film or layer of inflammatory exudate in which are embedded shreds of tissue in a state of coagulation necrosis. Immediately below this, exists a layer of epitheloid cells and polynucleated white cells possessing but little intercellular substance—a layer which is permeated by a lacework of capillaries with offshoots or branches passing vertically to the surface. This layer, furthermore, is clearly outlined by the massing together of the round-cell elements of its structure. Beneath this is still another layer, which is made up of distinctly transparent tissue, much richer in intercellular substance and containing fusiform cells and pale transparent fibres (Warren). Frequently this tissue consists, to a large extent, of an œdematous fibrous tissue with widely separated groups of cells. Below this is encountered some of the fibrous tissue of the deeper cutaneous layers and cicatricial tissue (Fig. 26).

The surface or floor of an ulcer may be either smooth or irregular, raised or excavated, *i.e.*, crateriform. It may be covered with necrotic tissue, or composed of well-defined granulations in different conditions; and from its surface may ooze either an odorless or a foul-smelling serum or pus. Or the base may be dry, presenting a bacon-rind appearance, or it may be covered with dried secretions forming a crust.

The margins or borders of ulcers determine their shape, and thus an ulcer may be circular, oval, or crescentic in shape; and it may have a regular or an irregular outline. The borders may be elevated above the base, or on the same level with the surface, or even depressed below it. Again, the edges may be sharply defined as if punched out, or everted, or undermined, and also the wall of the border may be steep and abrupt, or sloping. The edges may be red and inflamed, and often they are purplish-red or livid in color, by reason of the impeded and feeble circulation; then again, they may be bordered by a bluish-white line of advancing epithelial regeneration. As regards their consistence, the borders may be soft and smooth, indurated and leathery, thin or œdematous; and they may be attached to the deeper parts—as, for example, to the fascia; but, when the ulcer is situated over some osseous point which has only a superficial covering, the borders are likely to be attached to the periosteum and the bone.

The character of the discharge from the surface of an ulcer depends upon the condition or state of the ulceration; it may be profuse or scanty, and the

color and quality are also influenced by the special or individual conditions of the ulcer—that is, the discharge may be creamy or purulent, sanious or blood-stained, and ichorous or watery, having the appearance of serum. The quantity of the discharge depends a great deal upon the nature and location of the

FIG. 26.—Section of Chronic Ulcer of the Skin in Process of Repair. (From the Collection of Dr. Edward H. Nichols, of Boston, Mass.)

ulcer, as well as upon the fact whether it is or is not irritated. Thus, for example, the medicinal applications and the dressings employed in the treatment of the ulcer may exert either a stimulating or a sedative effect.

The surrounding skin may be unchanged, or it may be red, inflamed, and swollen. In the case of ulcers on the legs and about the anus, the skin is

often eczematous, and, if the ulcer be of a chronic type, it is usually discolored and pigmented.

The material discharged from a granulating surface, in process of healing, is known as *pyoid* or *puroid*, and is now understood to differ radically from true pus. It possesses all the common appearances of pus, but it is lacking in the usual distinctive features characteristic of that material. Its constituents, both fluid and corpuscular, correspond exactly with those of real pus, but it is not infectious, and it originates in a very different manner, being produced by the overflow or superfluous waste, as it were, of the various elements thrown out by the tissues and blood in the attempt at repair. It does not contain bacteria until after reaching the surface, and only then becomes infected through contact with infectious micro-organisms. But in the case of ulcers originating from certain local infections, like syphilis, tuberculosis, glanders, and so on, the discharges may contain the specific infectious agent which originally caused the ulcer, and in consequence they may be capable of reproducing similar ulcerations; in other words, they possess auto-inoculable properties. Again, the discharges from sloughing and gangrenous ulcerations contain the germs of putrefaction, and are ichorous and bloody and of a fœtid odor.

Symptoms and Varieties of Ulcers.—Normally granulating ulcers are designated as *healthy*—a more appropriate term is *healing*—when the surface is composed of small florid granulations of healthy appearance, secreting a moderate quantity of thick, yellowish-white pus, and manifesting along its edges the advancing bluish-white line of epidermization. These comprise every symptom and indication of inflammatory amelioration and natural repair.

When cell multiplication occurs more rapidly than is required for fibre formation—a degree of activity which is usually the result of infection—and granulations are produced so rapidly that they outrun, as it were, the contractions of the margins of the ulcer, these granulations are designated as *exuberant*. Commonly, when the granulations are tardy in formation, inactive, and blanched in appearance, the term *feeble* is often applied to them. An ulcer that is increasing and enlarging by molecular death or true ulceration is spoken of as *progressive*. When, through defective nutrition or other causes, the granulation tissue ceases to proliferate, and the granulations are few and of small size, the ulcer remaining stationary, it is known as an *indolent ulcer*. A linear, groovelike ulcer, with steep and sharply formed sides, is usually termed *fissured*, as in fissure-ulcer of the anus or the fissures of cracked nipples; and it is called *fistulous* when communicating by a tube or pipe-like passage with some deeper-seated lesion.

Ulcers are divided, according to their symptoms and course, into two principal forms or varieties: 1. The acute ulcer, and, 2, the chronic ulcer, and these are further separated into a number of subvarieties in conformity to some prominent feature manifested by the individual ulcer.

1. *The Acute Ulcer.*—This represents an ulcerated area of recent formation, covered with healthy granulations, somewhat inflamed, and showing a positive disposition to spread. It usually arises from a superficial wound or abrasion, and its base is formed of florid or deep red elevations or granulations of moderate size and healthy appearance. Usually the granulations are nearly if not quite on a level with the general surface of the part, and the discharge flowing from them is composed of a somewhat scanty, rather thick, yellowish-white pus. The sharply cut and irregular margins are not elevated, but lie on the same plane with the surrounding surface, and are only slightly infiltrated. A moderate-sized zone of surface congestion encircles the ulcer. The picture is that of a recent granulating wound.

2. *The Chronic Ulcer.*—The chronic or indolent ulcer is the opposite of the acute ulcer, and, as a rule, has the history of having existed for months and often for years, and possibly with little or no change either in appearance or in condition during this period. The appearance is characteristic: the yellowish-white excavated base is smooth, dry, and glossy, similar to mucous membrane, or frequently callous, resembling bacon rind; it is covered with a delicate layer of white necrotic tissue and is devoid of granulations. Not infrequently the ulcer extends deep into the tissues, exposing at the bottom of its base both fascia and muscular tissue. The edges are indurated and thickened, seldom ragged, but usually regular in outline, and are considerably elevated above the adjacent sound parts, giving an appearance of greater depth to the ulcer than actually exists. As regards their color the margins are generally somewhat pale, although they may be livid and of a purplish hue, or even crimson, and the white line of skin regeneration, seen in acute or simple ulcer, is not visible. Again, the surrounding surface gives little or no appearance of congestion or inflammation. The ulcer may be perfectly dry or covered with a thin watery discharge of small amount and with none of the characters of pus. There is usually no pain or sensitiveness, and often the sensibility of the surface of the ulcer is so diminished that we may speak of the latter as being almost anæsthetic. However, in some instances, as when nerve terminals have been caught in the contracting fibrous tissue surrounding it, a chronic ulcer may become exceedingly painful. When a chronic ulcer has been irritated and new infection has taken place, then the entire picture changes, and all the symptoms and manifestations of inflammation are present, engrafted upon those of ordinary chronicity. Chronic ulcers are commonly the outcome of the specific infections—syphilis (Fig. 28), tuberculosis (Fig. 27), leprosy, glanders, etc.—but they may also arise from non-specific agencies occurring in tissues possessing unusual susceptibility to such changes. This is observed in the chronic venous stasis of the leg below the knee which is dependent upon varicose veins, in which condition the ulcer is prevented from carrying on repair by the state of the circulation and nutrition of the part. Indeed, varicose ulcer of the leg presents the characteristics

of the typical chronic ulcer (see Plate XI). Another type of non-specific chronic ulcer is seen in chronic gastric ulcer, where cicatrization is held in abeyance probably by some abnormal condition of the stomach secretions.

A very frequent cause of chronic ulceration is to be found in the obstacles which interfere with the contraction of the ulcer—obstacles which are present in leg ulcers and more especially in ulcers of the scalp. The cutaneous covering

Fig. 27.—Extensive Tuberculous Ulceration. White, female, 67 years; ulceration of sixteen years' duration; beginning in skin over sternum (glandular structure of breast not involved); line of cicatrization along margin above, and islets of new skin in centre; healed ulcerations on shoulders and right side of neck and back, not shown in photograph. (Original.)

of the scalp is not prone to ulceration, but when this once occurs the process is apt to be slow and may extend over a period of years. This tardiness in healing is due to the character and anatomical relations of the tissues of which the scalp is composed, the granulations at an early stage fixing the margins of the ulcer to the deeper structures, and preventing that contraction of the edges which is necessary for its perfect cicatrization.

Some of the subvarieties of ulcer are the following:

(a) *Simple Ulcer.*—Simple ulcer is not due to any specific cause, but is the result of a variety of local conditions. It is clinically but a later stage of acute ulcer, and differs from it only in degree and age. In its primary state it presents abrupt margins, which may be rimmed with a bluish-white line indicating the slow advance of epithelial formation; brownish-red or yellowish-red granulations, which are flat and on a level with the contiguous skin; and a moderate
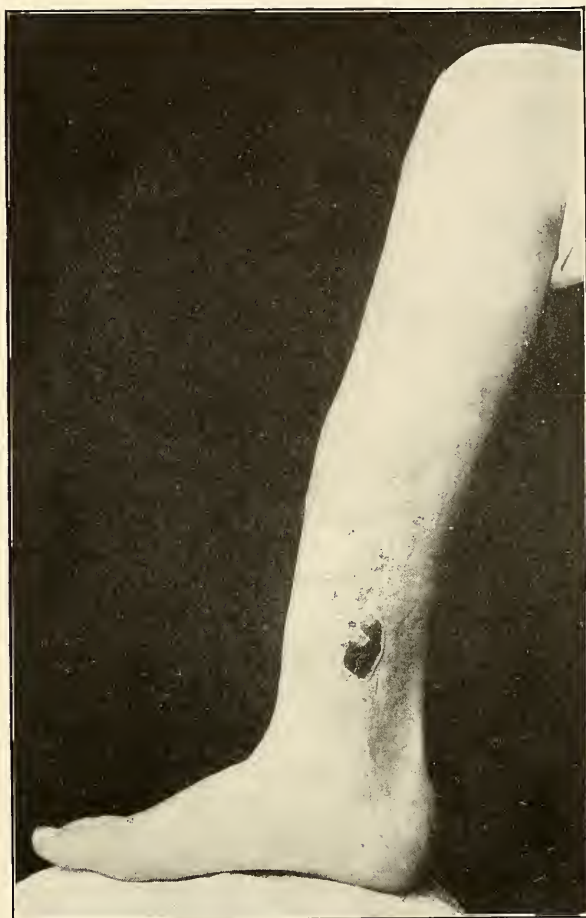
Fig. 28.—Hereditary Syphilitic Ulcer of Right Leg. White, male, 20 years; osteitis and periosteitis since childhood, producing "sabre-leg" deformity; extensive old scar tissue with pigment deposit shown; open ulcer below. (Original.)

sero-purulent discharge. Sometimes the granulating base is slightly sunken. The surrounding skin may be quite normal, but often this is swollen and infiltrated, and occasionally there is a mild inflammatory zone encircling the ulcer. The latter evinces no disposition to rapid extension, but progresses rather slowly and often is simply at a standstill. Various local causes are operative in retarding the process of repair, among which are muscular and joint movements, friction, and the effect of irritating applications and dressings and of chemical

changes in the secretions. Then besides—in those instances where neglect and want of cleanliness exist—a decided tendency to extension is shown. Not infrequently certain vocations favor, in a positive manner, the development of a simple ulcer. Infection, to which simple ulcers are easily liable, quickly alters the picture presented by the disease.

(b) *Inflammatory Ulcer.*—Any form of ulcer may become inflamed, and, when this happens, the symptoms presented will be those attendant upon an accession of acute inflammatory conditions. This is often caused by septic infection, but it may also result from any form of irritation, chemical or mechanical, meddlesome treatment not infrequently causing it. When inflammatory action begins in an ulcer the surface becomes hot and painful and changes in color to an intense red; it bleeds upon the gentlest touch; and it is often covered with shreds of necrotic tissue. Pus begins to be secreted in large and increasing quantities, and the ulcerative action rapidly progresses. The borders melt down and become irregular and eaten out, a bright red areola of vascularized and œdematous skin surrounds it, and secondary ulcers quickly form near the margins of the primary ulcer. The whole appearance and condition of the parts indicate rapid and progressive infection.

Such inflammatory changes are apt to occur at one time or another in the history of a varicose ulcer.

(c) *Callous, Atonic, or Indolent Ulcer.*—This is the form so frequently assumed by the chronic ulcer that it may be regarded, for all practical purposes, as representative of it. Consequently no additional description is necessary for this subvariety beyond what has been already said when the chronic type was under discussion. Its characteristic feature is the dense, lardaceous, or callous thickening of both the base and the edges—an alteration which has suggested the name of *ulcus atonicum;* and the most perfect examples of such an atonic ulcer are furnished by ulcers associated with varicose veins.

(d) *Varicose Ulcer* (Plate XI).—Varicose veins of the inferior extremities, particularly when they involve the smaller cutaneous veins, undoubtedly constitute one of the most prominent causes of ulcer; and, furthermore, the varicose ulcer stands as the classic type of all ulcers, and the one with which the surgeon is most familiar. These venous varicosities produce a passive hyperæmia of the skin and subcutaneous tissues, as a result of which these structures become infiltrated with serum and suffer correspondingly from enfeebled nutrition. This lowered nutrition leads either to a periphlebitis—which results in a small abscess that opens and leaves an ulcer—or to a local eczema, which readily ulcerates. Then, again, the lowered vitality of the skin is such that the slightest traumatism may result in bacterial invasion, inflammation, and ulceration.

These ulcers are most commonly situated on the leg near the malleoli, especially the internal, or a short distance above the malleoli.

ULCER OF THE LEG DEVELOPING ON A BASIS OF ECZEMA
AND VARICOSE VEINS.

(e) *Pressure Ulcer.*—A pressure ulcer is likely to develop whenever mechanical pressure, even of moderate degree, is exerted upon some part of the surface of the body for a certain length of time, and more especially if the nutrition of the part thus subjected to pressure be imperfect. A special form of pressure ulcer has been described as occurring on the plantar surface of the foot. In this ulcer the first stage observed is the formation of a callosity or thickening of the epidermis, beneath which an infective inflammation and suppuration take place; and ulti-

FIG. 29.—Ulcerations of the Sole of the Foot, due to Tabes. ("Cliniques Médicales Iconographiques," par M.M. Haushalter, Étienne, Spillmann et Thiry, Paris, 1901.)

mately there remains, as a result of these inflammatory changes, a deep ulcer with markedly indurated and thickened edges.

The usual form of pressure ulcer is seen in the simple or ordinary bed-sore in a patient suffering from some long and serious illness, with feeble cardiac action and lessened tissue vitality. In such a case, if the prominent portions of the body, as the promontory of the sacrum and other bony points, are subjected to pressure, anæmia and necrosis of the soft parts follow; and in addition, if secondary infection should ensue, extensive destruction may take place.

(f) *Ulcer due to Defective Innervation* (Fig. 29).—This variety of ulcer is the result primarily of deficient innervation, and may occur in a number of nerve

lesions in which the nerve supply to a region becomes defective. Superficial and often multiple ulcers, painless and of an atonic character, with imperfect granulations, are met with on paralyzed extremities; for example, on the fingers and toes. Sometimes they appear on the plantar surface of the foot, where they then partake largely of the characteristics of pressure ulcers proper.

The ulcer known as *mal perforant du pied* furnishes another example of an ulcer due to deficient innervation, although it is placed by some pathologists in the category of pressure ulcers. Probably both causes are operative. It is usually encountered in men of middle age whose occupation keeps them constantly on their feet, and is commonly situated beneath the heads of the metatarsal bones, especially that of the great toe, but may occur on any part of the sole. It is probably due to a peripheral neuritis and is not always associated with a paralytic condition. The symptoms are similar to those of the pressure ulcer of the foot; that is, a thickened and callous point first appears on the skin, and beneath it inflammatory changes and pus formation take place; then, soon afterward, there is developed a deep, funnel-shaped ulcer, which often penetrates deeply into the tissues, possibly even through to the dorsum of the foot; at the same time the bone not infrequently becomes involved and the disease may even invade the joint, in which latter event a rarefying osteitis may follow. The surface of the ulcer, in a case of this nature, is the seat of wart-like granulations, reddish in color; the cavity is piled up with a mass of decomposing epidermis; and the skin is foul and fetid.

In some instances trophic changes in the skin—possibly dependent on a vasomotor neurosis of some form, or caused by some disturbance in the function of the nerves that directly preside over cell life—may lead to death of the area involved, often at multiple points, and ulceration then results.

(g) *Acute Decubitus or Bed-sore.*—Closely related to the above-mentioned ulcers of defective innervation is decubitus or true bed-sore. This differs from simple bed-sore, or the pressure ulcer dependent upon local anæmia, both as regards the causes which give rise to it and as regards the symptoms. Acute decubitus usually develops in the course of spinal-cord lesions, and may be attributed to trophic derangements associated with the ischæmic condition of certain prominent portions of the body; this ischaemia being due to the fact that the patient is obliged to lie for a long time in one position. In the causation of such a bed-sore, therefore, both neurotrophic and nutritional causes are at work. Acute decubitus also develops in the course of transverse myelitis, in which disease necrotic changes in the tissues occur so rapidly that the effect of pressure can be positively eliminated. In these cases the decubitus must be ascribed alone to disturbance of vasomotor innervation and general nerve conduction.

Rapid and extensive sloughing may take place in acute decubitus, and often the entire sacrum, the vertebral spines, the scapulæ, both heels, and other prom-

inences are denuded of their soft coverings down to the bone, after the separation of large masses of gangrenous tissue.

(h) *Weak, Torpid, or Anæmic Ulcer.*—Ulcers become weak or anæmic whenever the blood supply to the part where they are situated becomes deficient in quantity or quality. In any case in which the supply of blood to the ulcer is interfered with, or in which the blood so supplied is poor in quality—as happens in certain constitutional diseases—a weak, flabby, or anæmic form of granulation tissue results. In some instances the granulations are yellowish and smooth and the edges of the ulcer are pale and flat, and from its surface there exudes a thin scanty secretion that quickly dries and forms a delicate crust; or the granulations may become pale, flabby, and œdematous. Finally, in still other cases the granulations may even show a disposition to grow luxuriantly—a result usually attributable to irritating applications or to lack of ability, on the part of the ulcer, to contract. This type frequently occurs in scurvy and tuberculosis.

(i) *The Fungous or Fungoid Ulcer.*—In this variety there is a luxuriant and rapid development of granulation tissue, which causes the base of the ulcer to rise considerably above the edges; at the same time there is a degree of cellular proliferation altogether out of proportion to the necessary fibre formation. This overgrowth of granulation tissue is caused in part by an excessive blood supply, often due to infection, and in part by an inability of the margins of the ulcer to contract; it is encountered in those regions which are quite vascular and where the skin is thick and unyielding—as for example, in the feet and hands. These exuberant granulations are vulgarly known as "proud flesh," and technically the term *ulcus elevatum hypertrophicum* is applied to them. Not infrequently several of these granulations are seen to project above the others as tumor-like formations, having somewhat the form of a mushroom with a slender stem. Each such button-like mass of granulations is supplied with a large arteriole which bleeds freely when the growth is cut off.

Fungous granulations often occupy the external openings of fistulæ, especially if they lead to necrosed bone and are of tuberculous origin.

(j) *Sloughing Ulcer.*—This variety of ulcer is characterized by progressive ulceration with positive necrosis or sloughing, although not reaching to the degree of gangrene.

(k) *Phagedenic, Gangrenous, or Diphtheritic Ulcer* (Fig. 30).—In ulcers of this character there are, not merely a slight slough, but also evidences of a phagedenic or even gangrenous process. The disease extends often with surprising rapidity, and is the outcome of some local virulent septic infection, or of a specific virus. The base is ragged and the edges irregular and gnawed out, and, when diphtheritic infection is the cause, the ulcer is covered with a grayish, pulpy exudate, which rapidly extends into the contiguous tissues, producing extensive tissue destruction and often a general systemic invasion. A typical example

of phagedenic ulcer is occasionally seen in chancroid, which spreads rapidly in circumference and often includes large areas of surface. In pre-antiseptic days this form of ulcer was more often associated with hospital gangrene.

FIG. 30.—Gangrenous Ulceration of Foot and Ankle. Mulatto, female, 68 years; chronic ulcer of many years' duration, but gangrenous condition of comparatively recent date; ulceration extends down to bone, exposing tendons on all sides of ankle, including heel tendon; infiltration and hypertrophy excessive, with nodular areas, suggesting elephantiasis; foul ichorous discharge. (Original.)

(*l*) *Serpiginous Ulcer.*—The term serpiginous is applied to an ulcer which breaks down and advances in one direction, while undergoing repair in other parts. It is really a form of phagedenic ulcer, and not seldom covers a large surface.

(m) *Hemorrhagic Ulcer.*—The surface of the hemorrhagic ulcer is composed of œdematous granulations of a dark-purplish color, which bleed with readiness and quickly break down. The blood oozes from the granulations and often coagulates on the surface in the form of a thin coagulum. Certain constitutional diseases—particularly scorbutus—seem to be responsible for this hemorrhagic tendency.

In certain cases where the menstrual flow has been suppressed, or where long-continued bleeding from hemorrhoids has been suddenly arrested, vicarious hemorrhage has been observed to take place from an ulceration of this form. Again, it should be remembered that the hemorrhagic ulcer is not infrequently epitheliomatous in character.

(n) *Erethistic, Painful, or Irritable Ulcer.*—The erithistic or painful ulcer is distinguished by the presence of exceedingly painful granulations, which also display a tendency to bleed. The cause has been ascribed to an unusual thinness of the granulations, but it is not yet positively known upon what this excessive irritability of the granulations depends, since granulation tissue is ordinarily not rich in nerve elements. It is observed commonly in neurotic and anæmic individuals, particularly females; and the anæmia following a large loss of blood has been known to occasion it. The skin covering the external malleolus is the seat of choice. Other examples of painful ulcer are frequently seen in cases of fissured ulcer of the anus, and again in certain ulcers of the cornea, where the sensitiveness and irritability are exquisite. It is also met with in old ulcers connected with bone.

(o) *Cicatricial Ulcer.*—Occasionally cicatricial tissue breaks down and suppurates, causing what has been designated as cicatricial ulcer. This is generally covered with granulations of a large size, which show no disposition to heal. Ulcerative degeneration of this character is usually observed in anæmic, weak individuals, probably with a tendency to tuberculosis, and frequently results from some slight or trivial injury, and from friction produced by wearing-apparel, or from a simple abrasion.

Results and Dangers of Ulcers.—It is probable that ulcers do not receive from surgeons the prompt and energetic attention which their importance demands, and especially when they involve the lower extremities in the form of an old chronic ulcer. And yet the results, dangers, and complications of ulcerations, no matter where situated, are so positive that the most careful and painstaking effort should be made to effect a speedy and lasting cure in every instance.

Without taking into consideration the state of semi-invalidism and the other hinderances to the pursuit of a business vocation which the disease is apt to entail, it should be remembered that a person afflicted with ulcer is menaced by certain dangers, not the least of which is lameness or positive crippling where an extremity is the seat of the lesion. The contractions of cicatricial

tissue cannot be regarded too seriously. The extensive contractures following the healing of ulcers situated over or in the neighborhood of joints are offered as a familiar example; indeed, they are not infrequently so pronounced as to lead to rectangular flexions and total disability of a limb. In the instance of the ankle joint this distortion may become so marked as to produce a state of extreme *talipes equinus*, as illustrated in Fig. 31. In this case a railroad crush of the soft parts of the heel and plantar surface resulted in ulceration and cicatricial contraction producing the deformity there shown. Also, when the ulceration has completely encircled a limb—as, for example, the leg, —the contracting scar tissues may impede the circulation to such a degree that œdema is produced and the use of the limb thereby rendered impossible. Then, again, where a large ulcerating area is located over muscles and tendons, the inflammatory infiltration may so cement and bind together muscle, tendon, and tendon sheath as to convert them into an inseparable mass, thus rendering the part deformed and useless. Finally, the distortion and disfigurement produced by contracting scars, when these follow ulcers that are located on such parts as the neck, face, mouth, eyelids, nose, or ears, may render life a burden to the afflicted individual. Extensive cicatricial contraction has caused lateral curvature of the spine.

Fig. 31.—Extreme Talipes Equinus of the Right Foot following Traumatic Ulceration. Negro, male, 24 years; railroad injury of heel and plantar soft parts one year before; extreme cicatricial contraction producing club-foot deformity; large ulcer of heel still existing. (Original.)

Various infections find a ready atrium through an open ulceration, and, when it is considered how universally ulcers are disregarded and neglected, it is remarkable that septic invasion in some form is not oftener encountered. This is only accounted for by the resistance offered by granulation tissue to the entrance of bacteria.

A simple phlebitis may ensue upon simple irritation applied to an ulcer,

or a dangerous septic inflammation of the veins may arise from virulent infection through this avenue. Furthermore, other infectious diseases—such as erysipelas, diphtheria, phagedæna, etc.—often invade ulcers and gain entrance to the system. Erysipelas is the most frequent form of sepsis observed in ulcers, being especially common among the poorer and less cleanly classes, and in some instances even causing death. Lymphangitis and adenitis constitute another serious form of sepsis, which may lead to extensive suppuration and burrowing of pus, and sometimes results in death from septic fever, amyloid degeneration of the liver and kidneys, and exhaustion. Rapid and extensive gangrene may supervene upon ulcerations, and may—when the part involved is a limb—necessitate amputation.

In ulcers of the hollow viscera a serious and dangerous complication is extension of the ulcerative process, with perforation into an adjacent organ or one of the great serous cavities of the body. This event, unfortunately, happens somewhat frequently in cases of peptic ulcer of the stomach, of typhoid ulcer of the intestines, of appendiceal ulceration, of ulcer of the gall bladder due to biliary calculi, and of ulceration of the urinary bladder. Again, this complication may occur in syphilitic or malignant ulcers involving the palate, cheek, or septum nasi, and in perforating ulcers of the rectum, vagina, uterus, and urethra. The persistent fistulæ, which often remain in such cases, are a source of considerable distress to the patient.

Hemorrhage is always a disturbing complication and may assume a most dangerous and even fatal form in some ulcers. This remark is especially true of gastric and intestinal ulcers and the ulcerations of malignant growths. Occasionally the hemorrhage which results when an ulcer erodes the coats of enlarged or varicose veins, contributes a complication both annoying and dangerous.

Another danger of no small consequence is the tendency to malignant degeneration that ulcers frequently evince. Although this change is largely confined to chronic ulcers, yet it should be noted that the simple ulcer sometimes undergoes carcinomatous transformation, and such development comes as a rule from long-continued neglect and local irritations. The epitheliomatous changes probably first take place in the margins of the sore, as evidenced by the edges becoming thickened and infiltrated with round and connective-tissue cells; and an examination with the microscope furnishes all the indications of commencing skin carcinoma.

Tuberculous ulcers of the face, especially those of the primary or lupoid variety, often show a disposition to take on epitheliomatous transformation, and the same malignant transmutation has been observed in the long-standing ulcer that results from x-ray burns. But the greater liability to carcinomatous development resides in the chronic ulcer (Fig. 32), and in the initial stages this change is often masked and obscured, rendering it difficult to make an early diagnosis. At first, the edges are observed to be thickened, indurated, nodular,

and irregular in outline, the induration not being strictly confined to the margins, but extending into the surrounding cutaneous structures. Beginning at the margins the granulations of the entire base of the ulcer soon become dense, but are easily torn and bleed readily, and finally grow into irregular nodular masses of granulation tissue that speedily assume all the characteristic appearances of true epithelioma. Frequently the rapid growth of the transformed granulations brings these above the level of the edges, producing a fungus-like tumor typical of the condition. Microscopic sections should include the full depth of the ulcer and also the margins, since examinations of the protuberant central granulations alone often do not afford conclusive evidence of the nature of the tissue.

Fig. 32.—Cancroid of the Leg, Developing from an Old Simple Ulcer. (Meyer, in Neisser's "Stereoscopischer Med. Atlas.")

Rare instances of chronic ulcer having undergone transformation into sarcoma are recorded.

Diagnosis.—An ulcer is not to be regarded as a separate disease, but as a lesion, often accidental, that may occur during the course of many diseases, and therefore the diagnosis of ulcer applies rather to the disease producing it than to the ulcer *per se.*

Whereas the location, depth, shape, and condition of the base, walls, and edges of an ulcer—as well as the fact whether the lesion is solitary or is associated with other similar ulcers—are of important diagnostic significance, these characters, nevertheless, have their chief bearing upon the malady of which the ulcer is simply an expression. Such diseases which are represented practically by the group of infectious granulomata—tuberculosis, syphilis, leprosy, glanders, actinomycosis, mycetoma (Madura foot), mycosis fungoides, and chancroid—are fully considered in the respective chapters which treat of these subjects, and the reader is therefore referred to them for a more elaborate consideration of their distinctive features.

Prognosis.—Inasmuch as ulceration is largely, if not wholly, the result of a pre-existing condition or disease, it naturally follows that the prognosis

of ulcer depends in great measure upon the cause producing it, and also, to some extent, upon a number of contributory factors, such as the state of health and age of the individual affected, etc.

A simple acute ulcer in a healthy, or rather healing, condition may generally be expected, under appropriate treatment, to terminate in prompt cicatrization with a minimum of scar tissue resulting. On the other hand, the prognosis of ulcers of a specific character will be governed not only by the nature of the underlying toxæmia, but also by the locality which they occupy. For instance, tuberculous ulcerations of the skin (Fig. 27), which, in former years, were regarded as incurable, now yield in the majority of instances to modern surgical methods of treatment; but, when they involve the alimentary tract, it is more commonly found that they resist the best directed efforts and finally end in the patient's death. Likewise the ulcerations in carcinoma and sarcoma unfortunately offer a grave prognosis, as is the case in many other specific infections. However, the discovery of the beneficial influence possessed by the Roentgen ray and the newer radium over these tumors has disclosed a broad therapeutic field which not only is full of realities, but also suggests greater possibilities. More especially has the audacious advance of latter-day surgery opened up avenues for successful treatment of certain forms of ulcer hitherto believed to be beyond the reach of medical skill, as exemplified in the single example of gastric ulcer, both carcinomatous and peptic, in which conditions a timely resort to excision of the diseased area, or an early gastro-enterostomy, affords a permanent cure, or, at least, adds both to the life and the comfort of the patient.

Treatment.—In the treatment of ulcers, as in the rational management of the vast majority of disease states, the cardinal principle is to attack the cause that produces the lesion. And, since it is recognized that ulcerations are due to a variety of causes, including infections, dyscrasic states, and local conditions, it is obvious that any successful method of treatment must comprise both constitutional and local remedies, and often a combination of these. Thus, when the basic element is an infection the treatment should be addressed energetically to neutralizing the specific poison; if the cause be attributable to depraved nutrition or blood impoverishment, the treatment should embrace those therapeutic measures which tend to raise the general state of the blood to the proper or normal standard; and when both systemic and local causes prevail, as is probably characteristic of the greater number of cases, the required constitutional measures, as well as those which are appropriate for the amelioration of the local conditions, should be adopted.

Constitutional Treatment.—The constitutional treatment of ulcer should be adapted to the individual or special case, although in a general way the measures employed in all cases have much in common. An uncomplicated ulcerated surface that is in a healthy or healing condition requires as a rule no systemic

treatment, unless it be that the patient is generally enfeebled or below the usual health standard, when tonics, especially the ferruginous preparations, together with nutritious food and proper hygienic surroundings, are called for. On the other hand, it is the general surgical infections and the anæmias and like dyscrasias that demand constitutional treatment and a careful regimen.

When the ulcer arises from luetic infection a specific or anti-syphilitic course of treatment is absolutely necessary before any change in the local manifestations can be expected. Here tonics, cod-liver oil, and similar preparations should be administered in addition to the judicious employment of the iodides and mercury. In tuberculous ulcerations food and proper hygiene are of the first importance, and these, together with appropriate internal medication, climatic surroundings, and external applications or surgical procedures, meet the indications. In ulcers dependent upon scorbutus the proper diet, including the liberal consumption of acid fruits, is most essential. This attention to diet and improved hygienic conditions, the administration of iron and other tonics, and the adoption of such local treatment as may be required by the individual ulcer will usually suffice for a cure of the trouble. The same line of treatment is applicable to most of the other dyscrasias. In diabetic ulcers an antidiabetic diet is imperative, and at the same time suitable intestinal antiseptics and constitutional remedies should be administered. It should also be remembered that operative procedures are most unsatisfactory in these diabetic cases. Hence, skin grafting by the flap methods or excision of the ulcer should be resorted to only in exceptional cases, and even radial incisions and curettage should be cautiously practised. In the ulcerations of glanders, leprosy, and actinomycosis the constitutional treatment is the specific one adapted to each infection.

Topical applications or surgical measures are usually necessary adjuncts to the general treatment in all these cases.

Local Treatment.—The local treatment of ulcers comprises certain essential points that need careful observance. Of these, cleanliness, which means *disinfection*, is of the first importance, and should be scrupulously practised in every instance; and this advice has reference, not only to the ulcer, but also to the adjacent skin. In the case of a *healing* ulcer the plan here suggested, in connection with the application of protective dressings, is usually all that is necessary to promote rapid cicatrization.

Skin sterilization is to be effected in accordance with the ordinary principles of asepsis and antisepsis—viz., by thoroughly bathing the field with soap and hot sterile water; scrubbing with gauze sponges in preference to a stiff brush (for the slightest break in the epidermis in the neighborhood of the ulcer is to be avoided); shaving the part, when this seems to be necessary, and applying to it a corrosive-sublimate or a carbolic-acid solution; and, finally, washing with plain sterile water or normal salt solution, alcohol, etc. If the surface of

the ulcer be foul and if infection be pronounced, it is advisable to disinfect the ulcer by the application of some positive antiseptic—either carbolic acid undiluted or a solution of zinc chloride of the requisite strength. Such applications may produce superficial destruction of the granulations, but this is of little consequence, and is probably rather in line with the treatment subsequently to be adopted.

After we have inquired thoroughly into the cause, our first effort should be directed to securing *physiologic rest* for the part affected. The measures to be adopted should be chosen with due reference to the location and type of the ulcer. In the majority of instances recumbency in bed is necessary, for this will procure both local and general rest, the value of which, in ulcerations occupying large surfaces on the trunk or on the extremities, cannot easily be overestimated. In ulcer of the leg, which is the most frequent seat of the ulcers that come under the observation of the surgeon, rest is obtained by elevation of the limb and by the adjustment of bandages, splints, and like retentive apparatus; and, in order that the immobilization shall be complete, it is necessary that the joints nearest to the lesion should also be included in the retentive apparatus and dressings. The elevated position lessens engorgement and clogging of the venous circulation, and favors both the venous return and the outward flow of blood. Venous obstruction is one of the principal obstacles in the way of cicatrization of an ulcer—a remark which is especially true of varicose ulcer of the leg—and not only retards healing, but, through its production of œdema and infiltration, promotes the transition of an ulcer, otherwise disposed to heal, into the classical chronic indolent variety.

In the case of an ulcer of the rectum or anus physiologic rest is secured by stretching the sphincter-ani muscle: and the same principle is acted upon in the operation of gastro-enterostomy for the cure of pyloric ulcer, in the establishment of drainage for the cure of ulceration of the bladder, and in canthoplasty for the relief of intense blepharospasm associated with irritable ulcers of the cornea. Rest also aids in *subduing the inflammation* that often exists when these cases first present themselves, and which must be controlled before healing can be expected to take place. Therefore, all irritating dressings, discharges, and crusts should be removed, and the congestion should be relieved by elevation where a limb is the part involved. At the same time it is desirable to apply bland and disinfectant lotions, which also aid in diminishing the attendant pain. Weak solutions of mercuric chloride, a combination of lead lotion and opium, or a solution of aluminum acetate will usually fulfil this purpose. Happily, poultices have been relegated to the past, except in certain cases where the application of moist heat is specially desired, and then they should be composed of sterile and antiseptic ingredients. But this indication can be more advantageously met by constant irrigation, by fomentations with compresses soaked in a hot antiseptic solution, or by the hot bath. Care should be observed

in respect to the long or constant use of watery applications, since they tend to render the parts sodden and to impair the vitality of a surface which has probably already lost some of its vitality. Often it is preferable to employ immersion in the continuous hot bath, the temperature of which should be as hot as can be borne with comfort. This method is particularly serviceable in foul, sloughing, and gangrenous ulcerations, and in the ulcers that result from burns, especially those in which a large expanse of surface is involved and from which it is desirable to hasten the separation of necrotic tissue. However, the difficulties and discomforts to the patient entailed by this valuable method are serious obstacles to its more general employment except in hospitals; and yet the ordinary household vessels can readily be made to serve all the purposes of this mode of treatment in private practice.

After the inflammation has been reduced and the necrotic tissue has been cast off, the ulcer may be considered ready to receive such *topical applications and retentive dressings* as are required in the individual case. And here our chief aim should be to accelerate the removal, by absorption, of the exudates that fill the tissues and exert mechanical pressure upon the minute vessels of the locality. As has been already stated, rest and position expedite the absorptive process, but this can be materially stimulated by additional treatment, especially of a mechanical character. Among such measures *massage*, when properly employed, is of utility, and should be first applied to the parts situated some distance above the lesion, and then, as they soften and become relaxed, the same manipulations should be carried out upon the parts below and around the ulcer, and possibly even upon the margins of the ulcer itself. This procedure stimulates absorption in a marked degree. But the application of *pressure* constitutes the most efficient means, and may be employed in a variety of ways. The common roller bandage is the oldest and the most universally used method, but strapping and elastic compression are superior. The compression treatment of ulcers by means of adhesive plaster was suggested by Baynton more than a century ago, and still figures as a valuable surgical resource in many of these cases. This dressing consists of evenly applied adhesive-plaster straps (the aseptic rubber adhesive plasters, especially the zinc-oxide plaster, have superseded the older makes), from one inch to one inch and a half wide and of sufficient length to more than encircle the limb. After the limb has been shaved the first straps should be applied below the ulceration; then the next ones should include the indurated and thickened parts; and, finally, the last one should extend to a distance of several inches above the lesion. Each strap should overlap the preceding one to the extent of from half an inch to one inch. Furthermore, the plaster should be so applied that it will conform to the curve of the limb; and, besides, the middle of each strap should be first placed at a point directly behind the ulcer, thus enabling the operator to finally pull on the plaster and thus approximate the edges of the

sore as the ends are crossed and made fast. This dressing affords firm pressure and uniform support, and should be reapplied at intervals of from twenty-four to forty-eight hours. The plaster is usually put on without an intermediate dressing, but it is preferable to interpose a few layers of antiseptic gauze or lint between it and the ulcer. This material absorbs the discharges and prevents them from accumulating about the ulcer and causing irritation, as often occurs when the straps are placed on the skin. A roller bandage, applied in such a manner as to cover in the foot and leg, completes the dressing.

Superior to this is elastic compression, as afforded by the Martin rubber bandage. This bandage, which is made of pure gum, measures from eight to ten feet in length, and varies in width from two to three inches. It is particularly applicable to ambulant cases, and at one time it was supposed that the rubber possessed a peculiar stimulating effect, over and above the effect produced by the mere pressure and support. The bandage should be adjusted before the patient rises in the morning, and it should be applied in the same manner as the ordinary muslin roller bandage is applied. Like this, it should extend from the toes to a point some distance above the ulceration, and it should be just sufficiently tight to furnish the required support without impeding the circulation. One of the difficulties experienced in the use of the rubber bandage is the tendency to sweating to which it gives rise in the bandaged limb; such sweating causing the skin to become sodden and favoring the development of an eczema which often complicates the original trouble. This evil has been measurably corrected by perforating the bandage with openings which maintain evaporation from the confined surface. At the present time it is not the usual custom to place the bandage directly over the surface of the ulcer; instead, a suitable dressing is interposed. It is desirable when this dressing is used, to abstain from applying any unctuous materials, since they cause rotting of the rubber; and, again, particular care should be exercised in keeping the bandage perfectly aseptic.

The Guérin-Volkmann occlusive cotton dressing was highly recommended by its authors, and stood in great favor at one time, but with the advent of the germ theory it has justly fallen into disuse. The protective and boric-acid occlusive dressing of Lister was intended to overcome many of the objections to the Volkmann dressing, and, although not in such repute as formerly, it still offers a most excellent form of dressing. Its principle is that of perfect antisepsis, which is secured by first preparing the ulcer antiseptically, then covering it with protective tissue, and finally applying borated gauze, an abundance of absorbent cotton, and a bandage. An application of some antiseptic powder or of any other material can be made before the dressing is put on. This may be worn for several weeks without changing. Probably still better than even the elastic bandage, and certainly very efficient in ambulant cases, is Unna's zinc-gelatin bandage, which possesses the advantages of affording

marked elastic support and at the same time preventing the patient from unduly interfering with the sore. This dressing presupposes, of course, thorough disinfection of the ulcer. It is quite similar to the Lister bandage except that the gauze and bandage are stiffened with a mixture of gelatin and zinc oxide (gelatin 10 parts, glycerin and water each 40 parts, and sufficient oxide of zinc to produce the desired stiffness), which solidifies at the temperature of the air, but is readily softened by moderately hot water. Heidenhain has somewhat modified the Unna dressing in the following manner: The limb is first thoroughly bathed with hot water and soft soap; then, after the parts have been dried, the ulcer and immediate neighborhood are washed with a bichloride solution (1:1,000), and all eczematous areas, together with a wide surface of skin around the ulcer, are covered with Lassar's paste; and, finally, the ulcer is dusted with powered iodoform and covered over with gauze smeared with red iodide-of-mercury ointment. When all these details have been carried out, the entire limb, from the toes to a point some distance above the ulcer, is painted with Unna's preparation, and then a starch bandage is applied and again covered with the zinc-gelatin solution. After three or four layers have been put on, a muslin bandage is applied over all. This dressing may remain unchanged for some weeks, unless it be noticed that there is a free discharge, in which event the dressing should be reapplied as soon as the discharge soaks through and produces a visible stain.

These several dressings are particularly serviceable in ambulant cases of leg ulcer, and furnish in many instances gratifying results; but, as a rule, recovery is more prompt and permanent under treatment by elevation and rest in bed.

The literature of the subject of ulcers, and especially of chronic ulcer of the leg, is appalling in its vastness, and evidences the unsatisfactory results of the endless variety of therapeutic agents suggested for them. Every possible chemical compound has been used, and even now the newer drug products of the laboratory find ready trial in these lesions. This broadcast treatment applies more especially to the *topical applications*, as represented by lotions, ointments, and powders. The majority of these remedies act by increasing or exciting the local blood supply, although some probably influence cell activity directly, as is witnessed in the use of weak caustic solutions of silver nitrate in inducing rapid cicatrization along the margins of an indolent ulcer.

Unna believes that a difference should be recognized between substances that stimulate the growth of granulations and those that excite epithelial formation; and he declares that those substances which possess reducing and dehydrating properties favor epithelial growth, while the oxygenating substances, including many of the antiseptic group, retard it. He maintains that corrosive sublimate, salicylic acid, and carbolic acid accelerate the formation of granulations, but delay cicatrization, and that iodoform and boracic

acid expedite both of these processes. With the cicatrizants he also places sulphur, and ichthyol (in particular), pyrogallic acid, silver nitrate, tannic acid, alum, etc.

Among the legion of topical agents employed, a few still uphold the reputation which they have enjoyed for years. Balsam of Peru, one of the oldest, is even now widely used, and the silver salts (especially the nitrate), the sulphate of copper, the preparations of zinc, nitrate of mercury, potassium permanganate, ichthyol, antipyrin, acetanilid, salicylic and chromic acids, iodine and its numerous compounds, subnitrate and iodide of bismuth, camphor, and aristol are the substances which are more frequently resorted to.

Iodine has been shown to be one of the most powerful stimulators of tissue growth, and it is its presence in iodoform that has obtained for this drug the prominent position which it holds in the treatment of all lesions belonging to the ulcer class. A more recent product is iodosyl, which promises to supplant iodoform in many of the cases in which it has long held sway. Where it is desirable to enhance the penetrating effect of iodine in deep-seated indurations and infections, this effect may be obtained through cataphoresis, a weak solution of the pure material or of potassium iodide being employed for the purpose.

Watery applications are preferable in many cases, while the ointments made up with mineral, vegetable, or animal fats are the preparations of choice in others. Again, the drying powders are serviceable in ulcers in which healing under a scab is desired; and similar in effect—while they also furnish local support—are the medicated flexible collodions and gelatins.

The vesicants, and particularly blisters, are serviceable in reducing the induration of a callous ulcer. They should be applied to the encircling skin rather than to the ulcer itself, on account of the rapid absorption that occurs when they are placed in contact with the ulcerated surface.

Among the comparatively recent applications are the *peptonized preparations*, such as peptonized cod-liver oil, bovinine, and like predigested nutrients, together with enzymol, protonuclein, and similar products. In ulcers in which there are sloughs and shreds of dead tissue clinging to the surface, these digestive preparations rapidly dispose of the necrotic masses, and also afford direct nourishment to feeble granulations, giving them life and vigor, as evinced in acceleration of repair. A pronounced digestive effect upon the decomposing material, in sloughing ulcers, may be obtained by dusting them with powders composed entirely or largely of pepsin, ingluvin, and papoid, all of which undoubtedly possess the property of liquefying and removing necrotic tissue.

Electricity, as a tissue stimulant and resorptive agent in indurated and indolent ulcers, promised much at one time, but the expectations have not been realized by the results.

On the other hand, *radiotherapy* has proved to be of the highest efficacy in the therapeusis of many of these cases.

The curative value of the *Roentgen rays* can be said to have passed the period of questionable value in the treatment of chronic ulcerations, notably those of tuberculous and carcinomatous origin. Numerous cases of chronic ulcer of the leg are on record as having been successfully treated with the x-ray and " Brush discharge." The remedial effect of the x-ray upon lupus is marked and brilliant in certain cases, viz., those which have not existed for too long a time; and these results have been obtained, not only in skin tuberculosis, but also in primary lupus of the mucous surfaces, as that of the faucial region and the naso-pharynx.

The x-ray apparently exerts a specific action on degenerative epithelium, and there is no doubt that it causes dissolution of new epithelial cells. Hence it exercises a powerful influence upon all varieties of carcinomatous cells, but it seems to exert the greatest effect upon cases of skin cancer, where its remedial impression is prompt and positive.

Ulcerations which develop in rapidly growing malignant neoplasms are more quickly controlled by the x-ray than are those which develop in tumors of slower growth. Consequently the slowly progressing rodent ulcer reacts more tardily to the ray than do the other forms, although they too eventually yield in a satisfactory manner. In some cases of superficial ulcerating epitheliomas the ulceration heals rapidly under this treatment, and often the entire growth disappears, the result being evidently due to fatty degeneration of the cells, with absorption. In large carcinomatous ulcerations the best results are often secured by combining x-ray treatment with surgical measures, that is, with excision, although the preoperative employment of the ray should be cautiously used, and possibly limited to cutaneous carcinomas.

The *analgesic effect* of the Roentgen rays in all ulcers has been amply demonstrated, and occasionally has been utilized in the place of pain-relieving drugs. The relief from pain afforded by this agent in malignant ulcerations has been immediate and complete in not a few instances.

The beneficial influence of the *Finsen light* in ulcerations has been demonstrated in a signal manner, and this method of treatment seems now to be established on a reliable basis. It has also achieved most gratifying results in combination with the x-rays. All forms of ulceration may be expected to react favorably to the Finsen light, and in the treatment of epitheliomatous and tuberculous ulcerations, notably in the region of the face, the curative effect is frequently prompt and most satisfactory.

The wonderful and subtle *radium* seems to promise much in the treatment of ulcers, but as yet it must be regarded in the light of an unknown quantity, or, at least, as one that is still in the balance. The reports as to its therapeutic virtues have been conflicting. Some observers assert that it produces undoubted effect upon carcinomatous tissue, while others report their experience with it as negative in cancer, but positive in tuberculosis. Several recent clini-

cal reports detail quite a number of cases of cancer of the skin and mucous membrane as yielding pronounced and gratifying results after exposure to this substance.

Recently the *atmospheric* or *open method* of treating ulcers has received the attention of a number of surgeons. H. Wagner has obtained excellent results by this method in chronic ulcers, and he advocates it warmly. The ulcer and surrounding parts are kept in as aseptic a condition as possible, simply exposed to the air during the day, and at night sprinkled with a dusting powder, such as the compound stearate of zinc. In addition to this the parts are protected at night by a covered framework, to maintain the proper temperature and prevent contact with the bedclothing. Ulcerations following extensive burns have been treated in the same manner, and there have recently been reported a number of such cases in which the slow and exhausting period of suppuration was greatly shortened and even prevented by these measures. It is also stated that the healing progressed rapidly, that the pain diminished, and that smooth flexible scars resulted (Sneve).

Bland and mildly stimulating preparations, such as boracic-acid ointment, the old-fashioned oxide-of-zinc ointment, acetate-of-lead ointment, etc., non-irritating lotions, and dusting powders of bismuth, iodoform, and boracic acid, may be used with advantage in the treatment of *simple ulcers*. In fact, in the majority of cases of this type the removal of all irritants—together with strict antisepsis, proper rest of the part, and a retentive dressing—alone suffices to bring about cicatrization.

Antiseptic and evaporating lotions and other antiphlogistic applications are the rational measures to be employed in the treatment of *inflamed ulcer*. They comprise those remedies which are generally employed in subduing any local inflammatory condition.

Stimulant and antiseptic applications are called for in both the *callous* and the *weak* or *anæmic, paralytic,* and *pressure* ulcers, and, indeed, in the larger proportion of all ulcers. Of these, iodine and some of its compounds (as iodoform and iodosyl), aristol, the salts of zinc, copper, and silver, naphthalin, mercurial preparations, balsam of Peru, guaiacol, carbolic acid, and ichthyol, singly and in combination, are among the most serviceable. Ichthyol exerts a remarkable stimulating effect upon epithelial growth. Iodoform, iodosyl, and aristol are most effective in sloughing, syphilitic, and tuberculous ulcerations.

Caustic applications are employed in *sloughing, phagedenic,* and *hemorrhagic* ulcers. Of the escharotic group, nitric, sulphuric, and chromic acids, caustic potash, and Vienna paste, or the actual cautery as represented by the Paquelin cautery or the galvano-cautery, are the cauterizing agents to be preferred. The latter (the actual cautery) is particularly effective in the destruction of phagedæna, since its action can be better regulated and confined within desired

bounds. Iodoform and stimulating applications are appropriate at a later stage in these cases. Applications having a mild or superficial caustic action are advised in *fungous* and *fungoid ulcers* and *irritable ulcers;* such are, for example, pure carbolic acid, solid stick of lunar caustic, solution of chromic acid, etc.

Local anæsthetic preparations are often beneficial in *painful* or *erethistic ulcers,* and also in certain other forms of ulcer, when it is desired to benumb the parts before making a stimulating or a caustic application. Those which are in more general use are cocaine, eucaine, orthoform, chloretone with boric acid, solutions of chloral, opium, and carbolic acid: the latter combining a mildly escharotic with a secondary anæsthetic effect. In painful tuberculous ulcerations bromoform has been recommended as a local analgesic.

Minor operative measures have been in vogue since the days of the ancients. All of these have as their object the removal of the encircling band of densely indurated cicatricial tissue which enters largely into the composition of the borders of the ulcer and adjacent structures, impeding the circulation and serving as an obstruction to the contraction and normal healing of the ulcer. This condition is characteristic of the chronic ulcer of sluggish type. For this purpose various *incisions* are made through the cicatricial deposit. They should divide, not only the immediate borders, but also to some extent the healthy structures that lie beyond them, and they should be of sufficient depth to include all resisting tissue. This gives the necessary relaxation and suppleness to the part, and the new blood-vessels which form in the line of the incision soon add to the blood supply.

These incisions may be limited to two deep cuts made at right angles across the base of the ulcer and passing into sound tissue—commonly known as Liston's method; or, they may be radial in direction, a number of them radiating or branching out from the base—this is the oldest method. Again, the crossed-incision method may be employed. This consists of a series of both vertical and horizontal incisions which divide the ulcer and adjacent marginal tissue into squares similar to those of a chess-board (Hardie, Harbordt). In many cases this plan effects the desired purpose in an admirable way. Another method calls for a circular incision—circumcision—which is to be carried through the skin along the margin of the ulcer (Nussbaum, Dolbeau). Again, this circular cut may be made up of a series of short incisions encircling the ulcer on the same line, but each incision separated from the next by an intervening bridge of skin; or the modification recently introduced by Hodgen may be adopted. According to his plan the ulcer is circumscribed by a series of short overlapping incisions, each incision on an outer circular line alternating with a similar one on an inner circular line. Still another mode of making the incisions is that proposed by Mariani, who claims radical results in leg ulcers from a circular incision of the limb made *above* the ulcer—an incision which divides the skin and subcutaneous tissue and blood-vessels down to the fascia.

Incisions are usually employed in old chronic ulcers that have resisted other forms of treatment, but they are also used in inflamed ulcers for the purpose of local blood-letting.

Relaxing sutures were at one time used to some extent, but they can no longer be said to occupy a place among rational surgical methods. These consist either of mattress or of button sutures, passed through the integument, above and below the ulcer, in such a manner that when tied they raise a fold of skin, thereby relaxing tension and approximating the margins.

Excision and cauterization may be practised in small ulcers, especially those of a carcinomatous or tuberculous nature. This procedure often accomplishes satisfactory results, but it has gradually given place to other and more rational methods.

Curetting or *scraping*, which is a procedure of universal acceptance and most valuable in many forms of ulceration, is probably oftener resorted to than any single operation. After its employment, in chronic ulcers that have resisted the usual routine plan of treatment, one often sees healthy granulations spring up and prompt cicatrization take place. Tuberculous and other ulcers belonging to the infectious granulomata group often quickly respond to this procedure. In treating tuberculous ulcers with the curette it is essential that the granulations should be thoroughly and carefully removed down to the healthy tissue, and at the same time the undermined edges should be accurately trimmed off with scissors and knife, and the cutting should extend out into sound skin. Curettage is frequently associated with or made a part of other surgical procedures. Thus, scraping is quite often combined with deep marginal incisions, both radial and circular, and also with nerve stretching and vein resection.

Sponge-grafting was at one time freely exploited, and possibly it still may serve a useful purpose in some cases. Although large grafts have been successfully made, yet the method must be regarded as having only narrow limitations. When it is employed, the strictest asepsis must be observed, or infection will follow and the graft remain as a foreign body until removed or thrown off by suppuration.

But the trend of modern surgery leads naturally to *radical operative procedures*, and these are rapidly superseding the older ones, not only on account of the greater promptness with which results are attained, but because the treatment is more effectual and the result more permanent. Thus, *skin grafting* is now becoming the method of choice, and surgeons are resorting to it at a comparatively early stage of the disease. This procedure was at first reserved for large ulcerations and ulcers that had resisted ordinary therapeutic measures, but the tendency now is to have recourse to it at a much earlier stage and even to employ it in small ulcers.

One of the earliest methods of skin grafting was that of Reverdin, which consists in clipping small slices and bits of the superficial layers of the derma from a healthy point, and placing them directly upon the granulating surface. These little grafts stimulate epithelial growth, the islets of skin grow and spread,

coalescence takes place, and soon the ulcerated area is entirely covered in. Thiersch modified this method by preparing the surface of the ulcer and utilizing large grafts, varying in size up to a width of one or two inches and a length of six or seven. The superiority of this operation over the older one was soon recognized, and at the present time it occupies the first place in the estimation of surgeons. In the employment of Thiersch's operation there are several essentials that should be strictly observed. First, the ulcerative process must have ceased, the ulcer being at a standstill; and, secondly, the ulcer must be in a healthy condition. It is worse than useless to attempt to graft upon a septic or a progressing ulceration, for the grafts quickly become infected and decompose. Thirdly, absolute asepsis in every particular is imperative, and is the primary step in the technique. The details of the procedure are as follows: The ulcer is carefully and thoroughly curetted and cut out, care being taken to remove all granulations down to the hard fibrous base of the ulcer—i.e., to the deeper layer of granulation tissue; at the same time the margins should be excised far enough back to get rid of all newly formed epithelium, and to secure a perfectly raw surface for the reception of the grafts. This amounts practically to excision of the ulcer; and, indeed, it is probable that the better procedure is to dissect out completely the entire ulcer with the knife. After perfect hæmostasis is secured, the grafts—taken preferably from the anterior surface of the thigh and including the full thickness of the rete Malpighii, the papillæ, and a portion of the corium—are placed upon the dry denuded surface. They should be pressed down firmly, in order to squeeze out every particle of blood and serum, together with all air bubbles, and also to bring into accurate apposition the under surfaces of the grafts and the raw surface of the wound. The grafts should slightly overlap both the denuded margins of the ulcer and each other, and they should cover over the entire raw surface. Protective tissue or thin rubber is cut into strips and systematically placed over the grafts and pressed firmly down; gauze, wrung out of weak bichloride—or, better, boro-salicylic or normal salt—solution, is next applied; and, finally, cotton-wool batting should cover the whole, a bandage being adjusted to hold it in place. If the part be a limb, this should be immobilized. The dressing should be reapplied in from three to five days, care being taken that the protective is not left on long enough to cause maceration of the grafts.

The grafts are usually found to have united with the underlying tissues by the end of a week, and their vitality is recognized by the pink color and by the fact that they are adherent at the edges. At the same time it should be remembered that they may easily be detached, and that they should therefore be delicately handled when it becomes necessary to apply fresh dressings. Grafts cannot be regarded as entirely safe until after several months have elapsed, and consequently care should be exercised in allowing the patient to use the limb or even to let it remain pendent during the period named. The grafts are con-

nected to the ulcer by a fragile and delicate line of blood-vessels, and, in the case of the leg, if walking is indulged in too soon, the parts become engorged, these thin blood-vessels rupture, and blood is effused beneath the graft. In this way the graft is lifted away from its vascular base and its integrity jeopardized. As a matter of course, this precaution applies especially to the lower extremities. If it be properly executed, and if sufficient time be allowed for solid union to take place, this method usually affords a sound, pliant, and most satisfactory cicatrix.

Recently, the open method, or that of leaving the parts exposed to the atmosphere, has been practised in skin grafting. After the grafts have been placed in position, and some bland antiseptic powder has been dusted over them, the part is left open to the air, and the limb is simply supported and protected from possible injury. Bruning, of Freiburg, and others report most gratifying results from the exposure method.

Another process of grafting, quite similar to that of Thiersch, is *skin transportation*, once employed in Eastern countries, revived some years ago by Lefort and Wolfe, and later improved by Esmarch. According to this method, after the granulations have been curetted and cut away, a piece of skin is transferred from a healthy point of the body and sutured to the prepared ulcerated area. The graft consists of the skin alone, all of the adipose and cellular tissue being carefully removed from its under surface.

The *whole-skin* methods of grafting, as advised by Krause and by Hirschberg, differ from one another only in these respects, viz., that the former surgeon trims away the subcutaneous fat, whereas the latter recommends that the adipose tissue be left undisturbed. The whole-skin graft has much in its favor; for example, it affords better protection than does the graft obtained by Thiersch's method. But, on the other hand, the whole-skin grafts very often fail to form a living union with the parts, and hence the results should be regarded as generally inferior to those obtained by the Thiersch method. Also a considerable wound remains at the point from which the graft is taken, and this wound must therefore be closed by suture.

The method of employing a pedunculated flap for purposes of plastic repair possesses one advantage, viz., the flap is connected to the body by a bridge of skin and therefore is sure of receiving its supply of blood. This method is largely employed in plastic work on the face. In the majority of cases, particularly in those of chronic ulceration of the limbs, the Italian method, which utilizes a flap from the trunk or from an opposite limb, is the one which should be preferred. One of the chief reasons why this course should be adopted is to be found in the fact that, oftener than otherwise, the skin in the neighborhood of the ulcer is too much involved to furnish a reliable flap. The ulcer should be prepared by scraping and excision, as in the other methods.

In cases of old sluggish varicose ulcers *ligation of the saphenous vein* is prac-

tised with success. Again, *excision of the internal saphenous vein* is sometimes employed in varicose ulcers. This method, combined with curettage, has been enthusiastically advocated. It is probable that in a certain class of varicose ulcers such excision should be the operation of election.

Division of the cutaneous nerve which supplies the ulcerated area, at some point fairly distant from the lesion, is employed to relieve the exquisite pain in neuralgic or erethistic ulcer.

Nerve stretching has been suggested and performed successfully in a variety of ulcers, as well as in perforating ulcer of the foot. In cases of varicose ulcer the nerves attacked were those which supply the diseased area, viz., the internal and external saphenous, the musculo-cutaneous, and the peroneal.

Combined nerve stretching and vein resection is recommended (Thévenat) as the procedure of election for ulcers that are kept up by nerve or vein lesion and that have assumed a rebellious attitude, with neuralgic symptoms. (The procedure is recommended without regard to the origin of the lesion.) In the cases recorded the nerve stretched was the external popliteal, with partial excision of the external saphenous vein.

Where the heel is involved in obstinate ulceration, *resection* of that portion of the foot by the Mikulicz-Wladimiroff operation may give a useful member; and, in cases of extensive and incurable ulcer of the leg, removal of a section of both bones, so as to shorten the limb, has been performed.

Amputation is called for in ulcers of the extremities that have undergone epitheliomatous degeneration, in those which have a gangrenous character or are associated with elephantiasis, and in large and incurable ulcerations that extend around the limb and that have proved resistant to all other treatment. These conditions usually mean that the sufferer is totally disabled and that the limb has become a burden.

From the remotest time ulcer and ulceration have been considered as coming within the natural province of surgery. But until a comparatively recent period, the surgical aspect of ulcer was confined almost exclusively to those lesions which implicate the cutaneous surfaces, the several orifices of the body, and the visible portions of the mucous membranes; ulcers of the alimentary tract and the hollow viscera being left, in general, to the exclusive care of the internist.

Now, however, that surgery acknowledges scarcely any bounds and that the surgeon penetrates with impunity to the innermost recesses of the body, all affections of this character should be regarded as surgical in the broadest sense. Therefore a discussion of ulcers should embrace every surface, internal as well as external, where ulceration occurs, and which may be exposed and subjected to operative intervention. But the space here assigned to the subject precludes such an extensive consideration, and for a fuller description of those internal diseases of which ulceration constitutes a prominent feature, reference must be had to the chapters which are devoted to them.

GANGRENE AND GANGRENOUS DISEASES.

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I. THE COMMONER FORMS OF GANGRENE.

(Mortification, Sphacelus, Sloughing, Necrosis, Caries.)

Terminology.—Formerly, gangreen; F., gangrène; Sp., Pg., gangrena; It. gangrena, cancrena, cangrena; Latin, gangræna, from Greek γάγγραινα, an eating sore—a reduplicated form of γραίνειν, γράειν, to gnaw.

History.—Gangrene must have been known from the very beginning of medical observation. It is mentioned in the Papyrus Ebers; both Hippocrates and Galen described gangrene and sphacelus, and recommended the cutting away of the rotten parts in cases of mortification. Avicenna and Vesalius followed the teachings of Hippocrates. Celsus expressly advised amputation, as did Paulus of Ægina, the latter probably through sound parts. Amputation, however, was first placed on a sound basis by Paré. La Motte, of Valognes, appears to have been the first to combat the practice of Hippocrates to attack gangrene radically as soon as it appeared.

As an example of the earlier views with regard to gangrene the following may be of interest: After saying that it may be caused by either external or internal agencies, John Woodall, 1655, continues: "It may be tearmed external, or from without, as well when it proceedeth by externall violence of the ayr, by thunder and lightning, or otherwise, by the mighty and immediate hand of God, as it doth to many, or by feavours violent, contagious, or pestilential, as anthrace, the smallpox, or the like, whose secret causes, with the reasons thereof, are hidden in God, and therefore by man's wisdome are not to be found out, although, some affirm, the conjunction or opposition of the planets have power or give cause hereunto, according to the poet, astra regunt homines, sed regit astras Deus" (the stars govern man's body, and God governeth the stars).

Definition.—Gangrene is the term used to denote the death of a portion of the body, as, for example, a finger, a toe, or a limb, or a portion of the soft parts.

The term *gangrene* is applied only when the death of tissue involves a portion of the body sufficiently large to be apparent to the eye, and is thus distinguished from *abrasion* and *ulceration*, which may be defined as *molecular death*. When the epithelium of an inflamed or injured part is exfoliated

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or rubbed off, the lesion is called an "*abrasion*" or "*excoriation*"; when the inflammatory process has extended to a greater depth it is an "*ulcer*," and the process is called "*ulceration*." In either case the dead particles are so small as to be invisible to the eye, and are cast off with the wound secretion, thus forming a portion of the "*discharge*." If, in the course of ulceration, the dead particles are absorbed, as occurs frequently when internal organs are involved, the process by which they are removed is called "*ulcerative absorption*" or "*interstitial absorption*." If, however, the process is only one of ejection of the particles from the surface of the inflamed area, the process is one of pure ulceration. The term "interstitial absorption" should be restricted to examples of molecular death affecting deep or concealed parts, and "ulceration" to lesions on the surface.

Gangrene has been defined as ulceration on a large scale.

The act of sloughing is a part of the history of gangrene. When a tissue has been the seat of a marked inflammation, which, however, was not sufficiently severe to destroy it, portions of the less resisting tissues, or those most involved, die, forming grayish masses in the wound, which in a few days become loose and are cast off. These portions of dead tissues are "sloughs," and the process is called "sloughing." Paget defines sloughing as the "process by which a slough is separated," and having the same meaning as exfoliation applied to a sequestrum. Typical examples are seen in the "core" of a boil, in carbuncles, palmar abscesses, cellulitis, etc. While the process resembles that observed in gangrene to some extent, the terms should not be employed synonymously. For example, a felon of a finger, opened early, may, in a few days, discharge *sloughs* of connective tissue, but the finger may fully recover; whereas, if neglected, gangrene of a part or of all of the finger may result.

The terms *mortification, mummification, sphacelus, sloughing, necrosis,* and *caries,* have all been employed as synonymous with gangrene. On the other hand, some authors have drawn a sharp distinction between them. The older writers used "mortification" (*mors,* death; and *facio,* I make) as a generic term to include the whole series of phenomena that occur in any inflamed part, from the first apparent diminution of vital powers to their total extinction. "Gangrene" was employed to express those stages of the process which precede the death of the part—a diminution, but not a total loss of vitality. By "sphacelus" was meant the complete death of the part.

Ashhurst apparently employed *gangrene, sloughing, mortification,* and *sphacelus* synonymously, as shown by the following quotations: "When the process is accomplished by the death of visible particles, it is called sloughing or gangrene." Again, "Where an irritant has acted with great intensity, so large an amount of tissue may be deprived of vitality that *mortification, gangrene,* or *sphacelus* is said to have occurred." On the other hand, the late D. Hayes Agnew said: "The retention of these terms is calculated to produce

confusion and misapprehension in the mind of the student; they should be discarded from surgical nomenclature, and I shall retain only the term 'mortification.'" The terms *necrosis* and *caries*, by almost universal custom, are employed to describe the death of bone or cartilage. Some writers employ *sphacelus*, to describe the death of soft parts in contradistinction to *necrosis* which refers to death of bone. The term necrosis is also applied, at times, to gangrene or death of portions of the internal organs. Necrosis of such tissue may be partial or complete. The special cells of an organ or tissue may die, while the mechanical or supporting tissues remain and undergo proliferation. According to Paget, mortification is the death of any portion of the body. *Sphacelus* and *gangrene* were used in the same sense, and *necrosis*, in that of death of portions of bone or cartilage—or, by some recent writers, of any other tissue. The dead portion of tissue is called a "slough" when it affects soft parts, and a "sequestrum" when it involves bone.

The term "*necræmia*" was applied by Sir James Paget to death of blood.

Mortification should be sharply distinguished from "*putrefaction*." Morgan, of Aberdeen, writing in 1840, speaks of the "vulgar error" of confounding the two conditions. Putrefaction occurs in dead matter only, but, on the other hand, all dead matter does not putrefy. As pointed out by Pasteur, this process depends upon the presence of micro-organisms, and does not occur if they can be excluded.

Every portion of the body is subject to conditions that lead to gangrene; all structures are, however, not equally vulnerable. If we except the scalp, the tissues that are most richly supplied with blood show the greatest tendency to gangrene. Cartilage, bone, tendon, blood-vessels, and nerve trunks retain their vitality longer than other structures. Bone may, however, be destroyed very rapidly. Being a firm structure, distention is impossible, and a violent inflammation may result in such a degree of tension that the blood supply is promptly cut off, but it does resist longer than the soft parts an equal degree of involvement.

The *signs of death* of a limited part of the body are given thus by Rose and Carless:

(1) Loss of pulsation in vessels.

(2) Loss of heat (no circulation).

(3) Loss of sensation. (There may be great pain prior to actual death; pain may be felt in the dead part from irritation of nerves above.)

(4) Loss of function of the part affected; a limb is motionless and flaccid.

(5) Change of color; the color depends upon the amount of blood in the part at the time of death: if it is full of blood, a purple and mottled appearance will be observed; if it is anæmic, a waxy or cream color develops.

The changes in the dead tissue depend on the condition of the part at the time of death and on the presence or absence of putrefaction germs.

Classification.—The different varieties of gangrene cannot be satisfactorily classified because so many of the cases depend upon two or more causes.

Clinically, we may first divide the cases into *dry* and *moist*. Whether a given case shall be dry or moist is largely a matter of accident, and depends in most instances upon attending conditions.

Dry gangrene results when the arterial blood supply to a part is arrested, while the venous circulation continues; thus, while little or no blood enters the tissues, they are drained of their fluids by the veins. Dry gangrene may be described as death plus mummification. The process of drying, or *desiccation*, or *mummification*, is also favored by evaporation from the surface. Typical examples of this form of gangrene are seen in the aged, when the circulation in the lower extremities is gradually arrested by atheromatous changes in the arteries, resulting in a slow but progressive diminution in the blood supply, until finally local death results. These cases are frequently referred to as "*senile gangrene*," because they occur in the aged. Hence, senile gangrene and dry gangrene are sometimes used synonymously. It must be remembered, however, that dry gangrene is observed in other conditions, its occurrence depending upon absolute arterial occlusion, an efficient venous circulation, and conditions favoring evaporation.

The usual cause is chronic arterial obstruction, such as atheroma, calcification of terminal arteries, and sometimes sudden or gradual occlusion of the main trunk. The dead part becomes dry, hard, wrinkled, and dark brown or black from diffusion of disintegrated hæmoglobin. The more fleshy parts may retain some moisture. Septic processes rarely affect dry gangrene, but the surrounding living tissues may become infected. Dry gangrene may become moist. Dry gangrene is also spoken of as "cold" gangrene.

Moist gangrene, on the other hand, results when the venous circulation, as well as the arterial, is obstructed, so that the tissues are not drained, and when evaporation from the surface is interfered with. This form might also be caused by complete venous occlusion, without any interference with the arterial supply. It must, however, be of very rare occurrence, inasmuch as the large number of veins present everywhere and their free anastomoses usually suffice to carry the return column of blood even when an important vein is occluded. Agnew stated that he was unable to recall a single case in which the gangrene was due to venous obstruction alone. In general, the more rapidly a gangrenous process develops, the more apt it is to be moist, as sufficient time is wanting to permit of the removal of the fluids by the veins and lymphatics and by evaporation. Sometimes a very simple factor may turn a case into either dry or moist gangrene. For example, when the foot is affected, if the part is allowed to be dependent, so that gravity impedes the venous current, a moist condition is apt to result, whereas if the part were

moderately elevated, thus favoring the return circulation, mummification would be favored.

Cases of gangrene due to infective processes, as well as those which become infected secondarily, are usually of the moist variety. Moist gangrene is sometimes spoken of as "*humid*," "*acute*," or "*hot*" gangrene. This form is also observed when gangrene affects internal parts, in which evaporation cannot take place, *e.g.*, strangulated hernia. Severe contusions, lacerations, fractures, with injury to large vessels, resulting in "*traumatic gangrene*," usually give rise to the moist variety, as does intense inflammation. "*Spreading traumatic gangrene*" results when, in addition to the devitalizing effects of the trauma, certain germs gain access to the tissues affected.

Two kinds of moist gangrene are therefore recognized: that which remains localized to the part devitalized by injury, and that in which the gangrene tends to spread rapidly. Moist gangrene may thus follow ligation, obstruction, or destruction of the main artery or vein, or both, long constriction, crushes, lacerated wounds, thrombosis, acute inflammation, chemical irritants, heat and cold.

Aseptic moist gangrene is a condition in which the dead tissues become discolored, purple, green, yellow, or black. The affected area remains about stationary in size, consistence, etc., so long as no germs are present; and it is cast off with very little evidence of inflammatory disturbance. There may be a mild degree of toxæmia from absorption of products of the tissue necrosis.

Septic or putrid moist gangrene is the same condition as the above plus infection of the tissues with germs. The process is apt to spread, and to be followed by rapid breaking up and disintegration; the part becomes black, green, or yellow. Blebs appear, being raised from the cutis vera; they contain offensive fluid or even gas. The tissues are soft, lacerable, and sometimes emphysematous crackling is observed.

The cases of gangrene are not always wholly dry or wholly moist, but the characters of each may be present, constituting a *mixed* form.

It seems impossible to make a satisfactory classification of gangrene, for the reason that, as already pointed out, few cases depend upon a single factor. Although the different varieties cannot conveniently be considered exactly in order, the following types will include most cases:

1. Gangrene due to traumatism of all forms.
2. Gangrene due to cardio-vascular diseases.
3. Gangrene due to constitutional causes.
4. Gangrene due to infections.
5. Gangrene due to disorders of the nervous system.
6. Gangrene due to heat and cold.
7. Gangrene due to drugs, either taken internally or applied locally.
8. Gangrene due to miscellaneous causes.
9. Gangrene due to unknown causes, hence called "idiopathic."

Terminations of Gangrene.—The possible terminations of gangrene are thus described:

(a) If the area is small and aseptic, the necrosed portion may all be absorbed as would a catgut ligature; or if the part is kept dry and aseptic, a dry crust forms which in time falls off, as is seen on the edges of flaps at times. Dead bone, if small in area, may be absorbed.

(b) If the area involved is aseptic, but rather large, or if certain tissues are affected, or if the patient is feeble, there may be partial absorption while the balance is cast off by "anæmic ulceration." When the gangrenous process is arrested the dead parts continue to decompose, and, if exposed in a dry atmosphere, they gradually shrivel and become dry and black. At this time active changes are occurring in the contiguous living portion. First there is noted a more decided limitation and contrast of color at the limits of the dying part. The dusky redness of the skin covering the healthy part becomes brighter and paler—pinkish rather than brownish. The contrast becomes marked as the redness of the living part brightens, and the dead becomes whiter, or more commonly darker. The touch would also detect a marked contrast. The living part is turgid with moving blood, and feels tense and warm; the dead part is soft, cold, and inelastic, and often sunken below the level of the living. These contrasts mark the *line of demarcation*. The separation of the dead part is accomplished by the process of ulceration or granulation in the portions of living tissue immediately contiguous to those of the dead. At this border a groove is formed on the surface by ulceration which circumscribes the dead part; and as it gradually deepens and converges to the centre, the separation is completed and the slough falls or is dislodged from the ulcerated living part. Closely following the process of ulceration is one directed toward repair. Granulation cells soon rise from the raw surface covering the wound as fast as the separation proceeds, and cicatrization follows.

(c) If the area involved is septic, the separation is accomplished by a distinct inflammatory reaction in the surrounding tissues. The extent is primarily limited by a line of demarcation, indicated by a change in color in the dead part, the living retaining its natural hue, which is heightened by congestion. The irritation of the chemical products in the necrosed mass causes inflammation in the surrounding structures, inducing hyperæmia and subsequently exudation, cell infiltration, granulation, and a line of separation. In the course of eight or ten days there usually may be seen a line of separation which spreads and deepens; local inflammation and fever are present. The inflammation may spread up the lymph vessels or veins or in the cellular-tissue planes and thus involve the whole limb. In this way patients may develop septicæmia or pyæmia, and death frequently results from these causes.

Pathogenesis.—Gangrene is the result of the failure of the circulation in a part. There are a number of conditions which bring about this result. The

blood supply may be deficient either in quantity or in quality; the latter is, however, an infrequent cause of gangrene and, in this limited number of cases, other contributing factors are present, such as a weak heart. Disturbed states or dyscrasias of the blood, due to failure of general nutrition,—e.g., alcoholism, diabetes, cancer, tuberculosis, inanition from severe illness, etc.,—may act as predisposing causes.

Deficient blood supply may be due: (1) To arrest of the arterial current; (2) to interference with the return of the blood through the veins; or (3) to capillary stasis. The various causes of these conditions will be considered in order, but it should be well understood that in the non-traumatic cases frequently more than one cause has been at work.

In illustration, a perfectly healthy person may have a limb crushed under the wheels of a car, and gangrene result directly in consequence; the effect, therefore, of a single factor—traumatism. On the other hand, in a large majority of the cases, the etiology is more complex. For example, one form is said to be due to diabetes, but it will be shown that an advanced stage of arterial atheroma is usually present in these cases also, although it is but fair to presume that the disordered condition of the blood materially diminishes its nutritive value.

Senile gangrene is said to be due to atheroma or calcification of the arteries, usually of the lower extremity; but, in addition, it must be remembered that the examples of this type are seen, as a rule, in patients advanced in years, in whom the heart action is feeble on account of myocardial changes, and the circulation impaired from this cause as well as from the general arterial degeneration. In the cases due to embolism and to ligation of an arterial or venous trunk, the termination in gangrene is the result of accompanying abnormal or unfavorable conditions, existing at the time of the local arrest of the circulation or coming on later, either in consequence of factors that were unavoidable or that are sometimes introduced by improper treatment.

The same remarks are applicable to many of the forms of gangrene. It is the intention here merely to call attention to the fact, as it has an important and constant bearing on treatment as well as etiology, and should be kept in mind in considering the various aspects of the subject.

The immediate cause of death of any part of the body is the arrest of the capillary circulation. The larger arteries play no part in the nutrition of the body, except to transmit the blood to the finer vessels, where the actual vital processes of nourishment and regeneration occur. As long as the capillary circulation is continued, the vitality of the tissues will be maintained. Fortunately, there is such a free collateral circulation that, if one arterial trunk be occluded, sufficient blood will, in many instances, reach the affected area through other vessels. Otherwise, gangrene would be very much more common than it is. Failure of an adequate collateral blood supply may be due to: (1) Anatomical conditions (absence of free anastomoses—as, e.g., in the pul-

monary artery and the superior mesenteric artery); (2) rigidity of the walls of the vessels, by which they are rendered incapable of transmitting an additional amount of blood to meet any abnormal demands; (3) extensive destruction of the walls of an artery (aneurism, or proliferating endarteritis, filling the lumen of the vessel); (4) an abnormally small calibre of the vessels, either congenital or acquired; and (5) feeble heart action.

Any condition that causes capillary stasis may predispose to or cause gangrene, *e.g.*, inflammation, pressure, hemorrhage, or blocking of the venous outflow, arterial ligature, embolism, thrombosis, or obliterating arteritis. The arrest of the circulation need not be permanent; a certain time suffices. The more highly specialized the tissue, the sooner it succumbs to the loss of its blood supply. Gray matter of the central nervous system and the epithelium of the intestine and kidneys live but a short time without blood supply (one to two hours, according to Cohnheim).

Direct injury, if severe, causes death by arrest of nutrition and devitalization of the tissues. Slight injuries may bring about the same result in the presence of a weak resistance.

Lowered vitality as a cause of gangrene.—Age is relative; the vital reaction depends partly upon inherited tendencies and partly upon the present state of nutrition. Premature decay may be inherited or acquired, and death ensues as soon as the vital energy is unable to cope with the antagonistic influences of its environment.

Senile death or decay occurs sooner or later in every case—when the vital energy is exhausted. Whether natural or premature, the tendency to death is much greater if some additional burden be added, such as injury.

The following general conditions profoundly influence the vitality of the tissues and frequently act as predisposing causes: Anæmia, hyperæmia, hemorrhage, œdema, inflammation, faulty blood mixture as found in inanition, diabetes, excessive use of alcohol, marasmus, and the specific fevers.

All of these bring about a low vital resistance and diminish the defensive power of the tissues.

Affections of the Heart as a Predisposing Cause of Gangrene.—The heart predisposes to gangrene when its action is feeble from degeneration of the muscle, or from some exhausting disease, and becomes the actual cause when it furnishes emboli to the blood stream.

(1) A weak muscle, due to fatty or fibroid degeneration, with or without dilatation, results in a feeble circulation, especially marked by capillary stasis. Under such circumstances, the circulation is barely sufficient to maintain the nutrition of the tissues under favorable conditions. If, under these circumstances, an injury is received, or a mild infection occurs, the capillary stasis is so increased by the resulting congestion as to overcome the force of the feeble blood current, and, as the collateral circulation is correspondingly defec-

tive, death of the tissues results. The same is true after a prolonged illness of a debilitating nature, as well as after accidents or operations followed by severe shock, etc.

Gangrene, Wagner says, never results from diminished action of the heart solely, either in acute or in chronic disease, but only with simultaneous changes in the arteries—thrombosis or continued pressure.

(2) When the heart acts very feebly, thrombi are apt to form within its cavities. Portions of these thrombi may become detached and, being carried by the current, lodge in peripheral vessels, occluding the lumen. Such fragments, being arrested in the arteries, are called "emboli." As a rule, these arrest the blood current in the affected vessel at once, and, unless there is a sufficient collateral circulation, gangrene will speedily follow.

(3) Vegetations from diseased valves may be carried by the force of the blood stream and cause embolism in the same manner. If the endocarditis is of the septic type, the embolus will partake of the same character and give rise to a septic form of gangrene. Gangrene of the extremities appearing in the course of cardiac affections rarely results purely from cardiac lesions. It depends usually on a combination of conditions, of which the factors are, to a varying extent in different cases, the cardiac lesion, the state of the vessels, the composition of the blood, the malnutrition of the tissues, and the functional disturbance of the nervous system, considered in its trophic rôle.

Affections of Arteries Predisposing to Gangrene.—Arrest of the circulation from causes arising within the arteries may be due to coagula resulting from acute or chronic endarteritis, fatty degeneration, and calcification of the muscular coat (thrombotic gangrene), atheroma, and arterial degeneration of whatever form, rupture of one or more of the coats, aneurism and periarteritis.

Compression of the arteries frequently leads to gangrene: *e.g.*, cancer of the œsophagus may induce pulmonary gangrene by compression of the pulmonary artery. Internal pressure from aneurism, rapidly forming abcesses, tumors, etc., would act in the same way. Vasomotor constriction of the smaller arteries causing spastic ischæmia may result in gangrene, as in Raynaud's disease or in ergot poisoning. In typhus fever, stases, petechiæ, etc., due to spastic ischæmia of the small and smallest arteries, are dependent upon the poisoned state of the blood.

Affections of Veins as a Cause of Gangrene.—Gangrene rarely results from interference with the venous system, because of the manifold anastomoses; and then only when *all* the veins are obstructed. In such a case, over-filling of the capillaries and hemorrhagic infiltration result. This does not occur in simple thrombosis; hence gangrene does not result.

As pointed out by Welch, cases have been reported in which no cause for gangrene could be discovered except venous thrombosis (femoral, iliac), but with peripheral venous thrombosis this is such an exceptional occurrence that it

seems clear, when gangrene does result, that complicating factors—such as arterial disease, pressure upon arteries, arterial spasm, great feebleness of the circulation or septic inflammation—must be associated with the venous thrombosis.

Surgeons are familiar with gangrene that occurs after ligating the femoral vein, but here, also, this result is exceptional and attributable to some other cause.

Braune, upon clinical grounds, attempted to demonstrate that gangrene is to be expected after closure of the femoral vein near Poupart's ligament, but the clinical evidence does not, in the majority of cases, support this view. Such cases do *occasionally* occur; Galliard, for example, has reported a case, and has collected others from the literature, in which gangrene had followed venous thrombosis without apparent coincident arterial disease.

Affections of the Capillaries as a Cause of Gangrene.—Gangrene due to obstruction of the capillaries may occur from: (1) Anæmia due to internal or external pressure or thickening of the walls of the arteries; (2) stasis of the blood from feeble heart action, etc.; (3) infiltration of the tissues with fibrin, extravasated blood, pus, and new formations; (4) degeneration of the muscular coat of the smaller vessels; or combinations of these.

Gangrene from dense infiltrations with nuclei and cells is due to narrowing or occlusion of the capillaries from the external pressure, and occurs in many suppurative processes (phlegmonous inflammations) in which there is continued pressure; of which bed-sores, pressure-sores due to improperly applied splints, etc., are examples.

Coagulation of blood beginning in the capillaries (marasmic thrombosis) gives rise to the typical examples of acute senile gangrene.

Embolic gangrene is due to embolism of a main arterial trunk; the femoral and popliteal are most frequently affected. The emboli arise commonly from vegetations on the valves of the heart, from coagula in the cavities of the heart or in the venous system, or from atheromatous arteries. Heart thrombi sometimes form in the course of severe infectious diseases, when there is great prostration, as in typhoid fever, measles, pneumonia, influenza.

The two commonest causes of gangrene are disease of the heart and disease of the peripheral vessels; of these, embolism is the more frequent factor, the fragment coming, in most instances, from vegetations on the heart valves. Embolism causes gangrene only in those cases in which the low vitality of the tissues, momentarily rendered ischæmic, results in death of the part before the collateral circulation can become established. This occurs especially in aged individuals, cachetic from advanced cardiac disease. Emboli are more frequent in old age, but they occur at all ages. In most cases they accompany affections of the mitral orifice, stenosis with insufficiency, or pure stenosis; also aortic affections, but more rarely; and they even occur in cardiac conditions unassociated with valvular lesions.

In embolic necrosis, the embolus may be near the gangrenous area, or located

at some distance from it. Embolic gangrene is common in the lower extremities on account of the comparatively rectilinear course of the vessels from the heart to the femoral arteries, and rare in the upper extremities.

The clinical picture of this dangerous and frequently fatal form of gangrene may be well illustrated by a brief reference to a few cases, which will at the same time call attention to the great variety of its manifestations.

The following example of extensive embolic gangrene, reported by Richardson, is worthy of record:

A woman, 60 years of age, with a systolic murmur, suddenly felt pain and numbness in both legs. The left leg became totally necrotic from the ankle half way to the knee. Amputation was performed through the left thigh. The femoral vessels were plugged by thrombi. Soon after, the patient had pain in the right foot, and, three days after the amputation, this was mottled and purple, and was amputated four days after the previous operation. The femoral vessels of this side were also plugged with thrombi. Eight days later, sudden pain and distress were felt in the epigastrium, followed by numbness in the right arm. The hand was pale, but there was no discoloration. On the following day a feeble radial pulse was detected, and the arm fully recovered. Here a collateral circulation was established, an event more likely to happen in the upper than in the lower extremity. Eighteen days after the preceding event, an embolus lodged in the brain, from which the patient died on the following day.

The following typical case is recorded by Vander Veer: A sudden numbness, pain, and loss of power of both legs, due to embolism of the middle third of the arteries of the legs, resulted in complete gangrene of both feet. Double amputation was performed, four and a half months later, three inches below the knee joints. Vander Veer believes that the gangrene was due to a calcareous plate breaking from the abdominal aorta and lodging in each artery.

A similar case, but having a different origin, is described by Widal and Nobecourt: A case of symmetrical gangrene of both legs followed the lodgment of an embolus in the left primitive iliac artery. A progressive thrombus developed in front as well as behind the embolus, the clot thus proceeding to the origin of the iliac and extending into the opposite iliac artery also. Hence the symmetrical gangrene due to a cause existing only on one side primarily.

The following are examples of embolic gangrene due to endocarditis: Goodfellow reports two cases in which vegetations of the mitral valve and near-by endocardium resulted in embolism and extensive thrombosis, and later dry gangrene of the lower extremities. In the first case, a woman 30 years of age, evidences of occlusion were observed about a month before the fatal event and about seven days prior to the appearance of gangrene. She had had an attack of acute rheumatism twelve years prior to her admission, when the heart became damaged, but she had no trouble, practically, from her heart until the signs of obstruction appeared. In the second case, a girl 17 years of age, the interval

between the evidences of obstruction and the appearance of dry gangrene was shorter; the pathological changes in and about the arterial walls at the seat of obstruction were less extensive. She had had an attack of acute rheumatism about three years before, and a second one eighteen months before the occurrence of the gangrene.

Embolic gangrene sometimes runs a course which suggests thrombosis, as in a case recorded by Mosham: A man, 48 years old, whose heart and kidneys were affected, complained of a swelling in the right leg accompanied with attacks of pain which became more severe and frequent. Gangrene of the right leg developed, and, later, gangrene of the left foot came on.

This slow development indicated a *thrombotic* lesion rather than an embolic
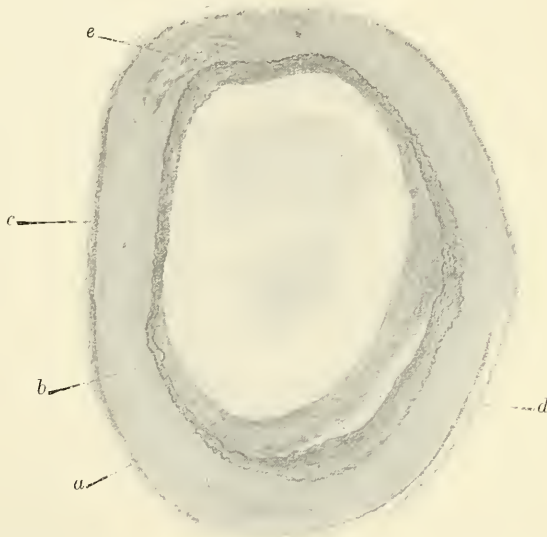
FIG. 33 —Arteriosclerosis of the Posterior Tibial Artery in a Case of Diabetic Grangrene. *a*, Thickened intima with a collection of atheromatous material (*d*); *b*, media with infiltrations of cells and calcareous deposits (*e*); *c*, adventitia. (Hildebrandt, in *Deutsche Zeitschrift für Chirurgie*, Bd. lxxii., 1904.)

one, but the autopsy showed embolism following thrombosis in an aneurism of the heart which was found to exist. This embolus came from the beginning of the aorta and lodged in the right common iliac. Then pieces came off from this point and lodged in the left iliac, obstructing the left hypogastric and femoral arteries.

Embolism following acute endocarditis is also met with. Cases are recorded in which gangrene developed in the course of influenza and other infectious diseases.

Atheroma and Arterial Sclerosis as Causes of Gangrene.—These conditions not only interfere with the normal elasticity of the vessels, but the formative changes and deposits of calcareous matter narrow the lumen of the arteries

or even entirely obstruct them. Among the factors that lead to these changes in the vessels are: Old age, syphilis, alcohol, over-eating, damp and cold, acute rheumatism, diphtheria, septicæmia, influenza, malaria, and other systemic infections. Barr believes that the most potent cause of arterial degeneration is syphilis. Typhoid fever, he thinks, plays a considerable part in the etiology of disease of blood-vessels. Garrett states, apparently with good reason, that arteriosclerosis is frequently hereditary and often congenital. It may be found as early as the twelfth year, especially in degenerates and imbeciles.

Barr has for some time suspected the toxin of the colon bacillus as being an important etiologic factor. He found that the blood of arteriosclerotics gave complete agglutination of the colon bacillus in fifty-five per cent of the cases
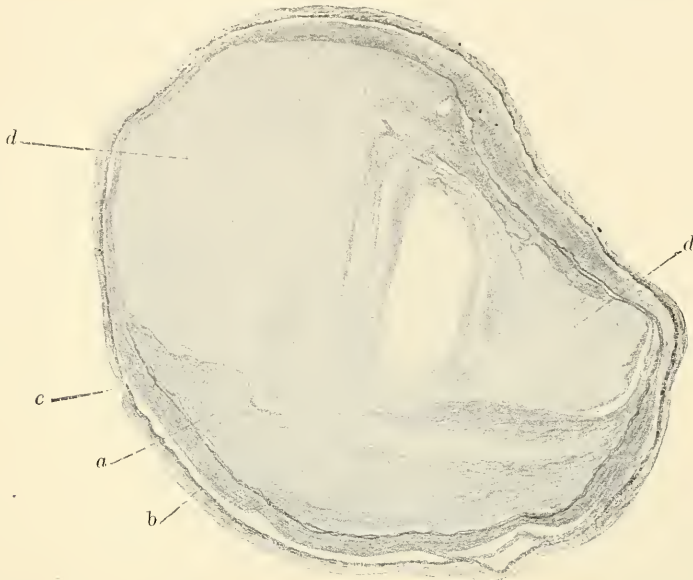
Fig. 34.—Well-Marked Atheromatosis of the Popliteal Artery in a Case of Diabetic Gangrene. *a*, Enormously thickened intima, with large deposits of atheromatous material (*d*), in the vicinity of which there are infiltrations of cells and decided evidences that a proliferation of the elastic fibres is taking place; *b*, very much thickened media, with clumps of leucocytes; *c*, adventitia. (Hildebrandt, in *Deutsche Zeitschrift für Chir.*, Bd. lxxii., 1904.)

examined, as compared with twenty per cent in the case of persons free from arteriosclerosis. Among mineral poisons, lead is mentioned as having a direct action on the blood-vessels and kidneys. High arterial tension being the precursor of arteriosclerosis, all pressor agents, such as coffee, tea, and digitalis, must be looked upon as playing a part in the causation of the disease. Although alcohol is credited with being one of the most potent factors in arteriosclerosis, it really has but little to do with it, except that it leads to the production of gout. The excessive use of nitrogenous food kills more adult men than alcohol—the mischief being due to the waste products. The disease is essentially one of late adult life, and differs from senile vascular degeneration; it is much more

common in men than in women; the former suffer more frequently from syphilis, have more mental worry, and are subject to more physical strain.

Hypertrophic Endarteritis as a Cause of Gangrene.—Benni described fully a lesion in the profunda femoris and popliteal arteries of an old woman of 86 years, who died of cerebral softening and spontaneous gangrene. The arteries above mentioned were obliterated by a mass which he claimed was continu-
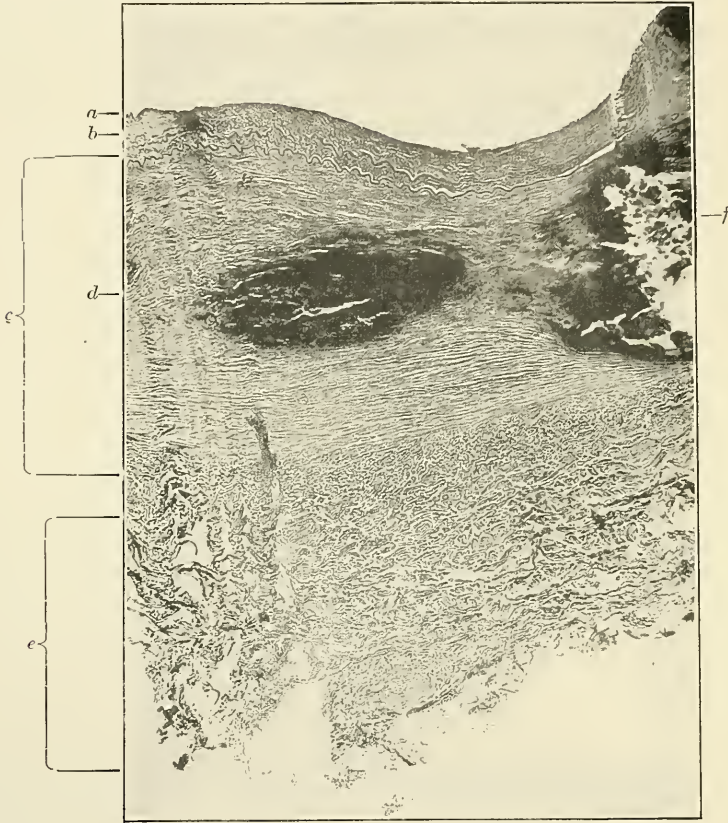
Fig. 35.—Section of Posterior Tibial Artery from Case Illustrated in Plate XII. (Original.) *a*, Intima; *b*, internal elastic coat; *c*, muscular coat; *d*, atheromatous abscess; *e*, adventitia; *f*, larger atheromatous abscess. (It was impossible to cut a satisfactory section on account of the large amount of calcareous matter present.)

ous with the intima, that it was canalized, and that it was apparently a hitherto undescribed lesion, which he designates as hypertrophic endarteritis.

Endarteritis Obliterans as a Cause of Gangrene.—There have been reported many cases which were supposed to be due to this cause. One form described by Billroth, under the title "*gangrena ex endarteritide hyperplastica*," is associated with circulatory changes, such as cyanosis and cold sensations in the extremities, paræsthesia and anæsthesia, lasting several years.

Von Winiwarter, after examining several cases of so-called primary, spon-

taneous gangrene, concluded that the underlying cause was an endarteritis resulting in complete closure of the vessel. Haga described obliterating endarteritis which he believed to be due to syphilis. The association of gangrene with the so-called *intermittent claudication*, studied by Charcot, Erb, and others, is well recognized. The following example of this condition is described by Fintermann:

The patient complained of weakness and pain in the lower extremities, first in the left and then in the right, most noticeable after over-exertion, either standing or walking. After rest, the symptoms would disappear for a time, always coming back after over-exertion, and the intervals between the attacks became shorter, so that finally, even when he was resting, the pain and weakness would not leave him. There were signs of imperfect nutrition of the parts, the foot would become stiff and cold, and signs of insufficient blood supply would manifest themselves. Impairment of motion and sensation became pronounced, nutrition became insufficient, and gangrene at the most peripheral parts developed, finally necessitating amputation below the knee.

Effect of Degeneration of Vessels on Nerves. — Jeffroy and Achard, Dutil and Lamy, Schlesinger, and others claim they have observed degeneration of nerves dependent upon thickening and obliteration of their nutrient arteries.
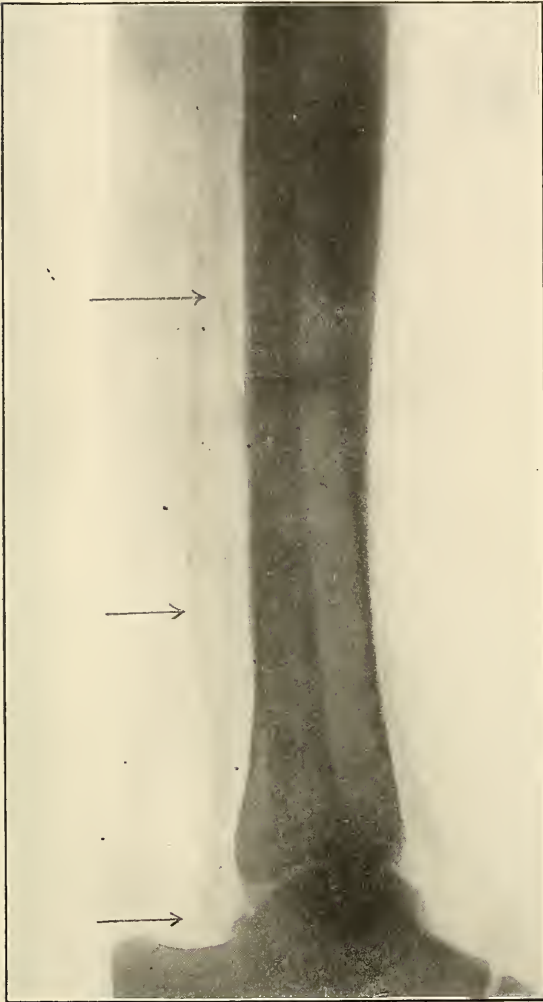
Fig. 36.—Skiagraph showing Well-Marked Atheroma of the Arteries of the Leg. The arrows point, from above downward, to the peroneal, posterior tibial. and the calcanean vessels. The anterior tibial artery may be seen, but less perfectly. (Original.)

Thrombosis of arteries results from disease, especially atheroma, acute arteritis, and embolism. Welch and others record interesting cases due to influenza, pneumonia, rheumatism, etc. It is probable that many of the cases of gangrene occurring in the course of the acute infectious diseases are due to this cause rather than to embolism, as heretofore has been supposed. Welch says:

"Thrombosis of arteries as well as veins may be secondary to certain varieties of gangrene which are not caused by primary plugging of the arteries. Wartburg has observed five cases in which the gangrene was due to thrombosis, evidently the result of a circumscribed endarteritis subsequent to some infectious disease. In various infective and chronic wasting diseases, gangrene may result from primary arterial thrombosis of the class often called marantic. Many of these thromboses are infective in origin; but we have not sufficient information to warrant the assertion that all are caused by germs."

Of special interest is the relation of thrombosis to certain forms of so-called "spontaneous gangrene," which occurs in middle life or even in the young, and is often preceded by definite symptoms indicative of gradual occlusion of

FIG. 37.—Old and Completely Organized Thrombus of the Anterior Tibial Artery. *a*, Greatly thickened intima, with elastic tissue that has undergone active proliferation; *b*, irregularly thinned media with (at *e*) a plate of bone; *c*, adventitia; *d*, organized thrombus, with newly formed blood-vessels and elastic tissue. (Hildebrandt, in *Deutsche Zeitschrift für Chirurgie*, Bd. lxxii., 1904.)

the arteries. These cases usually resemble senile gangrene and have been called "presenile."

Von Manteuffel thinks that arteries which are the seat of a primary sclerosis gradually become filled with a vascularized connective tissue by the depositing and organization of successive layers of parietal thrombi. Haga believes this endarteritis thrombotica to be of syphilitic origin. Haegerstedt and Nomser claim that, in general, the deposition and organization of parietal thrombi are important and usual processes in arteriosclerosis. Von Recklinghausen has described hyaline thrombosis of small arteries in spontaneous and arteriospastic gangrene. Hutchinson has reported rapid thrombosis of arteries without obvious disease of the walls.

A number of cases of gangrene of the lower extremities following thrombosis of the aorta and its branches are on record. Garrett studied his case microscopically. The sections showed the clot within the lumen of the vessel to be in an advanced stage of organization; small vessels and some young fibrous tissue could be seen forming. The intima was normal, showing no proliferation of endothelium, the media showed hyaline degeneration of a mild grade, and the adventitia was somewhat thickened. There was no evidence of any acute inflammatory trouble. This slight change in the media is somewhat inconsistent with the clinical condition found; and because of this lack of microscopic evidence to indicate that the clot was caused by the vascular lesion *per se*, it is thought that some unascertained coexisting exciting cause was responsible to a greater extent than usual.

Barraud's case is very interesting. A woman, aged 20 years, injured one of her finger-nails. A felon developed, and within a few days the lymphatics of the axilla became enlarged and painful. Within six weeks of the injury, gangrene of the lower extremity developed. This was followed, within a short time, by the same process in the other extremity. Three months and a half from the beginning of the process, the patient died with symptoms of sepsis. The autopsy revealed a thrombus filling the aorta, the upper part of the thrombus extending three centimetres above the diaphragm. The inferior vena cava was filled with a similar thrombus, as were also the veins below the point mentioned. From one of the axillary glands, Staphylococcus aureus was cultivated. The author believes that an embolism of this pus-producing organism in one of the vasa vasorum of the aorta was the cause of the thrombosis. In the second portion of his paper he publishes the details of 102 similar cases gleaned from literature. In all these, the extremities of young persons were affected; and in all, an infection of some kind had preceded the lesion. In 62 out of 68 of these cases there was arterial thrombosis, with or without simultaneous venous thrombosis. The aorta with all its branches was affected 11 times; 1 femoral artery, 13 times; 1 popliteal artery, 12 times; and 1 common iliac artery, 8 times. In discussing the etiology, the author finds the most important cause to be typhoid fever; it was responsible for 44 cases. In 11 cases, typhus fever was the etiologic factor; in 9 cases, puerperal fever; in 6 cases, measles. Scarlet fever, pneumonia, and acute inflammatory rheumatism were each responsible for 5 cases; and a number of other diseases for the remaining cases.

In a few cases autochthonous arterial thrombosis existed. Of the patients, 51.6 per cent died, the most of the fatal cases being due to acute inflammatory rheumatism and typhoid fever.

Laceration of Vessels as a Cause of Gangrene.—Wounds of important arterial trunks are frequently followed by gangrene, as might be expected. Wounds of veins are less apt to cause serious consequences on account of the greater

number of venous channels and their free anastomosis.   In these injuries, the anastomosis of the wounded artery with the distal portion of the corresponding vein might save the part.   This subject is so far wholly experimental, but is well worth more extended study.

The following examples will illustrate the subject: The wheels of a heavy wagon passed over both knees of a patient as he lay prone, crossing at the level of the popliteal crease.   Severe pain and the symptoms of approaching gangrene developed in the left leg.   Dissection showed laceration of the popliteal artery and vein, while the bone was not at all affected.

A case was recently admitted to the hospital of the University of Pennsylvania in which a posterior dislocation of the knee, caused by a similar accident, was followed by gangrene.   Dissection of the limb showed laceration of the popliteal vessels.

Rupture of the axillary artery in attempts to reduce old luxations of the shoulder has been followed by gangrene of the corresponding extremity.

Aneurism as a Cause of Gangrene.—Gangrene may result from the diminished blood supply to peripheral parts that is caused by the presence of an aneurism, especially if, in addition, the pressure of the swelling interferes with the venous return.   It is usually of the dry type, and often involves merely one or two fingers or toes; but, when attacking more fleshy parts, or if due to venous congestion, it is moist.

If the aneurism ruptures suddenly, the patient experiences severe pain in the part, which becomes tense, swollen, and brawny; all pulsation ceases both in the aneurism and below it, and gangrene of the limb supervenes, or death may occur in syncope.

Diffusion of a popliteal aneurism is not uncommon, and is very liable to lead to gangrene on account of the pressure exerted, not only upon the vein, but also upon the articular branches of the popliteal artery, which are most important factors in maintaining the collateral circulation.

Extirpation of the aneurism is indicated: (1) If the overlying skin is extensively gangrenous; (2) if important nerve trunks are compressed, leading to nervous and trophic disturbances.

Cases of gangrene cured after extirpation of subclavian, femoral, and popliteal aneurisms are recorded.

Gangrene from Ligature of Artery.—Ligature of the main artery rarely causes gangrene in a healthy limb; but should the latter be in a state of chronic malnutrition and anæmia from preceding arterial disease (or injury), death of a portion of the member is apt to result, the case running a course similar to that of gangrene due to embolus.

Gangrene from ligature of an artery may be due to: (1) Simple loss of vitality, the maximum amount of blood transmitted by the collateral circulation being insufficient to maintain life in the whole part supplied by the vessel tied.   This

happens particularly when peripheral vessels are in a state of calcareous degener-
ation. The tissues which receive the smallest supply of blood, such as the fin-
gers and toes, and the subcortical white substance of the brain die first. A
profuse hemorrhage is sometimes sufficient to cause gangrene. In these cases,
it is always dry if the terminal portions of a limb are involved, but it may be
moist if fleshy parts are affected.

(2) Interference with the venous return due to injury to the vein during
operation (inclusion in ligature), or thrombosis due to septic periphlebitis.
This causes *moist* gangrene. The pressure of a tight bandage obstructing the
venous return has the same effect.

(3) Injudicious after-treatment, too much elevation of a part, cold appli-
cations, ice bag, or erysipelas. Observe every precaution, and, if the vitality
of the part is threatened, treat promptly.

Rupture of the Intima as a Cause of Gangrene.—The wheel of a wagon passed
over the leg of a man of 60 years; there was no fracture or dislocation, but a
considerable effusion resulted. Gangrene of the leg developed, and when the
limb, two weeks after the accident, was amputated at the middle of the thigh,
it was found that the intima and media had been torn at the time of the accident
and thrombic occlusion of the vessel had occurred at the level of the knee joint.
The adventitia was infiltrated and thickened.

Herzog found 16 cases, in which the popliteal artery was injured in a similar
manner, that resulted in gangrene. Of these, 13 patients recovered after ampu-
tation, and 2 died.

Periarteritis as a Cause of Gangrene.—Terry and Sherman each report a case
due to this hitherto unrecognized form of arterial disease. Very careful study
of the amputated extremities was made by Dr. A. E. Taylor, whose report is of
great interest. Dissections were made of the anterior and posterior vessels, and
it was noted, particularly of the anterior vessels, that they were surrounded
by an abnormal amount of connective tissue, which was very dense and unlike
the normal areolar tissues usually found about the vessels. The vessels were
then measured and fixed. Thrombosis was noted in both anterior tibial vessels,
in both anterior veins and their subdivisions, and in the posterior veins in Dr.
Terry's case. As compared to the normal, these arteries displayed a great
reduction in the total diameter, and a normal thickness of the wall with a great
reduction of the diameter of the lumen. Normal arteries of the same total
diameter as these would have much thicker walls, so that these walls, though ap-
parently normal, were really increased in thickness. In no case was the area
of the dissected vessels as much as one-tenth of the normal area, while in the
anterior tibial vessels in Dr. Terry's case it was but one one-hundredth. Micro-
scopic sections of the vessels showed the elastic tissue and the muscular coat to
be qualitatively normal. The intima was not notably thickened in either case,
except in the areas of thrombosis, where it was involved in the process of oblitera-

tive fibrosis. No signs of lime salts could be found. The endothelial cells lining the vessels were normal in the patulous portions. The adventitia was thickened; it was unusually well outlined from the surrounding excessive fibrous tissue. In the areas of thrombosis the process was an obliterative arteritis. The portions of the vessels not submitted to microscopic section were dissected. The process of thrombosis did not extend along the entire length of the vessels involved, except in the anterior artery in Dr. Terry's case. There were small portions in which the lumen was patulous. These portions were carefully examined with a hand-glass for areas of atheroma; none was found. The vessels were not at all tortuous, but perfectly smooth and straight. The veins presented no other lesions than the thrombosis.

This report well illustrates the mixed character of cases of gangrene. The same case seems to show "periarteritis," thrombosis, and obliterative arteritis.

Venous Thrombosis as a Cause of Gangrene.—Venous thrombosis is a well-known complication of typhoid fever and is occasionally observed in other diseases. In some instances it has been supposed to be due to phlebitis, and this in turn has been made to depend on the primary infection. In other instances the obstruction of the vein has been attributed to the sluggish circulation due to the debility attending the original disease.

Although pneumonia is characterized by a notable increase in the coagulability of the blood, and by the presence of pneumococci in the circulation, the number of cases of venous thrombosis recorded in the course of this disease is indeed small. Steiner was able to collect but 38 such cases from a careful search of the literature, to which he adds 3 in 500 cases of pneumonia under observation in the Johns Hopkins Hospital. In the great majority of cases the disease appeared during convalescence—in 1 on the day of the crisis; in 4 during the course of the disease. In all instances, one or both lower extremities were involved: the left alone in 16; the right alone in 10; and both in 7. Death occurred in 9, and recovery in 25. In 5 of the former, the fatal result was due to pulmonary embolism.

Phlebitis as a Cause of Gangrene.—Bernard reports the case of a young soldier, ill with what appeared to be an insignificant indisposition, and designated as mild "grippe." He was suddenly seized one evening with violent pain in the left iliac region, which was associated with all the signs of grave collapse. The next morning the lower extremity on the same side presented the appearance of phlegmasia alba dolens. Gangrene subsequently developed, largely of the dry character; but asepsis of the eschar seemed impossible, and secondary infection took place, spreading through the deeper layers of the tissue.

The amputated limb showed that the arterial system was permeable, but all the venous trunks, superficial and deep, were obliterated. This is one of the rare cases of gangrene due to venous obstruction. The author says: " Evidently

here neither neuritis nor arteritis, nor any infection, was the accessory cause of the gangrene. And yet the arteries were not of normal calibre; they were *narrowed in their lumen*, and it is possible that, had they been normal, gangrene might not have developed."

Disorders of the Nervous System as Causes of Gangrene.—Various affections of the nervous system predispose to, or actually cause, gangrene.

Disease of Nerves.—It has been known for a long time that gangrene may result from disordered nerves without any vascular disease. Such views were held by Zambaco, Pitres and Vaillard, and others. Raynaud's observations on symmetrical gangrene, in which he found the vessels healthy, are well known.

As to innervation, section of the posterior roots of the cord in monkeys produced sores upon the feet, but section of an equal number of roots supplying the upper limbs produced no sores on the hands, the latter not being subject to the same amount of injurious pressure and microbic infection. Charcot claimed that the acute decubitus of the buttock on the paralyzed side in apoplectic hemiplegia was proof of the direct trophic cause. Even when patients had lain only on the non-paralyzed side, and when every precaution had been taken to prevent soiling with urine and fæces, sloughing occurred on the paralyzed side.

Further evidence of the influence of trophic disturbances in the production of decubitus is given by Dejerine and Leloir, Pitres and Vaillard, and others, who have observed changes in the peripheral nerves in many cases of hemiplegia with bed-sores. In Morvan's disease and syringomyelia (of the former, painless whitlows are an essential feature), and in the perforating ulcer of locomotor ataxia, typical changes occur.

The important fact remains that disturbances of the normal nervous influence —vasomotor and sensory—of the skin directly modify the nutrition of the parts and interfere with the defensive action of the individual against microbic invasion.

Gangrene of the extremities secondary to cerebral disease is illustrated in the following case:

A woman, 50 years old, suffering with a cardiac lesion of several years' standing, had also cerebral softening and left hemiplegia; gangrene developed in the left lower extremity. It is explained that there occurred an autochthonous coagulation, which had begun in the arteries. The hemiplegia of the left side probably had favored this coagulation.

Folot explains cases of this kind by assuming that the cerebral lesion results in a vasodilatation in the paralyzed limb; congestion follows; the circulation is impeded; and this, aided by the disease in the intima, results in the thrombosis and gangrene.

Effect of Degeneration of Nerves upon Adjacent Vessels.—Bervoets and Fraenkel, independently, claim to have observed that section of nerves causes

thickening of arteries in the same neighborhood. Sternberg did not observe this result. Czyhlarz and Helbing explain this discrepancy by the statement that changes in the vessel after nerve section occur only when ulcers result.

Lapinsky concludes that the vascular changes of nerve origin may be of several varieties. In some cases the lumen of the vessels is enlarged in the region of a diseased nerve and a local hyperæmia results; in others, the nutrition of the vascular walls is affected, as shown by local œdema and occasionally small hemorrhages. Anatomical changes in the vessels have also been found. He also refers to cases in which local heat and redness or œdema followed injury or disease of the nerves.

Disease of the Kidneys as a Cause of Gangrene.—Bright's disease of the kidneys is one of the causes of gangrene. In many cases of gangrene observed in diabetic subjects, albuminuria is also present, and doubtless plays an important part in the etiology of the gangrenous process.

Hanot described the case of a patient who, in the course of chronic nephritis, was seized with fulminating gangrene of the left leg, which in ten days resulted in complete spontaneous amputation of the limb. The general condition remained unaltered, there was no suppuration or fever, and the pain was slight. The following case of gangrene in the course of acute nephritis is described by Tchechikine:

A man, 37 years of age, of previous perfect health, was attacked suddenly by a cold sensation in the lower extremities, œdema of the legs followed, and then anasarca. Acute nephritis was diagnosed. He also had bullæ on the right foot, associated with a violaceous color of the skin and other signs of developing gangrene. The left foot was œdematous, but no other signs existed. The right foot and leg got worse, and gangrene developed, while the left foot also began to show signs of gangrene. The skin of the scrotum desquamated, and soon that of the lower abdomen also was invaded. The temperature throughout was normal; the urine was scanty and highly albuminous.

Death occurred five days after admission to the hospital, which was fifteen days after the onset of the disease.

It is possible that the infection which was causative of the acute nephritis had also given rise to alterations in the blood and vessels, producing gangrene just as any other infection may.

Traumatism as a Cause of Gangrene.—The term "traumatism" is here employed in its broadest sense as including all forms of external violence, and is not specifically restricted to visible wounds. It is not intended, however, to include in the term "traumatic gangrene" the so-called "spreading traumatic gangrene," which is due to a virulent infection, and hence should come under our second division.

Lacerated and contused wounds frequently result in gangrene, either on account of the accompanying injury to the blood-vessels or of the high grade of inflammation that follows the injury in some cases. Ashhurst divided these

cases into three classes: (1) Sloughing of the injured tissues to a greater or less extent is inevitable.   This is the usual form.   Parts which have lost their vitality will be thrown off and the wound will heal by granulation; or if sloughing be extensive, amputation may be needed.

(2) There may be gangrene from arterial obstruction at a point above the apparent seat of injury; this form of gangrene is principally met with in gunshot injury and often requires amputation.

(3) The most fatal form of gangrene is the true "spreading," "traumatic," or "emphysematous" gangrene; it is always *moist*, from involvement of veins; it is usually observed in cases of compound fractures or other destructive lacerations produced by railway and machinery accidents.

Gangrene sometimes occurs after simple fractures, due either to arterial injury or to obstruction at a point above the seat of fracture, to venous obstruction due to swelling of the part, to tight bandaging, or, finally, to a combination of these causes.

As regards the bandaging, one must ever bear in mind that a bandage may seem loose enough when applied, and yet in a few hours, from swelling of the limb, may become so tight as to cause constriction.   Hence the importance of not applying a bandage (primary roller) beneath the splint, and also of frequent observation of the patient during the first two or three days.   It is almost always the neglect of this rule that causes gangrene from bandaging; this is especially true in the forearm, where this complication usually occurs.   It may also be due to arterial obstruction, and in these cases is unavoidable.

If a case of this nature is seen in time, instant relief of the condition by removing the bandages is demanded.   If complete gangrene has already occurred, no recourse is left but amputation.   If it appears to tend toward self-limitation, wait for a line of demarcation, but, if it is rapidly spreading, immediate operation should be performed.   In cases of the first category, a favorable result may be expected; but in those of the latter, the prognosis is very grave.

Gangrene is much more common after compound fractures, because these cases are the result of a greater degree of violence, so that the destruction of blood-vessels is apt to be greater, and also because infection of the wound almost unavoidably occurs, and the resulting inflammation then still further compromises the vitality of the tissues.

Infection with certain forms of micro-organisms gives rise to spreading traumatic gangrene.

Senile Tissue Changes as a Cause of Gangrene.—Senile gangrene proper, as the name implies, is observed in elderly persons, and affects especially the toes; rarely, it is observed in the fingers. In the typical form, a bluish-red or a brownish spot occurs on one of the toes; later, this spot becomes livid and then black. The area of discoloration spreads, and the affected part shrivels until the whole toe becomes black and dry (mummified).   In favorable cases a line of demarca-

tion forms, and in time, if not interfered with, the toe would drop off. The process may, on the other hand, spread, and involve other toes, and extend to the middle of the foot, to a point above the malleoli, to the middle of the leg, or even to the knee. As the discoloration spreads, the part shrinks and becomes dry—the so-called dry gangrene. Severe pain is common in the earlier stages, but is absent usually when gangrene is fully established.

The common causes are changes in the arteries, the various forms of which are mentioned in the preceding paragraphs, and which result in obstruction or obliteration of the vessels. In some cases evidences of defective circulation are present for a long time—coolness, numbness, neuralgic pains, etc. In others, there are no prodromal symptoms, and either without apparent cause or from a very slight injury a discoloration of the skin occurs corresponding with the area deprived of nutrition. In the moist form there is œdema. Such cases may result from the slightest injuries—frost-bites, carbolic acid, incautious cutting of the nails or corns, etc. The multiple thromboses sometimes found in cases of arteriosclerosis may be the cause of this type of gangrene.

In another class of cases, the process begins with signs of inflammation—a dull red congestion, œdema, and severe pain. The part most affected gradually assumes a brownish-black color. Sometimes the surface presents a mottled appearance: dark spots indicating areas already dead, and livid portions tissues still preserving some degree of vitality. This condition has been called by the French *asphyxie locale*, from its resemblance to death by asphyxia. This form of gangrene is apt to involve all of the toes and shows a marked tendency to spread up the limb. Desiccation and shrivelling do not occur. The part remains œdematous, and soon decomposition (putrefaction) begins. The absorption of the products of decomposition results in a more or less pronounced septicæmia and adds greatly to the gravity of the case.

There is another type of spontaneous gangrene occurring in old persons which is distinguished from the preceding by the large area involved from the beginning. It occurs when the main artery of a limb becomes obstructed by a thrombus, which forms as a result of alteration of the internal coat of the vessel due to precedent atheroma. Layers of fibrin are deposited from the blood on the diseased areas. Additional layers are added until the lumen is quite obliterated. In this way the whole peripheral end of a vessel may be occluded, and even its central end also. This extensive thrombosis, obstructing all of the branches, renders collateral circulation impossible, and consequently death of a large part of the limb follows.

Of 11 cases of senile gangrene described by Matanovitch, there were 7 men and 4 women; the ages ranged between 64 and 79 years. In 10 cases the right lower extremity was involved; and the left in 1 case. Numbness, sensations of cold, and burning pain preceded the gangrene by a period of from

three weeks to ten months, in one case by a period of several years; one patient had varicose ulcers; one an ulcer and erysipelas; one patient had a severe cold before the gangrene began; two patients had pulmonary emphysema and chronic bronchitis; all of them had senile cardiac and arterial changes; two patients had albumin; two had fever; eight had toes affected, one the dorsum of the foot, one the leg; in one case the disease was complicated by suppuration.

Men are more frequently affected, as they are more exposed to injuries and local poisons. The lower extremities are usually involved because they do more work and are more exposed to injuries; the arteries lose their elasticity earlier, consequently disturbances of nutrition occur. In some cases capillary thrombosis occurs without trauma; in others, autochthonous thrombosis.

The mortality in 32 cases of senile gangrene was 63.75 per cent.

Treatment; Prophylaxis.—As senile gangrene is preceded by evidences of defective circulation, careful attention to the hygiene of the lower extremities may delay or prevent an attack. Everything that increases the congestion of the part should be avoided. Hence shoes should be carefully selected so that injurious pressure or chafing may not occur, and great care must be observed not to inflict the slightest wound in trimming the nails and corns. Exposure to cold and dampness may precipitate an attack.

Patients affected with heart disease, or persons suspected of having latent cardiac affections, should observe perfect hygienic rules; all sudden physical exertions which are capable of causing embolism by detaching a clot or of producing a rupture of a valve should be avoided. Violent exercise in the cold is especially to be forbidden. Alcoholic excesses favor the development of gangrene.

In old men with hard arteries, any constrictions such as garters, etc., which cause pressure at certain points where emboli are prone to occur (e.g., popliteal space), should be prohibited. In females especial precautions should be observed during pregnancy and the puerperium.

Presenile Gangrene.—This term is applied to gangrene of the senile type occurring in persons of early or middle life, as the result of vascular changes. It is observed between the twentieth and fiftieth years. When occurring before the twentieth year, it is termed infantile or juvenile gangrene.

It presents the following characteristics: While resting, the person experiences no unusual sensations; but after a certain amount of exercise he may observe sensory, motor, and vascular disturbances in the leg or foot—paræsthesia, itching, tingling, cyanosis, coldness, numbness, and weakness. These disappear upon rest, and recur after exercise. The term "intermittent limp" or intermittent claudication has been applied to this condition. The pulse in the arteries of the foot is small or absent. A gangrenous ulcer develops later, either without apparent cause or after a slight injury. This is very painful, and many of the patients, in consequence of the pain, acquire the morphine habit.

The arteries are found to be extensively obliterated and the intima of the veins thickened. Von Winiwarter and Billroth regard this as an obliterating or hyperplastic endarteritis beginning in the large vessels of the leg and spreading downward; while Weiss believes it to be the result of thrombosis due to endarteritis. The closure of the vessel above diminishes the blood supply to the area which it normally supplies, thus altering the relation between the lumen of the vessel and the blood current. This altered relation causes, according to Thoma, a compensatory narrowing of the lumen, and endarteritis with contraction of the media and growth of the intima. In this way Weiss explains the fact that thickening is present in the intima of the peripheral and only partially closed smaller vessels. The gangrene is ultimately due to the usual sclerotic changes in the vessels, only that here the sclerosis gives rise to the gangrene not directly, but indirectly through thrombosis. The origin is therefore the same as in many cases of senile gangrene, the difference being that in younger individuals the collateral circulation is sufficient to retard the process.

Bunge regards presenile gangrene as the result of premature arteriosclerosis, which usually produces multiple, rarely single stenoses, and is very apt to develop at the giving-off points of the collaterals. The thickening of the muscularis, the narrowing of the lumen, and the slight growth of the intima sometimes observed indicate that the gangrene may be due to abnormal vasomotor constriction, and secondarily to changes in the vessels analogous to those observed in Raynaud's disease.

Among the causes given for the early degeneration of the vessels are the action of cold, the abuse of alcohol and tobacco, syphilis, diabetes, mineral poisons, organic poisons, and congenital vascular weakness.

Progressive Endarteritis of Alcoholics.—Under this title Le Dentu describes a condition of progressive thickening of the arterial coats in young subjects, a condition which begins in the smaller vessels and ascends. It is accompanied by increasing pain. Complete obliteration of the vessels may result.

Terrilon describes a case of intermittent lameness in an alcoholic, 37 years of age. This condition was believed to be due to the obliteration of the principal artery of the extremity. In this case the tibial artery was reduced in its lumen to the size of a hair by a specific arteritis. The peculiarity of this case was that the gangrene developed and involved the leg and foot, a rare occurrence in intermittent lameness. Pain and severe cramps were associated symptoms in this condition.

Local Treatment of External Gangrene.

In certain cases it is a good plan to favor the circulation as much as possible by elevating the affected limb; in others, it is well to make frequent changes in the position of the limb.

Isambert claims to have increased the circulation by the intermittent application of an elastic bandage. He was able to avert gangrene after ligature of the femoral artery made necessary on account of traumatism. This prophylactic measure aimed to induce artificially a circulation through the parts by alternately expelling the blood and allowing it to rush back. He applied an elastic bandage to the leg, allowing it to remain for a time, and then removed it, repeating this procedure four or five times during the twenty-four hours. After each application the blood flowed into the limb much more copiously than before, showing that the paralytic vaso-dilatation caused a greater influx of blood than was possible before. He thinks that this mode of influencing the circulation has a wide scope of usefulness.

If embolism is diagnosed, do not rub the limb, as it may cause pulmonary embolism. If the gangrene is due to the action of cold, employ stimulating fomentations.

Attempts have been made to limit the progress of gangrene by vesication or by the use of the cautery (red to white heat). The actual cautery gives the best results, especially in moist gangrene, for the formation of the eschar antagonizes putrid resorption and prevents septicæmia.

Despies advises the use of fly-blisters. In two cases of gangrene in old men, due doubtless to alcoholism, he employed fly-blisters of good size (as large as the palm of the hand). Such blisters may also be applied in the form of long strips extending along the course of the femoral artery from the groin to the knee, or they may be applied in the popliteal space. In addition, cold compresses may be used, if agreeable to the patient, or the affected part may be wrapped in cotton. By this treatment he claims to cure gangrene due to arteritis, with the loss of only one or two toes. Energetic revulsion applied in this fashion, he believes, is capable of facilitating the cure. In such cases it is an error, he states, to amputate through the thigh.

Revulsion combats arteritis and prevents coagulation of the blood in the principal arteries until collateral circulation is established.

Bessette believes that the cautery is useful in gangrene, but, if the best results are to be secured, it must be applied deeply and preferably in the form of the thermo-cautery.

Numerous local applications have been recommended. Emollient lotions of alcohol, creosote, turpentine, phenol, salicylates, antiseptics, powdered quinine, etc., may be employed.

Baths of oxygen (Raynaud) have in some cases combated bad odor, hastened removal of eschars, and favored a cure.

It is essential to avoid infection in a case of dry gangrene and to try to change the moist into the dry form. The parts should therefore be sterilized and covered with dry antiseptic dressings. In the moist variety, if there is an offensive odor, boric acid, chlorine water, potassium permanganate, or alum-

inum acetate may be used. Poisonous remedies should not be employed for fear of absorption. Elevation of the affected limb in the moist variety is especially important.

The general treatment should be uppermost in the mind of the physician. Tonics, wine, alcohol, quinine, constitute the basis. General hygiene, ventilation, etc., must receive due attention. The antiphlogistic method of Dupuytren, by means of a low diet and debilitants, is no longer employed.

The alkaline treatment of Becquerel, Chevreuil, and others, given for the purpose of liquefying the clot or of preventing its formation, is not rational; but alkalies act as stimulants to nutrition and aid in oxygenating the blood; they may therefore be considered adjuvants to tonics.

Finally, it is the duty of the physician, when pain is present, to allay it by the administration of opium or morphine.

According to Verhoogen, the treatment of incipient gangrene should accomplish (1) an increase in the calibre of the vessels, and (2) strengthening of the heart action. He employs the iodides to widen the arteries, giving about 0.2 gm. (3 grains) a day. Hypodermatic injections of the alkaline nitrites, in the dose of 0.05 gm. ($\frac{3}{4}$ grain), are also efficient. Instead of the latter, one drop of the one-per-cent nitroglycerin solution may be given every three hours. As a heart tonic he gives the preference to theobromin, 1 or 2 gm. (15 to 30 grains) a day. It can be associated with 0.5 to 1 gm. ($7\frac{1}{2}$ to 15 grains) of caffeine a day. This treatment may be continued without interruption for several months.

When gangrene is once established, the parts should be disinfected with a 1 : 1,000 solution of potassium permanganate, followed by the application of hydrogen dioxid. When the arterial lesion is located high up, as for instance at the bifurcation of the aorta or in the iliac artery, surgical intervention is the only resource, and should be prompt. The cause is not inevitably atheroma. In one case Brissaud found at the necropsy a clot entirely obstructing the lumen, and he believed that its presence was due solely to intense angiospasm. Neurasthenics are extremely subject to the latter.

The state of the liver and the kidney is an important factor in the pathogenesis of gangrene.

Nerve-stretching for the Pain Due to Gangrene.—Morestin stretched the external and internal popliteal nerves in a case of gangrene of the foot, to lessen the pain. Moderate relief followed. Amputation was performed later. He advocates nerve-stretching while waiting for the line of demarcation to form.

Resection of Nerves in Painful Gangrene.—Bardesco has found it necessary to relieve the pain of gangrene of the leg before he could give thought to amputation. Stretching the nerve brought transient relief, but epidural injections of cocaine were entirely useless. He finally resected the internal and external popliteal nerves for a distance of about 5 cm. The pain was arrested at once, the general health improved, the œdema of the foot and leg subsided, and a line of

demarcation formed. The portion finally requiring amputation was much smaller than was at first supposed necessary, and the patient was spared this amount of crippling. Recovery was rapid and complete, and no sensory or trophic symptoms have developed to date. He proposes in future merely to sever the nerve and to suture the wound. This would relieve the pain, while the nerve would become regenerated later; in the mean time the gangrene would be cured. These operations on the nerves make it possible for the secondary amputation to be done under much more favorable conditions.

Amputation.—The formation of a line of demarcation should usually be awaited in senile gangrene, as the disease does not, as a rule, extend higher up than the foot. Amputation can then be performed in sound tissue. Early operation may be required if the process is advancing rapidly and is causing marked depression of the system. The prognosis is then unfavorable.

The same rules apply in general to diabetic patients. The disease should be treated and the local conditions attended to. The prognosis is governed by the result of antidiabetic treatment, and also by the extent to which the disease shows a tendency to spread. The younger the subject, the more unfavorable, as a rule, is the outlook. In favorable cases the sugar may disappear entirely after amputation. The level at which amputation should be performed is always a matter of concern. If the toes only are affected, it may be through the foot, or just above the ankle. If the gangrene has reached the ankle, some amputate through the thigh (Heidenhain and others), while others below the knee (Koenig, Landau). If the line of demarcation is distinct this will be the clue.

For the severe pain and defective circulation in the early stages of arteriosclerosis (gangrene), the parts should be put at rest with elevation, and tonics (Van Manteuffel) and potassium or sodium iodide should be administered (Erb). The use of morphine will be required if the pain is severe.

When the gangrene is more extensive than a mere superficial slough, amputation is usually called for. The accepted rule is: Do not amputate until the line of separation is well established. Thus, in gangrene after frost-bite, do not operate until the process has been arrested.

In strictly localized forms of gangrene due to trauma (a compound fracture, for example), amputate as soon as signs of the disease are certain. Delay, until a line of demarcation shall have formed, may cost the patient his life.

Immediate amputation is usually indicated in gangrene due to a wound of a main vessel at a distance—for example, in gangrene of the foot after a wound of the femoral artery (a condition often observed in military practice). The gangrene in these cases first shows itself by a change of color in the affected part, which is at first pale and tallowy, and subsequently mottled and streaked.

After gangrene has become established, the proper time for operation will

depend upon the location of the gangrenous process, as well as upon its extent and the degree to which it shows a tendency to become localized.

The decision must be made in every case by a consideration of the possible dangers if the operation is delayed, and of the ability of the patient to withstand the amputation. The first thought must be the saving of the patient's life; and the second, how much of the limb can be saved.

Murphy formulates the following rules:

(1) In gangrene of the toe, the line of demarcation should be complete, clean-cut, and advanced before amputation, which should be an exarticulation of the metatarso-phalangeal joint.

(2) When the sole of the foot or plantar fascia becomes involved, do not wait for demarcation, but amputate through the lower third of the leg immediately. If the line of demarcation is waited for in plantar infection, the patient usually succumbs to sepsis and exhaustion.

(3) If the gangrene involves the lower half of the foot, do not wait for the line of demarcation, but amputate at once in the lower third of the leg.

Many surgeons endorse the dictum of Heidenhain that, so long as the gangrene is confined to one or two toes, one may wait and employ antiseptic treatment, with elevation of the limb, allowing the part to be spontaneously thrown off. If the process extends, however, to the dorsum or sole of the foot, amputate above the condyles of the femur. Amputation below the knee, it is claimed, is almost always followed by gangrene of the flaps and exposes the patient to the danger of another operation. High amputation is indicated, then, when the gangrene progresses, even though the patient be without fever. Gritti advocates knee-joint amputation. A low amputation is advised by conservative surgeons, but if at the time of operation the large vessels are seen to be obliterated many advise to amputate higher up at once.

Even this will be unnecessarily radical in some cases. For example, if the conditions warrant a knee-joint amputation, and the popliteal artery is occluded by a thrombus, there may be no occasion to go higher, as the nutrition under these conditions is adequate, in many cases, to secure permanent healing.

Probably the majority of writers follow Van Manteuffel and Heidenhain, who advocate the high amputations. A minority make the operation selective, and dependent on the level of the disease and on the presence of pulsation in the artery. In diabetic gangrene, arteriosclerosis is always encountered. Here, also, high amputation is indicated, but greater range of individualization is permissible. If constitutional symptoms do not increase, one is justified in awaiting the line of demarcation. Conservatism is to be advised in all amputations where the vascular conditions warrant it. Digital compression is to be preferred to the use of a tourniquet. If, during the operation, there be but little hemorrhage, a higher amputation may be immediately performed. In embolic gangrene, the sudden onset is attended with immediate palsy of the limb, discolora-

tion spreading from above downward, and intense pain; and valvular disease of the heart will be discovered. It is the last factor that makes the prognosis in these cases worse than in those of senile gangrene. If no infection invades the body from the gangrenous limb, the line of demarcation may be awaited; otherwise the level of pulsation determines the choice of the place where the limb should be amputated. (Further details with regard to the subject of treatment will be found in the next section.)

II. GANGRENE DUE TO CONSTITUTIONAL CAUSES.

DIABETIC GANGRENE.

When gangrene is observed in a person suffering from glycosuria it is spoken of as "diabetic gangrene." Two varieties are described. In one the gangrene is said to be due to the diabetes *per se;* in the other, gangrene, due to other causes, occurs as a coincidence in a diabetic subject. The gangrenous process is distinctly modified by the presence of glucose in the blood. The course is more rapid, there is less tendency to limitation, and inflammatory changes are apt to be more pronounced. This form of gangrene almost invariably attacks those past middle life, usually beyond the fiftieth year. Very few cases have been observed in young persons. The gangrenous process usually starts in the toes or feet, where it may become localized, or it may extend up the leg. Occasionally other portions of the body are affected. Diabetic gangrene is moist, as a rule, although in rare instances it may be dry.

Etiology.—The cause of diabetic gangrene has been the subject of much speculation, and many explanations have been advanced. Küchenmeister believed that the gangrenous process was a means through which the sugar was eliminated. Schiff thought the glycosuria was the result of the gangrene, not the cause; basing his opinion on the fact that the sugar sometimes disappears from the urine after amputation has been performed. Demarquay and Ladeveze are of the opinion that the impregnation of the tissues by the sugar diminishes their resistance and renders them more susceptible to slight injuries.

Auche says: " (1) Peripheral neuritis may develop during diabetes without the interference of any other cause; (2) the nerve lesions are manifested by an *ensemble* of disturbances involving motility, sensibility, nutrition, and the vasomotor system; (3) the pathogenesis should not be looked for merely in the presence of sugar in the tissues of peripheral nerves. The neuritis is probably due to several causes, such as anhydræmia, acetonæmia, and disturbances in the general nutrition; and finally, perhaps, there may be some action from certain ill-defined chemical substances circulating in the blood of diabetic subjects." Auche considers the anæsthesiæ, pain, etc., as evidences of nerve trouble.

Reynier also admits the etiologic importance of the peripheral neuritis, and

claims a diagnostic and prognostic element in the absence or presence of the knee-jerk in diabetics. If this reflex has disappeared, Reynier considers all surgical interference as useless and dangerous. To neuritis he adds atheroma and arteriosclerosis as factors in the etiology of this affection.

Heidenhain says that the defective circulation of the blood is the cause of gangrene. The presence of bacteria distinctly aids the gangrenous process. On this point the experiments of Bujwid are interesting. He injected cultures of staphylococcus in animals, but the result was pernicious only when introduced with a 25-per-cent solution of glucose. If the solution was weaker, say 12 per cent, a single injection gave negative results; it was necessary to repeat the injections for four days to bring about serious consequences. The result was also negative if the sugar was injected four days after the germs. Bujwid found that gangrene resulted if the sugar was injected into the veins and the germs under the skin. Similar observations have been made by Hildebrandt. Cazin says that while the diabetic soil is exceptionally propitious for the development of microbian cultures, diabetes alone does not produce gangrene.

Varieties.—Jeannell divides diabetic gangrene into aseptic and septic forms, the former, as a rule, being dry, and the latter moist.

Heidenhain found a uniform involvement of the smaller arteries of the affected part. He reported 9 cases of gangrene, 6 occurring in persons having diabetes. In 5 the arteries were examined at different levels, and they were obliterated at the ankle in all. In 4 the posterior tibial was narrowed to the diameter of a pin by new connective tissue, and in 3 of these the occlusion was completed by fresh blood-clot. In 2 the obliteration was nearly complete at the lower part of the popliteal artery, and in 5 the popliteal was so changed that ligation here would have been unsafe. In 4 the femoral artery was distinctly diseased. There was, therefore, sufficient reason for the gangrene without the glycosuria. It is suggested that these cases are due to a deficient oxygenation of carbohydrates rather than to a true diabetes mellitus. Heidenhain thinks possibly the same change in the smaller arteries of the pancreas might influence the sugar-splitting function of this organ. The sugar disappeared in 3 cases after amputation, and in 1 it did not return when the patient resumed a regular diet.

Pathological Alterations.—According to Hildebrandt, examination of non-inflammatory diabetic gangrene shows that the glycosuria induces early degenerative processes in the arteries and veins; these processes are associated with compensatory proliferation of connective tissue and cells, which induces a narrowing of the vascular lumen, and therefore a weakness of the circulation, recognizable first in the peripheral portions of a member. The blood supply progressively diminishes and finally is arrested, marantic thrombi develop in the capillaries and arterioles, and gangrene is established. In other cases endothelial cells thrown off from the floor of an atheromatous focus induce an autochthonous thrombosis of the large vessels of the leg or foot, causing a

rapid development of gangrene. Quite often, on account of the gradual narrowing of the vascular lumen, a collateral circulation is established before complete closure takes place. Diabetic gangrene is, therefore, not a disease in itself, but develops because of the arteriosclerosis. An embolus may induce gangrene in a diabetic patient, but this is relatively rare, and the symptoms come on very rapidly.

Hildebrandt found the average age of 15 cases of gangrene in diabetic subjects to be 54.2 years, and that of 19 cases in non-diabetics to be 66.2 years. In this series of cases the diabetic cases averaged about 12 years younger than the senile cases.

The inflammatory type of diabetic gangrene is the common form. Usually some slight injury induces inflammation, to which the necrosis is secondary. Any part of the body may be affected, but the feet are most frequently involved.

Diabetes seems to produce, or to hasten the development of, arteriosclerosis, and it is due chiefly to this that slight wounds result so seriously. Neuritis, though sometimes present, is, according to Hildebrandt's opinion, never the cause of diabetic gangrene. Alcohol must also be considered as a predisposing factor in conjunction with the diabetes.

Wallace found that in eleven years there were admitted to St. Thomas's Hospital, London, 26 cases of diabetic gangrene (22 males, 4 females); 24 had well-marked atheroma; the condition was evidently of arterial origin and should not, he thinks, be separated from senile gangrene. The inflammation usually associated with such gangrene is secondary; neither it nor neuritis can be considered causal. Tactile sensation is often lost. The age of the patients averaged 60 years. Fifteen of the 26 died; of 11 operated on, 7 died; of 15 not operated on, 8 died and 7 were discharged unrelieved. Gross collected 49 cases of so-called idiopathic gangrene in 50 cases of inflammatory necrosis of the extremities—35 in the lower limb, and 15 in the upper. In 36 there was latent diabetes. The age varied from 28 to 73. The amount of sugar varied up to 10 per cent.

Whitacre also claims that (1) endarteritis obliterans is the main factor in the so-called diabetic gangrene, and that (2), in the absence of disease of the vessels, gangrene would be rare in diabetes.

Hildebrandt divides diabetic gangrene into (1) dry, non-inflammatory, non-septic, of rare occurrence; and (2) moist, septic, inflammatory, the usual variety.

The diabetic conditions favor the proliferation of bacteria; experiments have demonstrated that media containing a certain portion of sugar afford exceptionally favorable conditions for bacterial growth.

Koenig, Kraske, and others have shown that in phlegmonous diabetic gangrene the local infection has been added to the diabetic condition.

From what precedes, the following *summary* is justified: It must be ac-

cepted that atheroma and arteriosclerosis are usually, probably invariably, present in diabetic gangrene and that they play an important etiological rôle in these cases, a conclusion which is in full accord with the author's personal experience. It is, consequently, really a "senile" gangrene, with special features depending upon the presence of glucose in the blood; and, as in senile gangrene of the usual type, it is frequently precipitated by some slight injury to the foot.

It has been thought by Schiff and others that diabetes may be caused in some instances by the gangrene. Whether this be true or not there have been recorded a number of instances in which the glycosuria disappeared after amputation of the gangrenous part.

It should be added that in most instances, in addition to the amputation, a rigid anti-diabetic diet was given, as well as appropriate remedies, all of which may have contributed to the final cure.

It may be discovered at some future time that there are different varieties of diabetic gangrene, of which some may be cured of glycosuria by amputation, but at present such information does not exist.

Symptoms.—The first symptom of diabetic gangrene is usually a severe pain in the toes or foot, like that caused by a neuritis. At this time or subsequently the foot and perhaps the leg become swollen and œdematous. The part may be pale and cold, or, as usually observed, congested and of a dusky hue. This difference depends upon the relative involvement of the arteries and veins, for, as has been stated, both may be involved in the sclerotic process. When the former are markedly affected, and the latter free, the member will exhibit pallor and a lowered temperature. Such cases are apt to develop into dry gangrene. If, however, the veins are more affected than the arteries, the part will be swollen and congested. The temperature may also be subnormal, but not so low as in the preceding. This condition results in moist gangrene.

As the circulatory disturbances become pronounced, the pain becomes less or may disappear. If dry gangrene is to supervene, the part becomes shrivelled, a dark patch appears on a toe or on the foot, which gradually becomes hard and black. It may remain localized or it may spread. When the gangrene becomes localized the skin about the affected area will be of a pinkish color and warmer than the surrounding healthy portions, showing a condition of "active hyperæmia," which constitutes the line of demarcation. It is an indication that the process has become localized, unless some unfavorable condition causes it to extend. This "active hyperæmia" must be distinguished from "passive hyperæmia" or congestion. The former is of a brighter hue, and when the hyperæmic area is pressed upon by the finger the color may be displaced, but it rapidly returns when the pressure is removed. In passive hyperæmia the color is dull and cannot be entirely displaced by pressure. Such a condition should always excite apprehension, as the gangrene is liable to spread under such

circumstances. If the process is to be moist, the part remains swollen, and the surface becomes mottled, dark areas being mingled with others of lighter hue. Blebs containing bloody serum may form over the darker patches. In these cases the gangrene is prone to spread until the whole foot or the foot and part of the leg are involved. The dead portions assume a dark color, approaching black, the tissues are moist and macerated. The surrounding parts are of a livid hue, swollen, and œdematous. Infection frequently occurs in these cases, and putrefaction results. This is accompained by an offensive odor and usually by constitutional symptoms of septic intoxication, which are frequently accentuated by the glycæmia. When the process is about to become localized, a prominent hyperæmia of the skin, denoting the line of demarcation, will be observed.

If the gangrene is of the septic type, the patient will show the usual constitutional symptoms—fever, increased pulse-rate, coated tongue, etc.

Diagnosis.—Nothing need be said of the diagnosis of gangrene, which will be made instantly upon inspection. It may be proper to state here, however, that it should be an invariable rule to examine the urine in every case of gangrene, but it is especially important to do so in the cases of so-called "spontaneous" gangrene. The presence of either albuminuria or glycosuria demands active treatment; the latter, especially, calls for the most intelligent supervision, inasmuch as it may have a very definite bearing on the progress of the gangrene process.

Treatment.—The treatment of diabetic gangrene will be considered under the following headings:

(1) Prophylactic treatment; (2) local treatment; (3) constitutional treatment; and (4) amputation.

The following excellent outline of *prophylactic treatment* is given by Stern. Once for all, it should be understood that the best prophylactic is the suppression or reduction of the diabetic syndrome. This is accomplished almost entirely in wellnigh every instance by proper dieting. The diet should conform to the needs of the organism, but should not remain one-sided for protracted periods. It is much better to have the patient adhere to rigid dieting one week in every month than to have him pursue a strict regimen for many months, after which everything may be allowed him, without special restrictions to quality. Hand-in-hand with a suitable diet a special hygienic treatment should be instituted. First and foremost, the patient's work has to be adjusted to his diminished resistance and vitality. This pertains in the same degree to mental as well as to physical labor. Obesity should be reduced by exercise and gymnastics, and emaciation be ameliorated by the addition of absorbable fats of high melting-point. The heart should be looked after and treated, if necessary. The best heart tonic is absolute rest in the recumbent position. An absolute rest of two or three weeks, during which time the amount

of liquids to be imbibed is limited to physiological needs, is of more benefit to an overworked or weak heart than a year's stuffing with strychnine, digitalis, iron, nitroglycerin, and their likes. A great deal of attention should be devoted to the hygiene of the skin. Absolute cleanliness of the entire integument should be insisted upon. A mild antiseptic soap may be habitually employed. The body should never be immersed in cold water, but a sponge bath of cold water is permissible. Two or three times a week a warm bath of from 100° to 102° F. should be insisted upon. If the patient is obese, or if the heart displays symptoms of weakness, a daily bath of that temperature should be prescribed. The slightest abrasion of the skin, the most trifling injury of whatever sort, or even the oozing surface produced by cutting a corn, should be treated by strictly antiseptic methods. The body should be well protected against atmospheric influences. The heat should be equally distributed over the entire trunk; both hands, and especially the feet—the latter the most frequent seat of the gangrene—should be kept extra warm. A daily moderate perspiration around the toes indicates that they are not threatened by local gangrene.

Besides these measures, expedients are employed to avert the onset of idiopathic gangrene in the diabetic subject. This idiopathic gangrene occurs at times in patients whose diabetic affection has not made very pronounced inroads on the general condition; in other words, either in persons whose diabetes is of a mild nature or in those who have pretty well kept up antidiabetic treatment. Idiopathic gangrene in the diabetic subject supervening before the fiftieth year of life is rare, and, as it always concurs with angiosclerosis, the symptoms of which are usually more prominent than those of diabetes, it must be looked upon as a type of senile gangrene. Accordingly, one should treat the angiosclerosis and its complications with a view to preventing the gangrene.

Every diabetic person is a fit subject for anti-angiosclerotic treatment whose radial pulse pressure is above 150 mg. Hg. (von Basch's sphygmomanometer), even if a hypertrophic state of his heart and the accentuation of the second aortic sound are as yet not plainly discernible. The antidiabetic diet, of course, should be continued, but carbohydrates in limited amounts are to be allowed. Especially should this be the case with milk, which is a very acceptable and bland nutriment. Blandness of the nourishment, by the way, seems more important in the dietetic treatment of the arteriosclerotic patient affected with diabetes than the total exclusion of farinaceous material. Preparations of salts of iodine, in increasing doses, should be administered for protracted periods. The circulation and metabolism in general should be stimulated as much as possible by physical means. Severe pains in the thigh, calf, and foot are to be considered rather the result of the endarteritic processes and incipient thrombosis than a phenomenon of "rheumatism," "gout," "neuralgia," or "diabetic neuritis." Such pains, especially if they are of nightly occurrence, and tearing or burning in character, and do not disappear on the exhibition of salicylates and

other coal-tar derivatives, are probably pathognomonic of the progressive obliteration of the lumen of the arterioles. They should not be wrongly interpreted, for the reason that a rational management of the affected peripheral parts of the extremities—almost always of the lower ones—may yet effect amelioration of the endarteritic process. In the presence of the afore-described pains the administration of iodine should be insisted upon. There is no consensus of opinion as to the *modus operandi* of preparations of iodine in angiosclerosis; possibly it is the altered viscosity of the blood, ensuing after the administration of iodine, or the vasodilating properties of the drug, to which may be ascribed any beneficial influence. The best preparation of iodine to be taken for protracted periods is the sodium iodide. The patient may take short walks, but must not stand on his legs for any length of time. Hot foot-baths applied daily, and followed by brisk massage of the entire limb or the entire body, will greatly stimulate the return circulation. Still better service may be rendered by dry hot air. The affected limb should remain in the dry hot-air apparatus at a temperature of from 250° to 300° F. for almost half an hour. It is advisable to proceed with the "bake" twice a day for no less a period than two or three weeks. Each *séance* may be ended with massage or, if possible, vibratory massage. The high-frequency current has proved of special value in stimulating the local circulation and in overcoming venous stasis. In phlebo-sclerotic œdema the employment of the high-frequency current may also be accompanied by gratifying results.

Local treatment should begin, of course, as soon as the patient comes under observation. The indications are to protect the devitalized part in order to prevent infection, and to promote the circulation in adjacent parts with the view of limiting the disease by establishing a line of demarcation. The first indication is met by applying a liberal dry bichloride or salicylated dressing. Before this is done, however, the part should be thoroughly cleansed, the surface shaved if any hair be present, and the same routine employed as that used in preparing for an aseptic operation. Every effort should be made to avoid infection, as the septic process adds very greatly to the gravity of the case. Dry dressings are usually preferable, as moisture tends to macerate the tissues and to promote breaking down and extension of the gangrene as well as infection. If abrasions or ulcerations exist, accompanied by discharge, the wounds should be cleansed twice daily, or oftener if the secretion is very profuse, such antiseptics as bichloride solution (1:2,000), potassium permanganate (1:1,000), hydrogen dioxide, etc. being used freely. The wounds may then be dried as much as possible and the dressings reapplied. Cases in which extensive infection is a prominent feature may require wet dressings, and the same treatment becomes appropriate when a line of separation has formed, as it promotes granulation, especially if applied warm.

To aid the circulation of the part, two things should be done: First, as there

are usually swelling, œdema, and congestion, which interfere with the return of the blood through the veins, elevation of the affected member is essential; and, second, as the temperature is subnormal and the vitality low, external heat is to be applied, preferably by means of hot-water bags.

Constitutional treatment is equally important. For a systematic description of this subject the reader is referred to the treatment of diabetes in the standard text-books on medicine. The general rule that the diet should be as free from articles containing starch as possible is to be observed. If the patient takes milk well, one or two quarts may be given daily.

Whitacre mentions a number of remedies from which selection may be made: Arsenic, codeine, opium, antipyrin, acetanilid. Arsenic probably acts by increasing the number of the red blood corpuscles and thus increasing oxygenation of the blood. Iron may also assist. He uses the following formulæ:

Antipyrin, soda bicarbonate, āā gr. xv., t. i. d. for three days. This is said to reduce the sugar fifty per cent. (Not to be repeated.)

Dihydrochloride of quinine, gr. x. on rising, for six days.

Sodium arsenate 5 cg., aq. 30 c.c., three times daily for six days.

The last two should be taken in alternation for some time.

Tyson also advises small doses of arsenic—$\frac{1}{30}$ grain, or 3 drops of Fowler's solution—and the iodides.

Erb and Bunge recommend, in case of symptoms of alterations in the arteries, hot foot-baths with galvanization of the feet and the internal administration of potassium iodide. In these cases massage of the lower limbs is also beneficial, both in preventing and in treating arteriosclerosis, or even incipient gangrene. The question of prophylaxis deserves more attention than hitherto accorded. All writers agree that operative measures must be preceded by antiseptic bandages and antidiabetic diet. Powders are applied by some to transform the gangrene into a dry lesion and thus hasten demarcation. The most important factor in treatment is the close supervision of the patient. Bunge warns against allowing the most favorable moment for surgical intervention to slip past. The inflammation is liable to spread suddenly. Tuffier will not operate unless he is able to reduce the amount of sugar in the urine. Godlee distinguishes between the deep, vascular and the superficial, neurogenic gangrene, stating that the former is rapidly progressive and requires prompt amputation, while the latter form is chronic, and expectant treatment is indicated. Wolf, however, rejects this classification, as it does not include the gangrene in which bacteria are the chief agents.

The treatment outlined by Koenig has not been improved upon. This is to individualize in each case and convert a septic process as far as possible into an aseptic one. Phlegmons require incision and antiseptic treatment. If the process spreads and requires amputation local anæsthesia should be employed.

The quantity of urine passed in each twenty-four hours should be measured,

and the percentage of sugar estimated. In this way only may one form a correct opinion of the progress of the case from the constitutional standpoint.

In addition to the antidiabetic treatment, it may be necessary to administer tonics or stimulants, or both, especially if the patient is septic.

Amputation, through healthy tissue, may usually be performed after a line of demarcation has formed; high amputation is not always necessary. The state of the blood-vessels must be consulted; if the pulse is felt in both tibials, a low amputation is indicated; if it is not felt below the popliteal artery, a high amputation will be required; if there is no pulsation in the popliteal, a thigh amputation should be performed. König has formulated similar rules: Hildebrandt does not recommend either local anæsthesia or the Esmarch bloodless method.

If no sign of a line of demarcation is apparent, and the percentage of sugar does not fall after proper diet, etc., immediate amputation is the proper course.

The question of amputation in diabetic gangrene is of vital importance. In a review of 172 communications on diabetic gangrene, Wolf states that writers agree in advising an antidiabetic diet and waiting for demarcation in cases of non-inflammatory gangrene; but with the inflammatory form, expectant treatment is only allowable under close supervision, and is dangerous even in these conditions. Investigation of the arteries, especially of the arteries of the foot, is of great importance in all cases of gangrene in diabetic subjects. Whenever the pulse is weak or imperceptible in the arteries of the foot, operations below the malleoli are usually inadequate. If the pulse in the popliteal artery is likewise imperceptible, the operation should be at the point where the pulse is felt again. If, during the operation, the severed vessels do not bleed enough, the limb should be amputated at a higher point during the same narcosis. Operations on the thigh have no special advantage over those of the leg or knee. Local anæsthesia—but not infiltration anæsthesia—is preferable to general narcosis. The latter, in conjunction with the operation, favors the onset of coma. A comatose condition, however, is no indication against operating. Five to ten grams of sodium bicarbonate to be taken before the operation is recommended as a preventive measure. Irritating antiseptics and tightly drawn sutures should be avoided. Lidner lost none of 6 patients on whom he operated, and Bunge none in 4, but the general statistics collected show that 50 out of 110 patients died, and 28 out of 75 that were operated on—a proportion of 37.3 per cent. The possibility of the development of gangrene should always be borne in mind in examining elderly diabetic persons. In Wolf's 118 cases none of the patients was under 40, and almost all were approaching the 60th year. Violent pains in the lower limbs should not be diagnosed as gout or rheumatism, without careful examination, as they may be due to a vascular or nervous disease, such as frequently precedes the development of gangrene. There is often a history of pains, paræsthesia, and especially formication, in these cases,

and careful attention should be devoted to these symptoms. Diabetic sub-
jects should observe great care in cutting the nails or corns, and extreme
cleanliness and comfortable footgear are indispensable. Even a slight injury
requires immediate surgical treatment.

Cazin thinks that an aseptic wound in a diabetic subject ought to heal in the
same manner as it does in a healthy individual, and consequently he amputates
in case of gangrene, and without sacrificing more of the tissues than would be
necessary in a non-diabetic patient. He performed the Lisfranc disarticulation
on a diabetic patient, 63 years of age, inclined to atheroma. There was no pul-
sation in the tibialis posticus, but it was perceptible in the popliteal artery. Not
a drop of blood issued from the plantar flap during the operation. After recov-
ery from the operation the patient was able to walk well on his half foot and has
since shown no signs of a recurrence of the disease. Tedenat has also reported a
number of cases (both with and without diabetes) in which the external flap did
not bleed during amputation, but his results have all been highly satisfactory.
Guinard does not have much confidence in a flap that does not bleed, and in
such cases he removes the clots obstructing the artery. By this "catheterization
of the artery" applied to the femoral in a recent case, the blood flowed freely
after removal of the large clots obstructing the lumen.

As regards the question of amputation, the statements made in the preceding
section cover the ground in a sufficiently detailed manner.

Gangrene in Phosphatic Diabetes.—A case of spontaneous gangrene due to
phosphatic diabetes is reported by Cerné. A man, 60 years of age, thin, the
subject of phosphatic diabetes, developed multiple disseminated gangrenous
plaques without any known cause. He had polyuria (3 litres daily), phospha-
turia (acid. phosphoric. 4.40 grams to 7.70 grams in 24 hours), but the urine was
free from albumin and sugar.

A cure took place slowly, and at the same time the phosphates in the urine
gradually diminished.

Phosphatic diabetes was first described by Dr. Teissier.

III. GANGRENE FOLLOWING THE ACUTE, SPECIFIC FEVERS.

Gangrene affecting various portions of the body has been observed in the
course of all of the acute febrile affections. A well-known example is the occur-
rence of "noma" during measles. Gangrene is met with also in cases of ery-
sipelas, influenza, rheumatism, malaria, varicella, scarlet fever, pneumonia,
tuberculosis, typhoid fever, typhus, etc. The process may be either dry or
moist, and affects most frequently the lower extremities. The upper extremi-
ties, the buttocks, face, nose, ears, etc., are occasionally involved. The viscera
may also be affected, gangrene of the lung being the commonest example.

Etiology.—Gangrene is probably brought about in a similar manner in all of these cases; hence this subject will be considered but once, and it may be assumed that our remarks apply equally to all of the diseases above mentioned. As in all other forms of gangrene, the etiology in this depends upon a number of factors. As a predisposing cause we must consider the feeble circulation due to the cardiac weakness observed in this class of diseases, aided, perhaps, by congestions of dependent parts and those farthest from the heart; to inability to change the position of the body from time to time; or to pressure on salient parts for the same reason. The altered state of the blood may also constitute a predisposing factor.

The exciting causes are usually embolism, due to fragments coming from the heart or from a thrombus, thrombosis due to endarteritis, and pressure. It is now established that an endarteritis, due to bacteria in the circulation, may occur in the course of the specific fevers, giving rise to thrombosis.

This subject is too new to permit of systematic presentation, but a few very brief examples will illustrate the possibilities. Schmit described a case of erysipelas of the face, followed by enteritis, suppuration of the submaxillary glands, and gangrene of the leg. Morrison described a case of gangrene of the left hand coming on six days after the beginning of an attack of erysipelas of the face. Welch says: " In a remarkable case of multiple thrombotic vegetations, present in large numbers in the pulmonary artery, especially in the left main branch, and also on the pulmonary valves (other valves normal), Flexner, in my laboratory, found in the thrombus, chiefly enclosed in polynuclear leucocytes, very numerous, extremely delicate bacilli, which were identified as the influenza bacilli of Pfeiffer." This establishes the occurrence of an acute arteritis and thrombosis due to the bacillus of influenza. Eichhorst has collected reports of 19 cases of gangrene following influenza, and many cases following other infectious diseases.

Gangrene sometimes occurs in the course of pneumonia. Gibson, after reporting 3 cases, says: " The symptoms of vascular obstruction seemed to have developed in all 3 cases suddenly, at or about the time of defervescence." He believes they were directly due to the pneumonia, for the following reasons: "A pathological condition accompanying pneumonia which would explain the purely mechanical process is stated by Welch to exist. The gangrene was of a dry form, due to obstruction of the arteries. The sudden onset of symptoms was in favor of embolus rather than thrombus beginning in the arteries of the leg. The patients showed no obvious vascular or cardiac lesions which would favor the theory of embolism from this source."

Kieffer reports a case of gangrenous varicella in a child of 16 months. Only a small portion of the vesicles became gangrenous. The child seemed to be otherwise in good health. Direct examination of the exudate, as well as inoculations,

showed only the presence of Streptococcus pyogenes and Staphylococcus pyogenes aureus.

A description of gangrene occurring in the course of typhoid fever will serve as the type seen in all forms of the various acute infectious diseases. The occurrence of gangrene during and after typhoid fever has been well known for the past fifty years. It is one of the more infrequent complications of this disease, and appears to occur as frequently in mild cases as in severe ones. Keen, in his excellent work, "The Surgical Complications of Typhoid Fever," collected 133 cases. As a rule, the gangrene appeared during the later stages of the disease or early in the convalescence. In this collection the earliest case appeared on the fourteenth day of the disease, and the latest in the seventh week, the majority being observed in the third week. It is probable that the bacillus of Eberth is the exciting cause of gangrene in typhoid fever, although such predisposing conditions as feeble circulation from weak heart and the altered state of the blood due to the disease must also be taken into account. Endarteritis and endophlebitis are not uncommon, due either to the typhoid germs alone or to mixed infection. In such cases a thrombus may form, or the intima may merely be studded with small masses due to infiltration. The arterial thrombosis, being of gradual development, as a rule, usually results in dry gangrene. In some instances, at least, the thrombi contain bacilli. The endothelium may be destroyed in the occluded portion, due probably to the irritating action of the bacilli or their products.

Four varieties of interference with the circulation are described: Arterial

Fig. 38.—Dr. Nammack's Case of Gangrene of Both Lower Extremities Following Typhoid Fever. (Medical Record, December 27th, 1902.)

emboli originating in the heart; autochthonous thrombi in the arteries; similar thrombi in the veins; and capillary thrombosis.

Cardiac emboli have been found in the aorta, the primitive iliacs, and the femoral and popliteal arteries, without any evidence of disease of the coats. On the other hand, clots are often found in the vessels in typhoid without any evidence of their cardiac origin. These are called autochthonous thrombi. Both causes are apt to result in dry gangrene.

Venous thrombosis occurs more frequently than arterial, possibly because the current is more sluggish, and also perhaps because the superficial veins are more apt to be the seat of slight trauma. Venous thrombosis is not so apt to result in gangrene because of the very free anastomosis. In some cases there are a number of thrombi in both the arterial and the venous trunks; the venous thrombi are apt to be much more extensive than the arterial.

A case is reported in which the clot involved the deep femoral vein and the common iliac as far as to the vena cava; another case, in which there were clots in the right ventricle, left auricle, the femoral and popliteal arteries and veins, as well as the aorta. Gangrene from venous thrombosis is apt to be moist. Sometimes the arteries and veins are both affected, either at the same time or one following another. A certain number of cases are undoubtedly due to capillary thrombosis caused by disease· of vessel walls or by pressure or other factors interfering with the circulation. From his study of gangrene and arteritis in typhoid fever Bernheim concludes: "1. One may meet in typhoid either external or internal gangrene, among these noma and gangrene of the diaphragm. 2. The occurrence of noma was not influenced by the antiseptic treatment. 3. Visceral gangrene may be latent, and no special diagnostic symptoms may exist. 4. In arteries, pain may exist *only* at the site where gangrene exists, while the rest of the affected artery is painless. 5. The muscular tunic of the artery may become very vascular." Gangrene of the *bowel* during typhoid is probably due to embolism of mesenteric vessels. Hoffman found 9 cases in 250 autopsies: 6 of the ileum, 2 of the appendix, and 1 of the sigmoid. What has been said of typhoid fever applies equally to typhus.

Of 140 cases collected by Keen, 26 occurred before the 15th year; 64 from 15 to 25; and 50 after 25. (All ages, therefore, appear about equally susceptible.) About three males were affected to two females. The parts affected were: Ears, 6; nose, 10; face, neck, and trunk, 47; anus, 5; genitals, 20; legs, 126. Of 128 cases of venous coagula, 124 were in the lower extremities; 18 of 41 arterial cases, and 40 of 107 venous cases, occurred in the second and third weeks of the fever. At this time the peripheral circulation is apt to be weakest. If the emboli or thrombi or the inflammation of the vessels were the sole cause, the gangrene should attack the upper extremities as often as the lower. In all forms of gangrene it is observed that the legs are affected more frequently than all other portions of the body together. These cases show that

when the clot extends up to the popliteal artery only, the patient may escape gangrene; and when it did occur it was limited to the foot in 6 cases, to the lower half of the leg in 1, and to the upper calf in 14. When the clot extended to the femoral, the gangrene reached the upper calf in 11 cases, and to the thigh in 8. When the clot reached above Poupart's ligament, the foot only was affected in 1 as far as the calf in 8, and above the knee in 6.

In 46 cases of arterial gangrene, both sides were affected in 8, the right side in 19, and the left side in 19. In 52 cases of venous obstruction, both sides were affected in 4, the right in 10, and the left in 38. Keen's explanation is that the compression of the left common iliac vein where it passes under the right common iliac artery is the most potent factor. The evenly balanced bilateral obstruction in arterial gangrene would suggest the frequent embolic origin, whereas the marked difference in venous cases is explained as above. The male genitals are very rarely affected. Keen found but 1 case, whereas he collected 21 in females.

Treatment.—This should be preventive, and should comprise nourishing food, fresh air, and careful attention to hygiene. The circulation must be maintained. Care should be observed to avoid mechanical injuries, especially to parts most liable to be affected, as traumatism added to the low vitality and weak circulation sometimes causes gangrene.

When gangrene is threatened from poor circulation, the course pursued in the following case may be adopted: In a case of gangrene which was reported by Barringer, and which developed in the course of an influenza, the blood pressure, as estimated by Gaertner's tonometer, showed 101.5 mm. of mercury for the affected right hand and 115 mm. for the healthy left hand, thus showing that the digital arteries of the right hand were sufficiently diseased to produce a local decrease in pressure. In accordance with the advice of Buchner, bandages saturated in 95-per-cent alcohol were applied to the right hand and forearm for thirty minutes, and the blood pressure was then taken. The result was a local increase of pressure amounting to 10 mm. of mercury, thus demonstrating absolutely the remarkable action of external applications of alcohol on the local blood pressure. The propulsion of more blood through the diseased area must certainly aid materially in re-establishing normal conditions. This treatment was accordingly steadily persisted in. After six weeks of the treatment the blood pressure in the affected area varied between 108 and 115 mm. of mercury, which was an appreciable increase as compared with the former pressure of 101 mm.

Gangrene affecting other portions than the extremities cannot be treated operatively except by removing the necrotic tissues. In the extremities, amputation may be called for. It is not to be undertaken, as a rule, until the line of demarcation has formed. Just before the operation, the leg should be made bloodless by vertical elevation for five minutes, and the circulation controlled

by digital compression. The tourniquet is to be avoided, because it may injure the vessels and thus cause a new thrombus, or it may break up an already existing thrombus, causing embolism. The hemorrhage, as a rule, is slight, because of the occlusion of the vessels.

IV. GANGRENE ASSOCIATED WITH SYPHILIS.

In rare cases, gangrene of the integuments takes place in those afflicted with syphilis as a result of changes in the coats of the blood-vessels, the condition being known as *syphilitic arteritis*, or *arteritis obliterans*. It is especially apt to occur in debilitated subjects, whose mode of life and personal hygiene diminish their vital resistance. Syphilitic gangrene of the skin begins as a mottling which is at first a light brown such as might result from a bruise, and subsequently changes to greenish, deep brown, and black. Some cases take the form of moist gangrene, and others that of the dry variety.

Under the title "primitive gangrene," Fournier describes a syphilitic manifestation called by Bazin "tuberculo-gangrenous syphilide," which he describes as follows: "The lesion, as soon as it has formed, takes a livid color in the centre and a chocolate color in the peripheral portions, with insensibility of the deep parts; for, in reality, the formation of an eschar takes place, under which the mortified, insensible, sloughy tissues are found, no external cause being recognizable. The mortified parts take on the appearance of gangrene, they become detached, and, underneath, the syphilitic ulcer is found. The symptoms present the characters of spontaneous primary gangrene."

Gangrene of both upper and lower extremities is met with in syphilis in rare cases. In a case involving the legs, reported by Podres, microscopic examination showed inflammation of the external coats of the arteries, with degeneration of their endothelium, thickening of their walls, and obliteration of their calibre. There was also atrophy of the cutaneous glands and nerves. All of these changes were ascribed to syphilis.

Syphilis is thought to give rise to Raynaud's disease in some instances, examples of this affection occurring in syphilitic subjects having been observed by Hutchinson, D'Ornellas, Morgan, and Elsenberg.

Despies reports a case of fulminating gangrene of the right leg, that occurred in the early stages of syphilis, while the chancre and mucous patches were still present. Mendel records an instance of gangrene of the tongue, probably of syphilitic origin.

The characteristics of gangrene due to syphilitic arteritis, according to Darier, are the following: The disease is rarely sudden and massive in its development, but usually progressive and proceeding by jumps. (Despies' case was an exception to this.) It affects at first a portion of a toe, for example, then sev-

eral days later neighboring toes are affected; then the entire foot. The parts about to become gangrenous are chilled or cooled, insensitive, marbled by yellowish and violaceous colors; the horny epiderm peels off and is often elevated in blebs to the limit of the already mortified parts. Then follows the complete mummification of this last part also; dryness and blackness developing. It is impossible at first (and even in the course of the development), until the line of demarcation is well established, to foresee just how far the necrosis will extend; the persistence of œdema, soft or hard, often with lymphangitic growths or ecchymoses above the level of the seat of gangrene, is a sign of grave import from this point of view.

The treatment of gangrene due to syphilis is similar in every respect to that appropriate for the same lesions due to other causes.

Constitutional treatment (iodides) should be added in every case.

V. GANGRENE AS A COMPLICATION OF HÆMOPHILIA.

A case of this kind is reported by Faludi. A boy, $6\frac{1}{2}$ years old, had severe hemorrhage following circumcision, in the first or second week of life. From the fourth month subcutaneous hemorrhages began to appear in different parts of the body, at times as the result of an insignificant injury, at other times independently of any obvious traumatism. In addition, there were hemorrhages from the nose and gums. During the second year a copious extravasation of blood took place into the left knee joint. At the age of 5 years, following a fall, the entire right upper extremity became swollen and cool, while the pulse was scarcely palpable. Improvement ensued under treatment, leaving, however, stiffness of the elbow joint and contracture of the fingers. Somewhat later, an extravasation of blood took place into the right ankle joint and there occurred also a profuse epistaxis. In the following month the child fell and, it was thought, suffered an injury to the right popliteal fossa. An extravasation of blood took place, gradually involving the entire distal portion of the extremity. The part became cool and insensitive, and large blebs formed on the surface. Finally gangrene developed.

Post-mortem examination disclosed, apart from the direct results of the injury, the presence of pulmonary œdema, universal anæmia, hemorrhagic extravasation into various muscles, bilateral hydrothorax, dilatation of the heart, fatty degeneration of the myocardium and parenchymatous and fatty degeneration of the liver and kidneys. The percentage of hæmoglobin had been fifty, and the blood picture that of profound anæmia. No marked change was found in the walls of the vessels. In the family history a maternal uncle had often suffered from hemorrhage, dying from this cause after extraction of a tooth. A prematurely born brother died on the thirteenth day from epistaxis.

VI. LITHÆMIC GANGRENE.

Rosewater reports a case of gangrene of the anterior right tibial region which he attributed to lithæmia.

VII. EMPHYSEMATOUS GANGRENE.

(Spreading Traumatic Gangrene, Malignant Œdema, Gangrène Foudroyante.)

This is characterized by a rapidly spreading infection, especially affecting the subcutaneous and other loose areolar tissue, and accompanied by the presence of gas in the tissues which gives rise to "crepitation" on palpation. Various names have been applied to this condition by different writers, among them being: *malignant œdema, gangrenous emphysema, gangrène foudroyante, spreading traumatic gangrene, fulminating gangrene*, etc. It is impossible to say, at this time, whether these terms should be considered as synonymous or whether they should stand for different types of infection associated with gas formation.

Although this condition has been known for a long time, its etiology has not yet been settled. Prior to the recent development of bacteriology, surgical writers explained the presence of gas by stating that "air is suffused in the subcutaneous cellular tissue." It is now a matter of common medical knowledge that the emphysema in the tissues is due to the formation of gas caused by bacterial growth and activity.

The bacteriology of infections with gas formation is a very interesting phase of the subject, and has been carefully studied by a number of investigators. As there is no unanimity of opinion, and as the matter is one of great importance, the views of various authors are here given rather fully. The so-called bacillus of malignant œdema was described by Koch, in 1882, as a rod-like bacillus, in form and size resembling that of anthrax, but somewhat smaller and with rounded ends. The bacilli are joined in threads in a peculiar manner. They have the power of spontaneous motion (unlike anthrax) and of spore formation in the living body (unlike anthrax); they grow only in the absence of oxygen, but rarely enter the animal body with any activity, abound in garden soil, and may be in any soil or dust. The gangrenous and putrefactive phenomena are said to be due to admixture with ordinary putrefactive germs. Park found, when a pure culture of these germs was injected in an animal, that an extensive hemorrhagic œdema of the subcutaneous cellular tissue resulted, without any appearance of putrefactive action and quite free from gas formation. If an impure injection was made, or if the culture was mixed with garden earth,

gangrene and emphysema were added to the above phenomena. The germs must reach the subcutaneous cellular tissue to cause their specific effects. Inoculations on open wounds are harmless, owing to the free exposure to air.

A similar gangrene and emphysema may come from mixed infection with streptococci and the Bacillus aërogenes capsulatus. A spreading phlegmonous emphysema, local gangrene, and septicæmia characterize this disease. They cannot be differentiated clinically. Stolz believes that the Fraenkel-Welch gas bacillus plays the principal rôle in the etiology of gas infections. He reports one case, and von Wicklein three cases, in which a closely related species, namely, an anaërobic, mobile, butyric-acid bacillus, was isolated. Of the aërobic bacilli that may cause gas infections, Stolz mentions the proteus, colon and paracolon bacilli.

Howard has also shown that the Bacillus mucosus capsulatus may cause inflammatory processes associated with gas. Both Albrecht and Stolz claim that the name "bacillus of malignant œdema" should be employed as a collective name for a series of aërobic and anaërobic bacteria, any one of which may cause in guinea-pigs a disease similar to that observed by Koch in his experiments with the so-called bacillus of malignant œdema. What has heretofore been described as malignant œdema in man, in most cases, has been really a gas-bacillus infection—one due more particularly to the Bacillus aërogenes capsulatus. Other bacilli also cause such conditions, but all appear to belong to the same group. Schattenfroh and Grasberger have called the gas-producing bacillus the butyric-acid bacillus, and they have divided these bacilli into the mobile, the immobile, and the putrefying.

Fraenkel demonstrated the relation between a germ which he called Bacillus phlegmonis emphysematosus (Bacillus aërogenes capsulatus of Welch) and one obtained in gaseous phlegmons and emphysematous gangrene. Grasberger and Schattenfroh have since claimed that the gas bacillus is a variety of their acid bacillus (Granulobacillus saccharobutyricus immobilis), but Fraenkel does not agree with this view, because the gas bacillus proper does not produce spores in starch agar as does the butyric-acid bacillus.

Albrecht concludes, after studying a series of cases, that mixed infection with anaërobic bacilli and pus cocci leads to the typical picture of gaseous gangrene. In two cases he found an organism which corresponded more closely with the butyric-acid bacillus described by Schattenfroh and Grasberger, and which has the power of causing putrefaction in proteids; the other cases appeared to be due to typical gas bacilli. Cole demonstrated the Bacillus aërogenes capsulatus in the blood of a patient with infection and gas formation following a crushing injury of the lower extremities. There was no gas in the blood during life. Gillemot, in a case of gaseous gangrene in a small girl, isolated an anaërobic organism, immobile, non-spore-forming, hence absolutely different from the *vibrion septique*, but identified with the Bacillus phlegmonis emphysematosus of

E. Fraenkel. Inoculation of rabbits reproduced the same lesions, and death occurred in from thirty-six to forty-eight hours.

Achalme regards the bacillus described by him in 1891 as the cause of acute articular rheumatism, the Bacillus emphysematosus, Klein's Bacillus enteridis sporogenes, and Veillon and Zuber's Bacillus perfringens, as one and the same organism. He compares its pathogenic action to that of the streptococcus, which causes a specific disease, namely, erysipelas, as well as non-specific processes. So this anaërobic organism causes a specific disease, namely, acute articular rheumatism, and a variety of other lesions. This bacillus belongs to a group of organisms characterized by: anaërobic growth; spore-formation in alkaline media; liquefaction of gelatin; tryptic action on casein, fibrin, and albumin; fermentation of carbohydrates with the production of acetic and butyric acids (Bacilli anaërobes trypto-butryriques).

Hitschmann and Lindenthal described eight cases of "Schaumorgane," in all of which they found the same bacillus, an anaërobic, Gram-staining organism, which is not motile and forms spores; it ferments carbohydrates and proteids with abundant formation of hydrogen, and is pathogenic for guinea-pigs and mice. The authors attribute emphysema of the vaginal and other mucous membranes to the same bacillus.

Sandler believes, with Hitschmann and Lindenthal, that gaseous gangrene with suppuration is a mixed infection. In pure gas bacillus cases there developed necrosis and gas only, but not true pus.

After an extended study, Legros concluded that the fulminating gangrene of Maisonneuve, and the acute gaseous gangrene of many surgeons, do not depend upon a single specific microbe. The causative organisms are not all even anaërobes. The author claims to have fully and positively described the first case yielding *aërobic* organisms as the etiologic factor. This bacillus is not identical with any of the species hitherto classified. Legros has named it the "Bacille septique aérobe" or aërobic septic bacillus, a name which indicates at once its resemblance to and its difference from the septic vibrio of Pasteur. Since then the author has recovered the same organism from another case of gaseous gangrene in man.

Other species, anaërobic and aërobic, are capable of producing the same condition also, and their number is destined to grow larger as strict and systematic bacteriologic observations become more frequent.

Jacobelli emphasizes the distinction between the two clinical forms. One is characterized by primary gangrene without preceding inflammation; gases form in the tissues immediately after the injury; necrosis rapidly follows; and death occurs with symptoms of blood poisoning in a few days. The other form shows acute inflammation first; this is followed by gas formation and emphysema. The first is gas gangrene proper and is due to gas-producing micro-

organisms; the second is only progressive inflammation with emphysema, caused by a mixed infection of pus and gas organisms.

The tissues undergo disintegration unequally. The blood and softer tissues are first affected, and, if a microscopic examination is made, degenerated blood corpuscles are found in various stages of transformation into granular, pigmentary derivatives of hæmoglobin. Cell nuclei disappear, the protoplasm is turbid, disintegrating muscle fibres lose their striation, and the sarcolemma contains only fatty and granular matter. The connective-tissue fibres, owing to the swelling of the interfibrillary substance, break up into their primitive fibrillæ. Nerves, on account of their fibrous sheaths, resist longer than muscles, but the nerve fibres themselves very early undergo, in the myelin sheath, changes similar to those which characterize degeneration.

Among the chemical products of decomposition, are large quantities of fat, which arise even in tissues where there is no fat. Fatty acids, capric, caprylic, butyric, and valerianic, are formed, to which, and to ammonium sulphide and hydrogen sulphide, the foul odor is largely due.

Microscopic examination of the decomposed tissues might show crystals of tyrosin, leucin balls, characteristic needles of margarin and triple phosphates, and granular pigment.

Virchow has called attention to a rosy color caused by the action of nitric acid on a gangrenous part, and to this change he has given the name "erythroproteid reaction."

Dansauer concludes that the common colon bacillus is capable of producing gaseous gangrene even in the non-diabetic individual. It is not able to do this alone; its action, he says, is saprophytic and dependent on a primary local or general injury of the tissues from some nutritional disturbance either from trauma or from deranged metabolism.

Margarucci reports a case of gas infection. The culture showed pure Bacillus coli communis.

Rizzo reports a case of fatal gas gangrene of the neck and upper part of throat following extraction of a molar tooth. The colon bacillus was found in pure culture. This is said to be the third case on record in which the colon bacillus was found in pure culture in gas gangrene. Usually the bacillus is found with others. The condition of the tissues or the degree of virulence of the germs in a particular case may have a bearing on the result. When gas infections are due to the bacillus coli alone, they are always in the neighborhood of the digestive tract.

The Bacillus pseudœdematis maligni (Sanfelice) also appears capable of causing gas, but has been found in but a few cases. It resembles somewhat, in size and shape, the Bacillus coli communis.

It must be apparent, from what precedes, that a number of organisms, under certain conditions, are capable of producing gas in living tissues. These may

exist alone or with streptococci, staphylococci, bacillus coli, proteus, pyocyaneus, tetanus, or Sanfelice's bacillus.

The natural *habitats* of the various gas-forming bacilli are the intestinal canal and the soil. Walker found them in dust obtained by sweeping floors; and Harris, in an old cess-pool.

Albrecht has published a series of cases, some of which occurred after aseptic operations. In these cases it is probable that fresh wounds had become infected from atmospheric dust, as it was found on inquiry that repairers had been at work on the roof of the amphitheatre and that their hammering had given rise to a great deal of dust in the room. These cases also afforded an opportunity for studying gas-bacillus infections. They showed rather mild symptoms, essentially of intoxication, the patients feeling tired, appearing pale, and complaining of pain in the wounds. Some fever was also usually present. The bacilli were contained in a sero-hemorrhagic fluid, and, when this was evacuated, rapid healing followed.

The term gas phlegmon, according to some writers, is incorrect for a process produced by Fraenkel's bacillus; it is not a suppuration, but rather a form of necrosis. They prefer to call it gangrène foudroyante-Fraenkel, or necrosis emphysematosa-Fraenkel. It differs from gas phlegmon in respect to its clinical picture (necrosis, degeneration, extensive gas formation, no pus); the histologic picture is also different. Experimentally, the same clinico-pathologic picture can be induced. No other bacterium produces the same picture.

Kropac proposes to divide gas phlegmons and necroses thus:

1. Gangrène foudroyante-Fraenkel, due to a pure culture of the Fraenkel bacillus.

2. Emphysematous phlegmon, due to a mixed infection (bacillus coli, proteus, staphylococcus, and streptococcus); suppuration, followed by gas formation; probably gangrene later.

3. Malignant œdema: A process induced by a specific organism; œdema and hemorrhagic infiltration are paramount, gas formation a side issue and inconstant. It is pathogenic for rabbits; Fraenkel's bacillus is not.

Symptoms.—The part swells and becomes tense, dusky red, or of a purplish color; deep-seated, burning pain is felt. A dusky line soon gives way to a dark mottled appearance, vesications and bullæ form, the surface becomes soft and boggy; and emphysematous crackling in the deep layers of cellular tissue show gases of decomposition. Below the seat of gangrene, the limb has a cadaveric appearance. Above, œdema and discoloration rapidly extend, especially along planes of cellular tissue, reaching and perhaps invading the trunk in a few hours. While the process spreads up, the part first affected falls into a condition of a disorganized black and pultaceous mass. There is extreme constitutional depression. Death is almost certain to occur when or soon after the gangrene reaches the trunk, from gases in the circulation.

Parise observed several cases of sudden death in gangrene of the limbs, and in each instance believed that the fatal termination was brought about by the entrance of putrid gas into the veins and hence into the heart. Maisonneuve had previously (in 1853) published several cases of rapid gangrene, with the development of putrid gas in the veins of the affected member. But he believed that death was caused by blood-poisoning from this source. Parise, however, affirms that the putrid quality of the gas determines no septic action, but produces death in the same way that air accidentally entering the veins does. In the cases reported, the necropsies were made soon after death, and a very careful examination revealed the abundant presence of putrid gas in the right side of the heart and the principal venous trunks. Parise concluded, from the study of his cases, that surgeons should be on their guard against sudden death, particularly in those cases of gangrene which follow a violent traumatism.

Diagnosis.—The first symptom is œdema of the subcutaneous cellular tissue with crepitation on palpation. The disease spreads and may involve different parts (multiple gangrene).

Gas may appear as early as eight hours after the injury. In typical uncomplicated cases there is necrosis of the tissues and exudation of a variable amount of bloody serum. There is an absence of lymph formation and of the usual type of exudation.

Prognosis.—The disease frequently has a fatal ending, but cases do recover. The author's case (see Plate XII) is an example of the latter. The prognosis is more favorable than it was before the aseptic era.

Treatment.—This must be heroic: immediate free incisions, or amputation, high above the disease, according to the type of the case. In other situations, radical excision is indicated. Vigorous stimulation and supporting measures are imperative. If the disease is mild and not spreading, wait for the line of demarcation. Dress antiseptically; elevate the part, and if the circulation is poor, apply heat. If the disease spreads rapidly, promptly amputate high above the disease.

Fraenkel says that, in dogs, repeated intraperitoneal injections with cultures of the gas bacillus seem to produce some immunity to local subcutaneous injections, and the serum of dogs so treated appears to have some protective action in guinea-pigs. This, however, needs further confirmation.

The only hope, in gangrene of this type, is through surgical intervention. The germs are diffused by the lymphatics, and, finding a suitable soil, with moisture and warmth, grow more rapidly than they can be destroyed by phagocytes.

If the infection has not penetrated deeper than the subcutaneous cellular tissue, free incisions and disinfection of the affected area may bring about a cure. Such cases would occur after superficial wounds only. In more extensive injuries, such as compound fracture, lacerated and punctured wounds, etc., which

EXPLANATION OF PLATE XII.

The points in the picture which deserve special notice are the following: The gangrene involves the entire foot. Just below the external malleolus, and extending across the dorsum of the foot, there is a well-defined "line of separation," the extensor tendons being exposed at this point. There is an irregular area from which the skin has been lost by the exfoliation of a slough, the deeper parts retaining their vitality. The upper end of this area (in the centre of which a tendon is seen) and the raw surface above represent two of the original incisions into the emphysematous areas. Other incisions were made on the inner aspect of the leg. The history of the case may be briefly stated as follows:

E. B., aged 55 years, Italian, married, dyer, had good general health. During the three years prior to the attack of gangrene he was treated for chronic bronchitis. He was admitted to the hospital with excruciating pain in the left foot. The pulse was good, and the temperature 102° F. These rose during the evening to 120 and 103.6° F. respectively. On the following morning the left foot was cold and cyanosed. The urine was found to contain over five per cent of sugar. The toes soon became black, and the typical appearance of gangrene developed.

On the second day areas of crepitation (emphysematous gangrene) were noted extending up the leg. These were opened by free incisions. Amputation was not considered safe at this time on account of the profound toxæmia and shock present. The patient's general condition gradually improved, the glycosuria diminished considerably, and the gangrene became limited to the foot. Amputation through the knee-joint was performed on the twenty-fourth day, under scopolamine-morphine anæsthesia (neither ether nor chloroform was employed). The patient made a good recovery.

Dissection revealed the fact that the anterior tibial, posterior tibial, and peroneal arteries were extensively atheromatous from the knee to the foot. Near the latter point they were found to be almost occluded. (See Figs. 35 and 36 in the body of the article.)

This case supports the claim made by many writers that atheroma and arterial sclerosis are important factors in the etiology of diabetic gangrene.

PLATE XII.

GANGRENE OF THE FOOT—A. C. WOOD.

open the deep fascia, and are followed by gaseous gangrene, prompt amputation will be required in order to save the patient.

The method of operating in these cases differs somewhat from that employed in ordinary amputations.

Knott recommends the following technique in amputating for traumatic gangrene of the extremities: Being confronted with a case of traumatic gangrene, estimate as exactly as possible the line between the diseased and healthy soft parts, and, having first, under anæsthesia, made a most complete disinfection and cleansing of the skin, puncturing all bullæ and removing all discharges, envelop the gangrenous area in a sterile towel up to the line selected, and at this point make a circular amputation, cutting through soft tissues and bone at the same level. Ligate carefully all bleeding points, including none of the perivascular tissues in the grasp of either the forceps or the ligature. Leave the wound absolutely open, not introducing a single suture, and apply moist dressings of gauze saturated with salt solution, the dressings to be changed from two to four times in twenty-four hours, as circumstances demand. After from seven to ten days, if the wound is perfectly clean and the condition of the patient favorable, the classical circular amputation may be made by dissecting up the flap already outlined, and sawing the bone at the proper level.

If, for any reason, the circular method may seem undesirable, any other procedure may be substituted, but, in the class of cases under discussion, a typical circular amputation will be found entirely satisfactory.

The author carried out this plan once in the upper third of the thigh; once in the middle third of the forearm; and twice in the upper third of the leg; in all of them with good results.

VIII. HOSPITAL GANGRENE.

Sloughing Phagedœna; Pulpy Gangrene; Putrid Degeneration; Traumatic Typhus; Pourriture D'Hôpital; Nosocomial Gangrene.

Although hospital gangrene, as formerly met with, has disappeared since the general adoption of antiseptic methods in surgery, the subject is of sufficient historical interest to justify a brief notice.

The disease, which is encountered sporadically, was usually epidemic or endemic in hospitals, especially when large numbers of wounded were crowded together, as in military hospitals. The characteristics differed in different epidemics. Usually the local symptoms preceded the constitutional disturbances, and hence many writers regarded the disease as local. Other careful observers found that constitutional symptoms, fever, headache, furred tongue, etc., preceded the local symptoms by from one to three days.

Two kinds were described; they differed in degree only. For either to occur

a wound is necessary, although it may be trivial (the sting of an insect, prick of a pin, or scratch of a finger-nail).

The contagious character of this affection was well understood by Larrey, who wrote: "The inoculation or transposition of the putrefactive matter to other simple wounds, though their cicatrization shall have advanced already, produces the same kind of affection, and soon converts them into putrid ulcers, similar to the first. Instruments and dressing rags are very often excellent conductors. This inoculation I have seen performed, and have observed its progress up to the period of its termination. I believe, therefore, whatever may be the assertion of some authors to the contrary, that the contagious tendency of this disease, which differs essentially from gangrene, can be no longer doubtful." He also admitted other causes, however, especially mentioning a form due to a gastric nervous affection.

The disease is an infectious one, probably caused by an anaërobic bacillus; pure cultures that are beyond cavil have not yet been made, but the organism is constantly found in abundance in sections of the walls of the advancing ulcerations. It is a thin straight bacillus, 3 to 4 microns long, and 0.3 to 0.4 micron broad, usually single, though sometimes two are found joined end to end. It does not produce gas. It is colorable by Gram's method. Its infectiousness is not so great as to require strict isolation of the patients. These results have been confirmed by Brobec, who found the same microbes in a case of hospital gangrene. Streptococci are usually present. Koch produced in mice a disease resembling hospital gangrene in which streptococci were found.

According to Matzenauer hospital gangrene still occurs occasionally, though antisepsis has rendered its manifestions lighter. It is most often seen in the genital and anal regions. The ulcerations are peculiar in shape, form, and size, as well as in their rapid progression and the great destruction of tissue that they occasion. They have a dirty-gray, greenish or blackish covering, sometimes several centimetres thick; the odor is foul and penetrating; and marked fever accompanies the process. Matzenauer includes the ulcerations commonly called phagedenic and diphtheritic under this heading. Histologically, he found an inflammatory process marked by the very early occurrence of coagulation necrosis.

Symptoms.—Guthrie thus describes the worst form of the disease: A wound attacked with hospital gangrene "presents a horrible aspect after the first forty-eight hours. The whole surface has become of a dark red color, of a ragged appearance, with blood partly coagulated and apparently half putrid adhering at every point. The edges are everted, the cuticle separating from half to three-quarters inch around, with a concentric circle of inflammation extending an inch or two beyond it; the limb is usually swollen for some distance, of a shining white color, and not particularly sensible except in spots, the whole of it being perhaps œdematous or pasty. The pain is burning and unbearable in the part

itself, while the extension of the disease, generally in a circular direction, may be marked from hour to hour; so that in from twenty-four to forty-eight hours, nearly the whole of the calf of the leg or the muscles of the buttock or even the wall of the abdomen may disappear, leaving a deep, great hollow, or hiatus, of the most destructive character, exhaling a peculiar stench, which can never be mistaken, and spreading with a rapidity quite awful to contemplate. The great nerves and arteries appear to resist its influence longer than the muscular structures, but these at last yield; the largest nerves are destroyed and the arteries give way, the scene being frequently closed, after repeated hemorrhages, by one which proves the last solace of the unfortunate sufferer. The extension of the disease is, in the first instance, through the medium of the cellular structures of the body. The skin is undermined and falls in; or a painful red, and soon black, patch, or spot, is perceived at some distance from the original mischief, preparatory to the whole mass becoming one mass of putridity, while the sufferings of the patient are extreme." This virulent type is now very rare.

In the *milder form* the whole course of the affection is more chronic, causing less destruction of tissue, and accompanied with comparatively little constitutional disturbance. The general characters of the wound are the same, especially the circular shape and cup-like excavation or scooped-out appearance of the ulcer. There are less eversion and undermining of the skin, less œdema and pain, and the surface of the wound is covered with pulpy, ash-colored slough, instead of the putrid clots described by Guthrie.

The "American Text-Book of Surgery" describes three varieties: (*a*) Diphtheritic; (*b*) ulcerating; and (*c*) pulpy.

The diphtheritic form is characterized by coagulation necrosis in the granulations. The deeper parts are more affected than the superficial. The discharge is at first diminished and later watery; sloughs separate; the wound is crater-shaped and the edges eroded.

The ulcerating form is characterized by progressive enlargement of the wound, chiefly of the surface, which is covered by unhealthy grayish granulations. The edges break down, recede, and have a gnawed look, giving rise to the condition sometimes called phagedæna.

The pulpy form is more common in the epidemic variety. The granulations swell, become œdematous and necrotic. The surface of the wound soon swells enormously, there is a free fetid discharge. The wound margins are swollen, everted, and very sensitive. Great swelling and discoloration of surrounding parts occur, and profound constitutional depression follows. Secondary hemorrhages are common. The joints may be laid open and the deep structures exposed. If the disease is not arrested, the patient dies of sepsis and exhaustion.

The *constitutional symptoms* may at first present a somewhat sthenic type, but they change rapidly to those of a profoundly typhoid and adynamic condition, the patient presenting much the appearance of one with typhus.

The *mortality* has varied in different epidemics. In the Peninsular campaign it was from 20 to 40 per cent (Guthrie); the general average was 1 death in 3 cases attacked. In the Crimean war the uncomplicated cases gave a smaller mortality; in the Civil War the number of deaths was comparatively very small.

Causes of Death.—(1) Progressive exhaustion; (2) hemorrhage; (3) entrance of air into veins; (4) opening of large joints; (5) formation of bed-sores which subsequently became gangrenous; (6) diarrhœa; (7) subcutaneous disorganization of tissues around the original wound; (8) mortification of internal organs; (9) direct implication of vital parts; (10) pyæmia; (11) phlebitis; (12) profuse suppuration, necrosis, etc. (Jones).

Treatment.—When the disease appeared in a hospital ward, the patients affected were immediately removed, or, preferably, those still free were removed to fresh clean quarters. It was the custom, when possible, to empty the ward entirely, the patients being placed in tents when available, those infected being, of course, separated from those whose wounds were healthy.

Every known precaution was observed in the matter of ventilation and general hygiene, and especially in preventing the spread of the contagion by means of soiled dressings, instruments, etc.

Local treatment assumed a rôle of the highest importance. Various powerful remedies were employed: Oil of turpentine (Bartholow); powdered camphor (Netter and other French surgeons); removing the sloughs and thorough cauterization by nitric acid, bromine, or strong solution of potassium permanganate, ʒ i. to ℥ i. water (Jackson, Hinkle, Leavitt, and others).

Nitric acid was preferred by British surgeons (Jones and others); the hot iron by the French. Chloride of zinc was recommended by Herberg of Christiania; bromine by Drs. Goldsmith, Post, Moses, Thomson, Herr, and others. The latter was the most popular of all the caustics employed.

The wound being well cleansed, the bromine was applied undiluted or in solution with potassium bromide by brush or mop attached to a stick, or by means of a glass pipette or syringe. As the application was very painful, ether was given. Bromine has also been applied in the form of vapor, the wound being covered with dry lint, a cloth dipped in bromine applied and covered with oiled silk. Hypodermic injections of bromine have been made at the circumference of the sore. Bromine acts by producing an eschar, upon the separation of which the wound will usually be found healthy and disposed to heal.

Constitutional Treatment.—Tonics and stimulants were employed. In mild cases but little was needed; opium was the most useful single remedy; oil of turpentine, hydrochloric acid, quinine, iron, etc., were administered as indicated.

Amputation was sometimes needed for uncontrollable hemorrhage or on account of the extensive destruction of tissues.

IX. RAYNAUD'S DISEASE.

In 1862 Raynaud described a particular form of "symmetrical" disease of the peripheral portions of the body which has since borne his name. Three stages of the disease were mentioned: (1) Local syncope; (2) local asphyxia; and (3) gangrene.

The third or gangrenous stage only is of interest here. For a full discussion of the whole subject, the reader is referred to works on general medicine and diseases of the nervous system.

The disease is most frequently observed in the fingers and toes, but various other portions of the body have been affected in some cases, especially the tip of the nose, the cheeks, and the ears. Raynaud refers to cases in which the extremities were affected up to the wrists and ankles and even to the knees.

All cases do not manifest the three stages mentioned; in fact, there is a wide variation in the clinical histories as obtained from the reports of different observers. It is certain that cases depending upon a variety of pathological conditions have been reported as examples of Raynaud's disease; and yet it is impossible in the present state of our knowledge to classify them any better. The subject is being widely studied, however, and we may hope soon for a more accurate nomenclature in this class of diseases.

Strauss says, and with good reason, that Raynaud's designation "symmetrical" is incorrect, as it rarely partakes of this peculiarity, but is only bilateral.

The *pathogenesis* of the disease is by no means settled. Raynaud believed that the cases he described were due to a spastic contraction of the small blood-vessels, induced by abnormal vascular innervation—probably a central disturbance. He observed these spasms in the smaller vessels (retinal), and influenced them by spinal-cord experimentation. He met with amblyopia coexisting with local asphyxia. The former was noted every time asphyxia was, and was seen to be due to contraction of the arteria centralis retinæ. A great many writers accept Raynaud's view. Strauss thinks the condition is an angioneurosis rather than a trophoneurosis, and that it may develop independently or be secondary to some nervous affection.

Gandois divides the causes into: the predisposing, such as age, sex, heredity, various traumatisms, and neuropathic states or congenital anomalies of the circulatory apparatus; and the exciting, which embrace neuroses, lesions of the cerebro-spinal axis and of the peripheral nerves; and finally the infections or toxic diseases, syphilis, Bright's disease, scleroderma, exposure, etc.

The influence of functional changes in the nervous system (vaso-constriction; arterial spasm) plays a large part, and, if not of chief importance, as claimed by Baynaud, is at least a necessary part of the process. The organic changes in the nerve centres or peripheral nerves are of importance, but in themselves are

probably insufficient to give rise to the disease. The infections or intoxications constitute powerful agents in the production of Raynaud's gangrene; they act in association with the vascular spasm, of which they may be the cause in cases where no general neuropathic state exists.

Guillain and Thaon appear to be right in declaring that Raynaud's disease is not a pathological entity, but a syndrome created by very different causes. Local asphyxia of the extremities has been noted in the symptomatology of syringomyelia, lepra, scleroderma, Pott's disease, and certain forms of neuritis. It has been known to originate from such infectious diseases as typhoid fever, pneumonia, grippe, acute articular rheumatism, and malaria, from exogenous poisoning with lead, alcohol, and arsenic, and from endogenous intoxication in diabetes and uræmia. Tuberculosis is one of the infectious diseases which has rarely appeared in the pathogeny of this trouble.

Calonne, after reviewing the subject, concludes: (1) That Raynaud's disease often is accompanied by morbid manifestations which at first appear to be without any relation to it. (2) The most common of these associations are, in the order of their frequency, cutaneous manifestations, renal manifestations, and, finally, cardiac manifestations. The digestive apparatus is but rarely disturbed. (3) It seems best to consider these different manifestations as belonging to one morbid family; but in many cases their connections with one another are not clearly seen.

Weber holds the theory of spasm of the involuntary muscles of the skin, pressing the sweat through the pores and displacing the blood inward by compression. Weiss assumes a diseased state of venous tonus, producing a spasm of the veins and a diminution of their lumen. This theory explains the cases in which asphyxia is the first sign, no syncope preceding. Komfeld says it is a tabetic process; Hochenegg, hysteria or syringo-myelia; Pitres, Vaillard, and Mounstein, multiple neuritis; Calmann, spinal-cord tumor; acute infectious vascular disturbances, psychic diseases, are also mentioned. Oppenheim considers it an independent disease, as well as a symptom in other diseases; Auspitz classes it as a congestion dermatosis; Matanovitch assumes a combination of vasomotor and trophic disturbances.

Lannois and Porot report a case of gangrene of the extremities occurring in an old woman who was suffering from erythromelalgia and arteriosclerosis. Autopsy revealed degeneration of the left pyramidal tract of the spinal cord, with atrophy of the left half of the body. Schlesinger observed a case, associated with erythromelalgia, in which autopsy showed a sarcoma of the posterior spinal roots, compressing the spinal cord. The peripheral vessels were normal. The disease appears to affect all ages. Harold described a case that occurred in a boy, 4 years old: both the hands and feet were affected; the former got well, the latter dropped off spontaneously. The organs were all normal. There were no antecedent diseases.

Symptoms.—Raynaud's disease is usually preceded by a long history of paræsthesia and attacks in which the affected part becomes cold and either pale or cyanotic. Mental depression, sleeplessness, and disturbances of vision, audition, and taste are not uncommon.

The local symptoms are well known—syncope or asphyxia of the affected parts appearing in paroxysms; gangrene occurring as a late stage.

In some cases gangrene follows recurring cyanosis of the extremities; in others, the chief manifestation is syncope; the fingers are white, bloodless, and painful. The paroxysms increase in frequency and gradually become almost constant; the fingers appear shrunken; coldness and pain are prominent in both forms. Gangrene occurs suddenly in some cases.

Bullæ may form over an area which later becomes gangrenous. The process is usually limited. Sometimes there is gradual mummification, one or several fingers being involved. When the toes are affected, the plantar surface is more involved than the dorsal.

Diagnosis.—Symmetrical gangrene may simulate certain cases of senile gangrene.

	SENILE.	SYMMETRICAL.
1. Distribution .	One limb alone, or first one limb and then the other; usually the lower.	Corresponding parts usually.
2. Extent.......	Affecting whole part..............	Limited to skin and subcutaneous tissues.
3. Progress. . . .	Begins at one point; apt to be serpiginous.	Definite, several digits both sides; does not spread.
4. Arteries......	Atheroma........................	No change.
5. Age......·....	Old............................	Young, any age.

Embolic gangrene affects one member only, as a rule.

Treatment.—The treatment of the early stages of the disease will not be considered here. When the stage of gangrene has been reached, the dead parts should be removed, as in any other case of gangrene. Operation is not to be advised at once in all cases, however. In order to secure the best results, the local circulation must be increased in many cases and the general health improved.

According to Gandois, the indications are: (1) To treat the local condition; (2) to counteract the infection or intoxicating agents; (3) to treat the neuropathic state.

Heat, dry or moist, is the best local measure; galvanism is usually recommended.

Raynaud found, in cases of amblyopia and local asphyxia, that the application of the galvanic current along the spinal column from above downward cured both conditions.

Diehl reports three cases considerably improved by electricity. He used

faradic currents of feeble intensity, with frequent inversion of the current, last-
ing twenty minutes.

De Bovis treated a mild case of Raynaud's disease affecting the fingers of a
woman, 49 years of age, by stretching the median and ulnar nerves of each side;
gradual improvement followed; the trophic ulcers disappeared, as did also the
sweating. Sensation was not influenced. He reports a second, much graver
case: A weak and sickly-looking woman developed gangrene of the terminal
phalanges of all the fingers. After six weeks' preparatory treatment, stretching
of the median and ulnar nerves above the wrist, and the radial nerve above
the elbow, was performed; the latter was normal on both sides; the former
thickened and dark. In De Bovis' opinion this was an expression of peripheral
neuritis. The gangrenous parts were then removed. The marked paræsthesia
disappeared immediately after operation, and there was a marked improvement
in the local condition, but not a complete cure. Overstretching of the right
radial induced a paralysis, which disappeared after six weeks of treatment. Pal-
liative measures (warm baths, astringents, liniments, glycerin) are advised. Only
primary cases are said to be suitable for nerve-stretching. Cases secondary to
nephritis or infections are not benefited by this treatment.

X. GANGRENE DUE TO DRUGS.

Gangrene may be brought about by the influence of certain drugs taken
into the system either by being inhaled or swallowed, or by being applied locally.
The most classical example of this form is that due to ergot; and while in these
cases the ergot was taken as an impurity with the food, it should be considered
under the head of drugs.

Ergot.—Rye bread, containing ergot, *Claviceps purpurea*, eaten for some time,
causes tonic contraction of the peripheral arterioles, degeneration of the inner
coat, thrombosis and gangrene. The gangrene is of the dry type and is peri-
pheral, affecting the fingers or toes. Chronic cases recover, but acute cases die
in from one to two weeks. The condition resulting from the prolonged use
of excessive amounts of ergot is called ergotism. The disease was chiefly ob-
served in Europe.

Ergot taken internally for a long time is universally recognized as a cause of
gangrene, but cases of this type are rarely if ever met with at the present time
—a fact that may be explained by the statement that the use of grain con-
taining such quantities of ergot is no longer common. Therefore, the follow-
ing report, published in the English papers by a Dr. Wollaston, is of historical
interest. It is quoted by O'Halloran ("A Complete Treatise on Gangrene and
Sphacelus," 1765):

John Dowling, a poor laboring man, had a wife and six children; the eldest, a girl of 15 years, the youngest about four months. They were all, about the middle of January, 1762, seized with violent pains in one or both legs. In about five days the legs became blue and covered with black spots. The mortification became gradually formed, and nature began to separate the livid from the sound flesh. In April following their case stood thus:

Mary, the mother, aged 40, had lost the right foot at the ankle; the left foot was also separated, and the bones of the leg were almost dry with a little putrid flesh adhering in some places. The flesh is sound to about two inches below the knee; and the bones would have been there sawn off, but she would not consent to it.

Mary, aged 15, both legs off below the knee.

Elizabeth, aged 13, both legs off below the knee.

Sarah, aged 10, one foot off at the ankle; the other foot was affected, but not so highly, and is now again sound.

Robert, aged 8, both legs off below the knee.

Edward, aged 4, both feet off.

An infant, 4 months old, dead.

It is remarkable that during all the time of this misfortune the whole family are said to have appeared in other respects well; they ate heartily and slept well when the violence of the pain began to abate.

The mother is now emaciated and has very little use of her hands. The eldest girl has a superficial ulcer in one thigh, and also seems ill. The rest of the family are pretty well; the stumps of some of them are perfectly healed.

Mercury.—A child 12 years old, afflicted with syphilis, was given four injections of *calomel* in fifteen days, in the gluteal muscles. Complications followed rapidly. First came gingivitis with difficult mastication and speech. Soon the little patient could not open his mouth, and was a martyr to continual salivation and hemorrhages which followed the salivation. At the same time the teeth became exposed, and the gingivitis continued; a large number of teeth were shed. Besides, the necrosis brought on the destruction of a greater part of the lower jaw, the dead parts being cast off as sequestra from time to time. Then cicatricial adhesions followed, causing a complete closure of the mouth.

Fournier has well observed that no one can know to what danger a patient is liable when there is injected into his system a massive dose of mercury. Once the large dose has been injected, the possible accidents arising therefrom cannot be restrained or averted.

Stanley cites a case of necrosis caused by several grains of *calomel*, no dental caries being present.

Faitaut reports the following case: A woman of 25 years swallowed 40 to 50 grams of a 1 : 10 solution of *bichloride of mercury* (4 to 5 grams of sublimate). The usual symptoms and treatment followed. The stomatitis was very severe, with ecchymotic spots in several places in the mouth. There was tenderness on palpation over the stomach and sigmoid flexure.

Three days later, patches of sphacelation were noted between the labia

majora and minora on both sides, each patch being situated at the junction of the upper and middle thirds of the vertical axis of the vulva. There was some ulceration about the meatus urinarius. Two days later, several plaques of sphacelation appeared in the buccal cavity opposite the last upper molars on both sides and opposite the last lower molars on the left side; also a plaque of sphacelation appeared in the floor of the mouth on the right side. The vulvar lesions were arrested by an application of zinc chloride.

Collapse supervened and death occurred on the sixth day of the sickness.

Autopsy.—Of special note was a large eschar of blackish-green color, occupying the posterior wall of the stomach. It was 8 cm. in length and 3 cm. wide, and firm to the touch; the base was indurated and elastic.

Most interesting were the large and extensive eschars found throughout the entire large intestine; they were due to mortification of the intestinal wall, and were similar to that discovered in the stomach; they occupied the summit of the plications. (During the latter days the patient had passed at stool a flap of tissue of dysenteric character.)

A case of diffuse gangrene after intramuscular injection of *sozoiodol of mercury* is reported by Neumann and Bendig. A patient with the eruption of syphilis received two injections without any unfavorable results. The third injection of the mercury in the buttock was supposed to have injured a nerve on account of the severe pain; swelling occurred and the pain continued; the temperature was elevated; there was no fluctuation. Three incisions were made; there was no pus. Sloughing followed; the wound required three months for healing.

Orthoform.—Dubreuilh describes two groups of orthoform eruptions: (1) Erythematous eruptions with or without vesicles or pustules; (2) gangrene.

Asam has dealt especially with the gangrenous cases, nine of which are recorded, following the use of orthoform on wounds or varicose ulcers. He compared the appearance to lupus vulgaris treated by pyrogallic acid, a statement confirmed by Dubreuilh. The gangrenous lesions appear in the course of a few days, with great pain, which Wien says the drug will not allay.

The following examples are typical: A woman was ordered orthoform for violent pruritus ani. The itching was replaced by a burning pain, and ulceration followed, which had a gangrenous appearance. A second case presented gangrenous-looking ulcerations about the fingers of both hands following the use of the drug. Pressure caused no pain, but there was severe spontaneous pain.

Vincent reports the case of a primigravida, whose nipples on the fourth day were excoriated; they were dusted with orthoform and protected with shields. On the thirteenth day the whole of the front of the chest was covered with a dark red rash. By the nineteenth day the nipples were definitely gangrenous; the rash was much faded. The gangrene was attributed to the use of orthoform.

Sodium Salicylate.—Shepherd describes the case of a man of 32 years

who was suffering from traumatic synovitis of the left knee, which disappeared from there and the right knee then became affected. Twenty grams of sodium salicylate were given three times daily; after the patient had taken three doses, there appeared an urticarial eruption which later became petechial; some of the petechiae became gangrenous; the neck, shoulders, and upper arm were affected.

Phosphorus.—The occurrence of necrosis of the jaws in persons who work in phosphorus has been known for a long time. The frequency of the disease in phosphorus-workers is variously estimated from 1 in 20 to 1 in 50.

Several theories have been advanced to explain the manner in which the phosphorus affects the bone. The majority believe that the local action of the phosphorus fumes is responsible. Others think that the vapor enters the system through the lungs, inducing a disease of the osseous system in general, and that the necrosis of the jaw is precipitated by the addition of bacterial infection from the mouth. It is also claimed that the presence of various impurities, such as sulphur and arsenic, increases the deleterious effects of the phosphorus. Irrespective of the question which of these theories is correct, the presence of carious teeth, tartar, gingivitis, pyorrhœa, or an inflammatory condition of the mouth from any cause, certainly predisposes strongly to the bone affection.

The reader is referred to the article on "Diseases of the Jaws," in a later volume, for a full discussion of the subject.

Carbolic Acid.—In 1871 Tillaux reported 3 cases of gangrene due to the local application of carbolic acid, and Kellock recorded 2 cases in 1877. Since this time cases have been observed by a number of medical writers. In 1900 Harrington collected 114 cases from the literature, and to this number he added 18 observed in the course of five years at the Massachusetts General Hospital.

It has been given the name "carbolic gangrene" or "carbolic-acid gangrene." The great majority of the cases reported have involved the fingers and toes, although in a few instances other portions of the body have suffered. Curiously, it has been caused in most instances by the application of dilute solutions, although gangrene due to the action of the pure acid has also been recorded. The typical examples have followed the application of a moist dressing of dilute carbolic acid to a finger for a slight wound, as in the following:

A child was bitten on the finger by a dog. The wound was dressed at once with 1:100 carbolic-acid solution. The next day, gangrene appeared and the finger had to be disarticulated. (Peraire.)

A girl, 2 years old, had her finger jammed in a door. There was no visible wound, yet her mother dressed it with linen moist with the carbolic-acid solution and allowed the dressing to remain on the finger for twenty-four hours. On removal of the cloth the finger was found to be cold and livid. When seen eight days later the finger was gangrenous up to the mid-phalangeal joint. A line of demarcation existed and the finger was amputated. (Movestin.)

A man, aged 30 years, scraped the end of the middle finger on a nail. His physician ordered that a cloth should be moistened with a 2-per-cent carbolic-acid solution (to be further diluted with an equal quantity of water) and wrapped around the finger. The patient kept the bandage wet with the solution. When the dressings were removed at the end of twenty-two hours, the finger was found discolored and shrivelled as far as the bandage reached. The patient's urine was normal. (Herold.)

October 16, 1904, 12 noon: A light dressing of carbolic acid 1:50 was ordered for four hours, for the purpose of abating a felon, with instructions to remove the
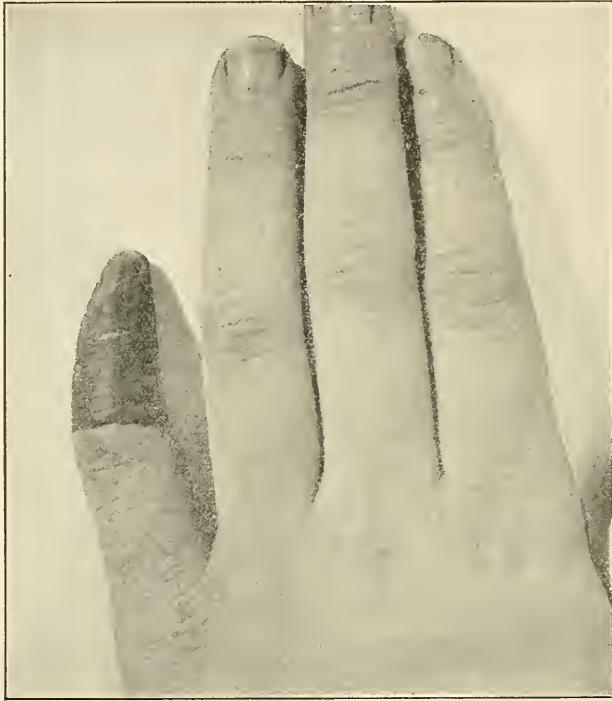
Fig. 39.—Carbolic-Acid Gangrene of Finger. (George Erety Shoemaker, in *American Medicine*, July 9th, 1904.) The patient, a child of seven, having met with a trifling injury of the finger, an officious servant thrust it into a bottle of carbolic acid of unknown strength (possibly undiluted) and then tied it up. The photograph shows the condition of the finger ten days after the application had been made. Spontaneous separation of the last phalanx occurred at the joint, and ultimately the patient was left with a somewhat tapering and quite useful stump.

dressing as soon as the skin was blanched. At 5 P.M., the finger was reported blanched, but pricking somewhat. The acid was ordered diluted to 1:100. About this time a friend offered some oiled silk to prevent wetting of the clothes. This was applied over night. Next day the finger was numb and blanched, but the same dressing was continued and covered with oil silk. At 6 P.M. the nail was black and the skin dusky where it had been covered with the oiled silk, but the proximal segment was less discolored than the others. The circulation was encouraged by warm poultices. The distal phalanx did not recover and became mummified. October 27, amputation at mid-phalangeal joint. (Kenerson.)

Lanngier reports a case in which gangrene was caused by the application of phenate of soda in 1-per-cent solution.

The following is an example of gangrene caused by the application of *pure* carbolic acid:

A young woman, 18 years of age, applied pure carbolic acid to a slight wound of the right middle finger. Four days later, the finger was black and a physician made the diagnosis of gangrene from carbolic acid. The finger was amputated thirteen days after the application. (Cote.)

Gangrene may be produced by a 1-per-cent solution of carbolic acid in twenty-four hours (Bruns and Peraire), in twelve hours by a 2-per-cent solution (Lévai), and in three or four hours if the solution is more concentrated (Kortum).

Various theories have been advanced to explain these cases. Kortum thought gangrene was caused by the action of carbolic acid upon the trophic and vascular nerves. Frankenburger showed by experiments on animals that dilute solutions of carbolic acid would produce complete destruction of parts to which they were applied. He thought the action was exerted directly upon the red and white corpuscles, producing stasis and thrombosis.

Lévai showed by experiments that the death of the part is due to a direct chemical action on all the tissues. He also claimed that other dilute chemicals might have the same effect. "Five-per-cent solutions of muriatic, nitric, sulphuric, and acetic acids and of caustic potash caused gangrene when applied by moist compresses for a period of from twenty to twenty-four hours. The histological examination showed that, in the beginning, each of the diluted chemicals, applied in a moist dressing, produces the same effect: the epithelial layer becomes œdematous and loosened." As soon as it has made its way to the deeper layers, each agent produces in a different way the same result—necrosis.

Acids and Alkalies.—Strong acids and alkalies destroy the tissues by their caustic effects. Acids cause immediate local death, by coagulation of the blood and tissues, and usually dry gangrene. Alkalies disorganize living cells by causing liquefaction, which results in a soft eschar, hence in moist gangrene.

XI. SECONDARY GANGRENE.

The presence of gangrene in one part of the body may be followed by secondary foci elsewhere. They generally appear in the lung, being due to emboli. The parts most exposed to microbic infection are most often the seat of gangrene —thus, the skin, alimentary tract, and respiratory tract furnish a large number of the cases of gangrene.

XII. SPONTANEOUS GANGRENE.

The term "spontaneous gangrene" is employed by some writers to describe those forms of gangrene for which no efficient cause can be found. It is, however, an undesirable term and its use should be restricted as much as possible. As will be observed by what follows, in all of the cases studied carefully the condition of the vessels afforded an ample explanation of the gangrene. These cases are therefore analogous to those which at the present time, for want of a better name, are called presenile.

The lower extremities are usually involved, but the arms may be affected.

Beketoff studied carefully 10 cases of so-called spontaneous gangrene, and found endarteritis obliterans constantly present.

Wulff has observed 5 cases of spontaneous gangrene in young men. Israel has also seen a number in the last few years. The patients were all Jews from Russian Poland, between 20 and 35 years of age and free from hereditary or syphilitic predisposition. All had smoked cigarettes to excess, thirty or more a day, for years. The gangrene first appeared in the toes, in all but one case, and was preceded by years of rheumatic pains in the legs, with chilliness, tingling, and sluggish circulation when the leg was dependent. Wulff is inclined to attribute the etiology to abnormal vasomotor constriction, inducing secondarily the endarteritis and thrombosis, which are the essential factors in senile gangrene.

Haga reports 10 cases, all in males from 27 to 47 years old; Watsuji 5 male cases and 1 female case, the ages varying from 31 to 48 years; and Tanaka 3 cases of gangrene of the foot, and 1 of the thumb. Kojima's personal experience embraced 2 cases in men, aged 44 and 48 years respectively. The microscopic findings were those of sclerotic thickening of the intima of the artery, and occasionally of the vein, with secondary thrombosis extending upward or downward from the area of thickening, and entailing the occlusion of the vessel. The arteriosclerosis does not differ materially from ordinary arteriosclerosis, except that the subjects are younger. The gangrene is probably induced, he thinks, by predisposition, by certain mechanical or chemical factors, and by others which produce sclerosis of the vessels. The left side is affected more frequently than the right, and males more than females. The process may run a chronic course, or it may develop suddenly.

Symptomatic Gangrene.—Dupuytren seems to have used this term in describing the preceding class of cases. The objection to the name is that it is too comprehensive. As gangrene depends upon some preceding abnormal condition, every case may be said to be symptomatic.

XIII. PUERPERAL GANGRENE.

Gangrene during or after the puerperium is occasionally met with. Wormser has collected 80 cases. In 7 there were signs of necrosis even during the pregnancy; and in 7, Raynaud's disease developed before or after childbirth. Infection during or soon after delivery seems to have been the cause of the gangrene in childbed. Whether it was due to thrombo-phlebitis, endarteritis, or embolism, there was always preceding puerperal infection. Raynaud's disease probably bears only a casual connection with the pregnancy, as does also the occurrence of gangrene in the course of gestation. The 58 cases in which gangrene of the legs was observed during childbed prove that this is not so rare as is generally supposed. Age seems to bear no particular relation to the frequency, as the patients were from 17 to 40 years old. In 17 instances, the patients were primiparæ, and more than 6 births had occurred in only 8. In 4 of the 42 cases in which these details were mentioned, there had been premature delivery or abortion. Wormser claims that the affection can always be traced to some obstruction of the arterial or venous system, or both.

In the 22 cases of puerperal gangrene which Mandi collected, the gangrene made its appearance during pregnancy in 4. Great compression of the pelvic veins during the course of the pregnancy was noticed in several others, especially his own personal case, and Wormser's. In both of the latter the physicians were sued for damages by the family, but the courts dismissed the suits. In Mandi's cases, only two were bilateral. Heart disease was present in two, and suspected in one. All recovered except two, one of whom succumbed to pneumonia after amputation. Physicians should be on the lookout during pregnancy for conditions suggesting possible future gangrene.

According to Etienne the pathogenesis is as follows:

(1) Concomitant infection of the veins and arteries occurs in the course of septicæmia; the process in the veins being an acute reaction, resembling that of phlegmasia alba dolens; the changes in the arteries are of a more chronic character, consisting in obliterating arteritis, which is the cause of the gangrene.

(2) An infection of the veins which is transmitted to the arteries by way of the lymphatic channels.

(3) An initial venous infection, total in its extent, involving even the finest venules and their ramifications. As in phlegmasia alba dolens, the process extends by way of the venæ vasorum to the arterial wall, which thus also becomes infected.

XIV. GANGRENE DUE TO HEAT AND TO COLD.

Heat causes gangrene by inducing coagulation of the albuminous elements of the tissues. Myosinogen and fibrinogen coagulate at 56° C. (132.8° F.). This temperature would solidify the tissues and hence would destroy them.

Cold, when it reaches a point below 16° C. (60° F.), is competent to destroy the protoplasm of the body. The effect of cold will be determined by the period of exposure and the resistance of the tissues. A limited exposure to intense cold, but more particularly a longer exposure to a more moderate degree of cold, may result simply in *chilblains* or *pernio*, an affection which usually involves the toes or feet, and which, as a rule, causes them to assume a dusky-red or even a purplish color, and perhaps to manifest some œdema. There is usually a good deal of itching and burning—symptoms which furnish the only indication for treatment. The affection is usually self-limited and tends to disappear as warm weather approaches. As the trouble is apparently due to some defect of circulation, either of vascular or of nervous origin, people subject to chilblains should be well protected when they are exposed to cold.

To relieve the intense burning or itching, cooling lotions such as lead water and alcohol, or dusting powders containing menthol, may be used. Every effort must be made to restore the capillary circulation of the part.

Gangrene due to prolonged exposure to cold, or to frost-bite, is common in cold climates. The peripheral portions of the body—fingers, nose, ears, feet, etc.—are most commonly affected. In the mildest grades of frost-bite, the affected part remains red after reaction, and is the seat of a burning or itching which is very troublesome. It recurs when the part is subjected to changes of temperature. In the more severe cases, the parts are devitalized by the long exposure to cold, or gangrene results from excessive reaction after the person has been brought into a warmer temperature.

Persons who are exhausted by illness, want of proper food or clothing, or who have used alcohol to excess are especially apt to be affected by exposure to cold. The two extremes of life are also susceptible. Gangrene is said to result also from long exposure to cold and damp, without actual freezing taking place.

Treatment.—It is important to remove the person from the low temperature as soon as possible. The effect of the cold is to cause contraction of the capillaries; and if this be continued for a sufficient time, the circulation cannot be re-established. The person must be placed first in a cool atmosphere in order to avoid a sudden reaction, and the affected parts should be subjected to frictions in order to restore the circulation. In the worst cases it is advised to make the friction with pieces of ice, or with snow, so as to avoid a sudden hyperæmia. The important point is to prevent over-reaction. Therefore, when the blood

is found to be returning, the parts should be elevated in order to prevent congestion. If gangrene actually occurs, it should be treated on general principles.

XV. PRIMARY CUTANEOUS GANGRENE, INCLUDING HYSTERICAL GANGRENE.

Gangrene affecting the skin only, or the skin and subcutaneous tissue, is called *cutaneous gangrene*. In some of the cases the lesions have followed some form of traumatism; in others, no cause could be assigned. In some of the latter cases the patients were hysterical subjects, and hence the employment of the term "hysterical gangrene."

Carle thinks that every case is preceded by an injury, such as a cut, burn, sting of an insect, etc. One form of this disease is called *erythema gangrænosum*, *gangrenous urticaria*, *gangrenous zona*, etc. These cases appear to depend on disturbances of innervation. They occur in people who appear to be well and who are free from any organic or constitutional disease, as far as can be discovered.

Some of the cases are undoubtedly due to infection. Auche, who has studied this phase of the subject, found in one case (1) a short bacillus without virulence, presenting the characteristics of the short bacillus of diphtheria; (2) a pyogenic streptococcus, very slightly virulent and endowed with special necrotic properties. In another case he found (1) Bacillus coli, slightly virulent; (2) Streptococcus pyogenes, but little if at all virulent; (3) Staphylococcus aureus, possessing the same necrotizing powers as the above streptococcus. Similar results are reported by Mensi, Babès, and others.

The subject of *hysterical gangrene* is far from being settled. Some writers believe that every case is the result of self-inflicted injuries made for the purpose of exciting sympathy or some other form of interest. Other writers believe the manifestations to be due purely to defective innervation. A number of very interesting illustrations are reported, but these cannot be referred to here on account of want of space.

Children are affected as well as adults, the affection appearing especially after acute exanthemata, particularly measles. It does not present any different problems from those observed in adults affected with the disease.

White Gangrene of the Skin.—There has been described by Quesnay, Brodie, and others, a form of dry gangrene in which successive patches in various parts of the body undergo mortification. These areas preserve for a time their white color, but subsequently become horny and straw-colored, the capillaries filled with coagulated blood showing in the form of red streaks.

Gangrene of the Eyelids.—A number of cases of gangrene of the eyelids have been reported. It is probably merely a variety of cutaneous gangrene.

Gangrene after Subcutaneous Infusion of Normal Salt Solution, Cocaine,

Adrenalin, etc.—Gangrene of the skin occurring after the subcutaneous injection of fluids of various kinds undoubtedly results from infection or interference with the blood supply, or both.

Treatment.—The treatment of cutaneous gangrene must be carried out on general principles. If possible, favor desiccation by dry antiseptic dressings. If suppuration occurs, an active antiseptic treatment should be adopted, in addition to measures which will insure complete drainage. Tonics may be given, if indicated.

XVI. TROPICAL PHAGEDENISM.

Le Dantec has contributed an article on this subject. Ulcers are very common in the tropics after slight wounds; those of a phagedenic type are covered by a pulpy, grayish exudate; they spread into healthy tissue very rapidly. The third stage resembles very closely hospital gangrene, both clinically and bacteriologically. Le Dantec found in phagedenic gangrene, in 1884, the same bacillus which Vincent isolated from hospital gangrene in 1896.

It is reported that tropical gangrene has become so prevalent in the island of Guam that it has been proposed to establish a hospital where these cases can be isolated.

Gangrene with Spontaneous Amputation.—The two cases reported by Thurston show to what an advanced stage natives of India allow disease to progress before applying for relief. The first case occurred in a man aged 50, and, so far as may be judged from the slow onset, the disease was probably due to thrombosis. The amputation, which occurred spontaneously about the middle of the forearm, was complete, and there remained a conical ulcerated stump. The second patient, aged 40, had gangrene of the right foot and leg. The leg began to slough, and, as the sloughs separated, the patient removed them, until finally only the bones remained, from the ankle to the level of the tubercle of the tibia. The gangrene in this case was probably dependent upon embolism, and this in turn resulted from a thrombosis which formed in consequence of a weak heart during an attack of fever.

XVII. GANGRENE DUE TO THE EFFECTS OF ELECTRICITY.

A powerful current of electricity will destroy living tissues. At the positive pole a dry, yellowish eschar is produced, similar to that resulting from contact with strong acids. At the negative pole a soft eschar results resembling that due to contact with strong alkalies.

A case has been reported in which gangrene, caused by an accidental electric shock, affected all the extremities. A man had received a severe electric shock and, although apparently dead, he was resuscitated. The arms and feet

were burned and were very painful; all four extremities were swollen and very œdematous, and no pulse could be felt at either wrist or ankle. Gangrene developed. The right arm was amputated at the shoulder joint for dry gangrene of the hand and three inches of the forearm, and moist gangrene above this point. There was thrombosis of the brachial at the point where the superior profunda is given off. The left leg was amputated at the middle, and the right at a point above the knee. Death followed.

XVIII. RARE FORMS OF GANGRENE.

Gangrene following Vaccination.—In isolated cases gangrene occurs at the point of vaccination. It is said to have been sometimes observed in syphilitic subjects (Balzer, Wheaton). Hutchinson does not accept this view, and mentions the fact that noma, etc., occur after specific fevers without any syphilitic taint being present.

Gangrenous Phlegmon following the Sting of a Spider.—According to a published report the bite of a spider was followed by a reticular lymphangitis, blister formation, and abrasion of the skin. The appearance presented was that of a small, red, fluctuating mass, in the centre of which an eschar appeared. The diagnosis was gangrenous phlegmon, probably venomous.

Gangrene following Surgical Operations.—Gangrene sometimes develops after operations. These cases may be due to embolism or to injury inflicted upon nerves.

Fat Necrosis.—Disseminated fat necrosis consists of small, white, opaque areas, from one to several millimetres in diameter; they have been observed in the omentum, the subperitoneal tissue, about the pancreas, and in fatty tissues elsewhere. These lesions have been found to consist of fat cells which have undergone necrosis. Fat necrosis is by most writers thought to be due to pancreatic disease, although instances have been reported in which no such association appeared to exist. Fat necrosis has been produced experimentally by different operations on the pancreas, most of which were combined with ligation of the pancreatic duct. Simmonds thinks that the pancreatic affection is often of traumatic origin. Hart ascribes the fat necrosis to the influence of the secretion of the injured pancreas.

Fraenkel does not believe that the fat necrosis is due to the extravasation of the pancreatic juice, inasmuch as in some of the cases no injury or disease of the pancreas is visible, and also because the necrosis may be situated at some distance, as in the right iliac fossa, about the ascending or descending colon, etc. Haffner reports a case in which the peritoneum, hepatic ligaments, epiploic appendages, mesentery, and properitoneal fat showed a marked degree of fat necrosis, and yet the pancreas was perfectly normal, both macroscopically and histologically. Similar cases are reported by Benda, Israel, and others.

XIX. GANGRENE OF THE SOLID VISCERA.

Gangrene of the Heart.—Gangrene of the heart is very rarely observed, and, as it is not susceptible to treatment, is chiefly of academic interest. The etiology of this condition is not fully established. By some writers it is thought to be due to infection which sets up inflammation. Whatever the primary cause, the gangrene must be preceded by conditions which bring about either arterial ischæmia or venous stasis, or both. Thrombosis and embolism must be considered as prominent factors.

Deidier reported two cases occurring in pestilential fevers. Corvisart saw a case, caused, he thought, by extreme debility, and Fischer observed an example which followed a blow on the chest. Godle described a case of multiple necrotic patches in a child, 6 years of age, who had a popliteal abscess following injury. The autopsy showed necrosis of the tibia, suppuration of the knee joint, and gangrenous spots on the posterior surface of the left ventricle ready to break down. These necrotic areas were supposed to be due to emboli.

This subject is probably related to acute and chronic myocarditis. The former is probably caused by infectious emboli. Referring to the latter, Huber describes a *molecular necrosis* of the heart muscle as preceding the stage of *fibrosis*.

Ziegler believes that the sclerotic patches of chronic myocarditis are practically cicatrices of old infarcts which have resulted in insular necrosis of the muscular elements. Yet he affirms that some patches are inflammatory in origin.

He describes a case in which examination revealed a rupture of the heart at the site of an infarct due to thrombosis of the coronary branch.

Brault and Réné Morie have concluded, in their recent review of the subject, that in infarct of the heart three types of cases may present themselves:

1. Death supervenes because of the extent of the necrotic area (very rare).

2. Rupture of the heart takes place at the focus of necrosis.

3. The patient survives while the infarct area undergoes a series of metamorphoses ending in complete resolution.

Gaulay enumerates the symptoms as follows:

1. Very great irregularity in the movement of the heart and in the pulsation of the arteries.

2. An acute fever is usually present (Morgagni).

3. Very severe pain is felt in the region of the heart (Bonnet).

4. Fainting attacks precede death, which occurs usually three or four days after the beginning of the inflammation of the viscus, according to the intensity of the process (Portal, Morgagni).

5. In his two patients the face presented a very striking appearance, of

some diagnostic value: the features were pinched; the eyes were sunken and expressive of the greatest suffering and depression; the patient could rest only on the right side. In Turner's case of necrosis of the mitral valve, the symptoms were those of general septicæmia.

Konshoff reports an instance in which the disease occurred in a professor of the University of Kieff. He had suffered for ten days with what was supposed to be simple grippe; then bloody expectoration occurred, the patient complaining of syncopal sensations; death followed. The autopsy, made fourteen hours after death, revealed a rupture of the anterior wall of the left ventricle. Konshoff concluded that this was a case of generalized arteriosclerosis; that clots had been formed, one of which, transported by the blood stream, lodged in the coronary artery, giving rise to necrosis of the walls of the ventricle. Under the influence of some excitement, and while the heart was contracting with unusual force (the patient was catheterized just before death), the necrotic area ruptured. There was general arteriosclerosis, while the lungs and intestines showed signs confirming the diagnosis of grippe. An embolus was found in the left coronary artery (descending branch). The border of the rupture in the heart was 6 to 7 mm. thick; the cardiac muscle at the site was pale yellowish, consisting of a soft tissue, evidently necrotic.

Gangrene of the Thyroid Gland.—Gascoyen and others have reported instances of gangrene of the thyroid gland. Such cases are so rare that they are surgical curiosities. They are mentioned as such and require no special consideration.

Gangrene of the Lung.—Gangrene of the lung is not a specific affection, but occurs as a result of certain diseases or of trauma, which diminish or arrest the blood supply to a definite area of the lung. It is always of the moist variety, and may be either circumscribed or diffuse. Fortunately, the former is the prevailing type. Seventy-three per cent occur in men, probably because of the greater exposure to the conditions that cause pulmonary gangrene. The lower lobes are more frequently affected than the upper. The gangrenous area may vary from the size of a pea to that of a whole lobe. If the focus is superficial the lung will be retracted. Diffuse gangrene may be secondary to a circumscribed process. Either variety may be followed by metastases.

Etiology.—The list of conditions which may give rise to pulmonary gangrene is a large one. These are: Lobar pneumonia, croupous pneumonia, pneumonia in diabetic subjects, fetid bronchitis, bronchiectasis, abscess of the lung, purulent interlobar pleurisy, embolism, hemorrhagic infarct, ulcerating cavities, suppurating bronchial glands, foreign bodies in the air passages drawn in by inhalation, stab wounds, gunshot wounds, compound fracture of the ribs, necrotic processes in the pharynx or larynx, retropharyngeal abscess, carcinoma of œsophagus, perforation of septic foci in other tissues (suppurating hydatid cysts, etc.) through the pleura or diaphragm, general septic states, especially

the puerperal variety, trauma of various kinds (such as severe concussion), tuberculosis (rarely), carious vertebræ, etc. Insane patients, and those suffering from marasmus, cough, bulbar paralysis, and similar conditions interfering with deglutition, are particularly apt to have particles of food lodge in the air passages and thus give rise to gangrene.

Leyden has traced cases to caries of the middle ear from thrombosis of the veins in the petrous bone. Volkmann thinks that, in these cases, the infection passes through the Eustachian tube into the pharynx and trachea.

An important predisposing factor is the anatomical fact that there is no anastomosis between the branches of the pulmonary artery; hence arrest of the current in any one of the branches is apt to result in the death of the area of distribution of that vessel.

The arrest of the blood supply to a part of the lung, without the influence of any other factors, would result in aseptic necrosis or interstitial absorption. Owing to the free access, however, which the air has to these organs, the lungs are constantly exposed to the various forms of micro-organisms inhaled with dust, and it is the presence of the saprophytic forms, especially, that gives to pulmonary gangrene its characteristic features.

Babès summarizes the pathogenesis of pulmonary gangrene as follows: Primary pulmonary gangrene does not exist. When it appears to exist in epidemic form, tonsillar changes or retropharyngeal abscess are frequently responsible. Infection occurs by way of the lymph nodes, which are found in a state of advanced gaseous gangrene; thence it spreads to the parenchyma of the lung.

Pneumonia is not a necessary precursor. The pneumonias which Babès saw end in gangrene were not frank examples, but cases having a peculiar character which developed into gangrene, characterized by the presence of a streptococcus or a staphylococcus of extraordinary virulence, each capable of provoking necrosis of tissue, and associated afterward with a saprophytic organism sometimes analogous to the colon bacillus, sometimes appearing as a separate species.

Two organisms capable of producing gangrene of the lung without previous preparation of the territory are: A form of bacillus of malignant œdema, and a saprogenic microbe resembling the colon bacillus, but which liquefies gelatin and produces, experimentally, progressive gangrene.

As for the diphtheroid bacilli often found in gangrenous processes, Babès is not prepared to assign them a place among the causative agents, yet they should be mentioned in the pathology.

The following are Ophüls' conclusions: "1. Pulmonary gangrene is very probably always due to mixed infection with pyogenic cocci and other bacteria of a more saprophytic nature. 2. Quite frequently the latter belong to the class of actinomyces (in which class all branching bacteria like tubercle bacilli,

diphtheria bacilli, etc., are included), and they may be more or less acid-proof.
3. The gangrenous process is always accompanied by pneumonic processes which in the more chronic cases usually appear in the form of a chronic catarrhal pneumonia with carnification."

In the majority of cases the Staphylococcus pyogenes, albus, and aureus have been found. Several varieties of fungi were found by Leyden and Jaffe. These were supposed to be derived from Leptothrix buccalis.

Ophüls, in 5 cases of pulmonary gangrene, found long slender bacilli with irregularly staining protoplasm, often in clusters, and in every case some forms showing true branching. Stained with carbol-fuchsin, the bacilli were decolorized in acid alcohol, but not in aqueous solutions of sulphuric acid (12.5 per cent). Successful cultures were not secured.

Folli, in 6 cases of gangrene, found acid-proof tuberculoid bacilli that were decolorized by tartaric acid.

Streng found infusoria in the plugs contained in the sputum collected from three cases of pulmonary gangrene. The infusoria were oval, apparently structureless cells, the size of leucocytes. They had at one pole cilia, which were of the same length as the bodies of the cells. The cells possessed pseudopods. They died after the sputum had stood for some hours. They were found in the plugs only. Streng cultivated the organisms artificially; the bouillon became turbid and offensive. By the fourth or fifth day the greatest number had formed; by the eleventh to twelfth day they had largely disappeared. Kamenberg has observed the same organisms.

An example due to embolism is reported by Silcock. The autopsy showed a cavity in the middle lobe of the right lung containing gangrenous fluid. Its pulmonary artery was closed off by a solid thrombosis. Circumscribed gangrene due to this condition is very rare. A case is reported where a patient with phlegmasia alba dolens had an embolic infarct and gangrene of right lung develop. Apoplexy of the lung may cause gangrene by the pressure of effusion, etc.

A case following septic abortion is mentioned by Meyer. A woman aborted and became septic; the temperature remained high after curettage and uterine douches; gradual local improvement followed. On the eighth day embolic pneumonia developed; after a short time one of the pneumonic areas became gangrenous.

Another illustration of embolic pulmonary gangrene is reported after gastroenterostomy, performed in a case of cancer of the stomach. Death followed two weeks after, from a septic embolus (derived from a pyloric ulcer) lodging in the lung, and causing infarction. One of these infarcts ruptured into the pleural sac and caused hydro-pneumothorax.

Cases Due to Foreign Bodies.—At autopsy, there has been found, in both lower lobes, a gangrenous condition which was due to the presence of foreign bodies in the bronchi.

Büdinger reports a case in which gangrene was caused by a "wheat shaft," and Warrack one due to a tooth that had lodged in the bronchus.

Bergé reports the case of an insane woman who threw herself into the River Seine. She was rescued and placed in a hospital. At first there was at the base of the right lung an area of broncho-pneumonia, and then at the base of the left lung there was an area of pulmonary gangrene with fœtor of the breath and of the expectoration. These two conditions, both of which terminated in recovery, were evidently caused by the bacteria of sepsis and of putrefaction contained in the Seine water which had made its way into the air passages. The coldness of the water and the mental depression which instigated the suicidal attempt would probably assist in the development of the pathological processes.

Cases Due to Traumatism.—The following are examples of gangrene due to traumatism:

Kulenkampf reports the case of a coachman who fell from the seat of his coach during an attack of vertigo. Prior to the accident he was perfectly well, but, from this day on, he constantly complained of pain in the chest and cough. He worked for several weeks after the accident, but finally had to go to bed because of weakness, emaciation, fever, etc.; the sputum had a gangrenous odor, but no localizing symptoms could be discovered until about ten weeks later, when the left lower lobe was found to be inflamed. The autopsy revealed a large gangrenous cavity in the left upper and a recent pneumonia in the left lower lobe. The gangrene evidently was in etiologic relation with the accident.

Cases Associated with Phthisis.—Localized gangrene occasionally takes place in connection with a rapidly spreading excavation in the lungs. It is, however, a remarkable fact that, in spite of the existence of numerous profusely secreting cavities, putrid changes are very rarely met with as a result of tuberculous disease.

Scurvy and Pulmonary Gangrene.—Pneumonia and gangrene of the lung are observed as complications of scurvy. These were very prevalent among the scorbutic patients in the Crimean War.

Rupture of an Ulcer of the Stomach into the Lung.—Bramwell records two cases: (1) An ulcer of the upper wall of the stomach ruptured into the thorax; a cavity was formed which penetrated into the lung tissue. (2) After some gastric symptoms, hepatic pain appeared, followed by expectoration of foul-smelling material and dulness over the right lower chest. A pulmonary cavity was opened and drained.

Gangrene of the Lung and Bronchiectasis.—Dilatation and sacculation of the bronchial tubes, followed by ulceration, are apt to set up pulmonary gangrene. It was observed in 12 of 24 cases (Rapp), in 3 of 40 (Barth), and 5 of 54 (Biermer). The gangrene may erode a branch of the pulmonary artery, as recorded by Lebert.

Perforation of the pleura is less rare than it would be but for the adhesions, which prevent pneumothorax and emphysema. These have, however, both been observed.

Pleuro-pulmonary Gangrene following Measles.—This is a rare complication of measles. Of 12 cases of gangrene in measles, in the experience of Rilliet and Barthez, 4 were of the lung. Mary and Lorrain report the case of a boy 3 years old who was taken sick with measles, followed by broncho-pneumonia; then, before death occurred, symptoms of general infection, with fetid breath, made their appearance. The autopsy revealed a left pleural effusion, a displaced heart, and a focus of gangrene, the size of a large nut, in the left lung. The surrounding lung tissue was congested. The upper lobe was the seat of broncho-pneumonia; the right lung was emphysematous. The microscopic examination revealed the presence of three varieties of bacteria:

1. Streptococci. 2. Diphtheroid bacilli resembling the short and medium-sized diphtheria bacillus (found also in 10 out of 12 cases of broncho-pneumonia following measles). 3. A long bacillus resembling streptothrix.

Cultures also revealed a large rod-like organism, putrefactive, probably the proteus; also some others.

Latent Pulmonary Gangrene.—Rendu cites the case of an old man of 73 who suffered from inanition. At no time did the patient show symptoms which suggested pulmonary gangrene. Thus, for fifteen days after admission for inanition, he improved somewhat; then a mild fever developed, with purpuric spots on the trunk and arms. Right-sided pleurisy occurred, followed by effusion. He was tapped; the fluid was lemon-yellow and odorless. He died several days later.

The autopsy revealed gangrene of the lung. He had presented no symptoms of the septic broncho-pneumonia which existed and which was sufficiently virulent to cause gangrene of part of the lung. Although the process was of marked severity it gave rise to no functional trouble.

Pulsating Gangrene of the Lung.—The post-mortem examination made in the case recorded by Steven showed that the pulsation was caused by the intimate relationship of the gangrenous lower lobe of the left lung to the left surface of the pericardial sac. There was a distinct tumor-like projection inward of the pericardial wall which received the systolic shock of the heart, and this in turn was transmitted to the chest wall through the semifluid contents of the gangrenous cavity. There was no localized bulging of the chest wall, as in most of the cases of pulsating empyema; the bulging in this case being internal into the pericardium. The pulsation was distinctly felt in the intercostal spaces of the left axilla, and at the base behind, and was of the same character as that felt over the apex beat of the heart. It was a distinct systolic pulse. The heart was neither hypertrophied nor fixed. The anatomic findings seemed to indicate that, in order for an empyema to pulsate, the pus-filled cavity must

directly abut on the pericardium, and the adjoining lung must be firmly bound to the chest wall by adhesions.

Gangrene of the Lung in Children.—Gangrene of the lung is infrequent in children. No absolute symptom or set of symptoms invariably separates its features from many that are common to septic pneumonia, empyema, and bronchiectasis. When the disease is observed in the course of such an affection as measles, the symptoms are pronounced. The physical signs are not always conclusive. Pneumonia and gangrene are usually associated. The sputa are blood-streaked, rusty, greenish, and frothy. Expectoration and odor may be absent. Constitutional symptoms are marked.

Seitz states that any one of the pyogenic bacteria may be present. Surgical interference is to be advised. Over sixty per cent of a series reported by Herczel were saved by operation. Carr reports a case of gangrene of the lung in a child one year old, and three cases are reported by Huber. All died.

Symptoms of Gangrene of the Lung.—The most prominent symptom, as a rule, is the odor. This is extremely foul and penetrating and usually permeates the whole room. Expectoration is, as a rule, very free, and is also offensive. The sputum is of a dirty green or brownish color, which on standing separates into three layers: The superficial is frothy and yellowish or greenish and mucopurulent; the middle layer is watery, lighter in color, cloudy, and contains shreds of mucus; the lower layer is a dirty green sediment containing pus and detritus in which Dittrich plugs are found. There may also be blood-clots. The question always arises whether the pathologic process is in a dilated bronchus or in the lung.

The following three signs point to lung implication: 1. When the physical signs of a cavity develop rapidly. This must be distinguished from cases in which a cavity was present when the case was first observed,—a cavity due to a longstanding pneumonia which was followed by abscess or induration, but without gangrene. 2. When the sputum contains bundles of elastic fibres resembling the arrangement of the fibres in the lung. These fibres are not very frequently present in the expectoration, being destroyed largely by the process of fermentation. 3. When the expectoration contains elongated grayish tabs with fine black lines or dots resembling tinder, and the microscope shows an abundance of black pigment particles. Dittrich's plugs contain fatty crystals, scattered promiscuously or arranged in bundles, drops of detritus, and bacteria.

Large foci may be recognized by the coarse bubbling râles and amphoric breathing. Fever, remittent or hectic, is always present. Chills are common; cough is a prominent symptom.

Bazy calls attention to the importance of two signs very valuable in localizing pulmonary gangrene:

(1) A breath sound that is fugacious in character, now inspiratory, now expiratory; and, associated with it, (2) *sharp* pain on pressure. Distinct

lulls in the symptoms occur, but relapses follow, hence one should not be misled.

The *diagnosis* of the existence of pulmonary gangrene is not generally difficult, but the exact localization of the morbid focus or the decision as to the number of foci is often impossible. The diagnosis is made by auscultation, percussion, exploratory puncture, skiagraphy, and palpation of the lungs. The diagnosis may often be made by percussion and auscultation alone, even if the focus is deep-seated. Tuffier states that if one relies on the information obtained by auscultation, one is apt to operate too low in attempting to expose the focus. Delbet modifies this, claiming that it is true only for parts of the lung below the hilum; while in cases where the lesion is situated above the hilum, there is a tendency to cut too high. This misleading condition is due to the fact that the sounds heard on auscultation are transmitted along the bronchial tree, and consequently such sounds attain their maximum intensity at a point beyond the actual lesion. In the upper part of the lung the bronchi *ascend*, in the lower they *descend*. These facts afford an explanation of the misleading character of the evidence furnished by auscultation.

Superficial cavities are usually easily recognized, but not so the deep ones. In the case of these latter the sounds are transmitted to points on the periphery not coinciding with the level of the lesion. Tuffier says that it is the direction of the dense tissues (about a cavity) which the sounds follow, and hence the lesion, although located at some depth, often appears to be near the surface. These are some of the causes of error, especially where the base of the lung is affected, for in the apex there is less room for error.

Palpation of the thorax gives equally important signs, in certain cases. Sharp pain elicited on pressure over the seat of the lesion is one sign. Exploratory puncture, when it furnishes a positive result, is valuable, but often it gives a negative result. The obtaining of a positive result does not throw any light upon the question whether more than one cavity exists. Then, again, the main cavity may be overlooked; or infection of the pleura may follow in case the lung is not adherent to the chest wall; or the track of the needle may be infected.

For direct palpation of the lung Tuffier advises that the pleura of the chest wall be stripped off for some distance, and the lung palpated through the pleura. Bazy advises pleurotomy and palpation of the lung. The former method is better accomplished by resecting 1 cm. of a rib, and stripping away a large area of pleura.

To prevent pneumothorax, Bazy, in his pleurotomy, at once stuffs the hole in the pleura with a finger wrapped in aseptic gauze. He then explores the lung and notes any induration or adhesions. Then he closes the wound, and does a thoracotomy at the level where he found the induration or adhesions.

Delgenière advises exploratory pleurotomy. He makes an oblique incision large enough to admit a hand.

The lesions found may be of three varieties:

1. Where the pleural cavity is the seat of an effusion, and there exists a communication between the pulmonary cavity and the pleural cavity.

2. No effusion, pleura adherent to the lung in one spot; here one should suspect a cortical lesion in the lung at the site of the adhesion.

3. Where the lesion in the lung is deep-seated, or not inflammatory in nature —*e.g.*, a hydatid cyst, where no adhesions exist at all.

Skiagraphy gives valuable information as to localization of lesions in cases where the stethoscope fails. By the aid of the *x*-rays we can localize multiple lesions. It is not infallible, however, and sometimes is negative when auscultation clearly shows a cavity. This can occur when the lesion is near the base of the lung, where the heart and abdominal viscera will throw shadows or where the *x*-rays fail to penetrate.

Complications.—Pyæmia, abscess of the lung, pleurisy with or without effusion, pyo-pneumothorax, etc.

Diagnosis.—Pulmonary gangrene must be distinguished chiefly from putrid bronchitis.

Prognosis.—The mortality without operation is stated to be from 75 to 90 per cent; according to the experience of the writer, it may be even greater. But little may be expected of medical treatment; however, in very rare instances, the disease tends toward spontaneous cure. Operation may be refused in some cases or it may be thought advisable to defer operative measures for a time. In such instances it is proper to control the symptoms as far as possible with appropriate drugs.

Treatment.—*Inhalation of Carbolic Acid.*—Paul used this method in 7 cases of pulmonary gangrene. In none did symptoms of intoxication result; and in all, perfect and quite rapid cure followed. He employed a solution containing 100 grammes of carbolic acid to 700 grammes of water, enclosed in a flask, whence the patient inhales the vapors. He combined with this the internal use of spirits of eucalyptus—dose, 2 grammes per diem. Unfortunately, few physicians have had such a satisfactory experience. Devereaux treated a case of gangrene of the lung with daily inhalations of the vapor of creosote. He claims that improvement followed, as shown by the weight, which increased 21 pounds (68 to 89). The physical signs also gave evidence of improvement.

Medicated injections were used by W. Koch and by Fraenkel, who employed iodine and carbolic-acid solutions; Hewelke used solution of thymol in alcohol, and Chaufford resorted to naphthol in solution.

From the standpoint of treatment, Tuffier describes the following distinct types of gangrene:

1. Acute pulmonary gangrene, metapneumonic, with pleurisy in the vicinity, which may or may not be interlobar.

2. Pulmonary gangrene following bronchial dilatations, multiple and chronic in character. Perhaps one might also distinguish gangrene due to foreign bodies, either inorganic or organic, and gangrene due to the inhalation of fluids.

Type 1 is usually superficial, and often communicates with pleural interlobal foci. These are readily reached by operation, which is usually followed by full recovery.

In type 2 operation produces an amelioration but never a complete cure. Since 1898 Tuffier has operated on 11 more cases of pulmonary gangrene. Of these 4 died and 7 were cured. (Of those cured only 2 were absolutely cured.)

Only the circumscribed form is amenable to surgical treatment. It is usually in the base of the lung, but may be anywhere, even in the apex. Pleural adhesions may arise, and usually do (they were present in 68 of 74 cases); the adhesions are usually very close and firm, a fact which is of interest to surgeons. Communication with the pleura, if present, is usually by a small orifice, and may give rise to purulent pleurisy, a troublesome condition to the surgeon.

Monod insists upon operating in *all* cases of localized gangrene of the lung if the focus is accessible to surgical treatment. He never considers spontaneous drainage through the bronchi efficient. His rule is to make an exploratory puncture as the first step of the operation, the trocar being used as a guide. If the puncture gives negative results, he abstains from operating.

Tuffier emphasizes the importance of careful diagnosis in pulmonary gangrene. The primordial indication for operation is imperfect drainage of the cavity. But in diffuse bronchopneumonic gangrene operation is useless, and most dangerous. The indications and prognosis of operation vary with the cause and form of the gangrene.

Indications for Surgical Intervention.—Surgical treatment is to be advised if a positive diagnosis can be made and if no contraindications exist. It is especially indicated because this process is a rapid and usually fatal one. Very rarely does spontaneous evacuation into a bronchus occur, and even when such an occurrence takes place we do not know whether it affords drainage sufficiently perfect to bring about a cure.

Operation is especially indicated where a single focus, definitely circumscribed, exists in an accessible region, and success is to be expected, even if the lesion be extensive. The gravity of the general condition of the patient is not a contraindication unless the patient is actually moribund. Operation offers the only chance of life in all other cases.

Contraindications.—Operation is not to be attempted in the early, uncertain period when it is impossible to localize the focus. Again, before operating, one should examine the opposite lung to see if it is diseased also.

Do not operate when there is diffuse gangrene with multiple, small foci in one or both lungs; such cases are incurable.

As the subject of surgery of the lungs is to be treated in a separate article in one of the later volumes, we shall refer the reader to it for further information in regard to the operative treatment of gangrene of the lungs.

Gangrene of the Kidneys.—*Necrosis of Renal Papillæ in Hydronephrosis.*—Friedreich ascribed this condition to mechanical pressure; he believed it was fairly common, but, as the papillæ are easily cast off, was not often noticed. Chiari agreed with this opinion. He reports several such cases, and describes a series of animal experiments. The ureter was ligated, and the animals were killed from one month to a month and a half afterward. Necrosis and sequestration of the papillæ were observed. The correctness of the mechanical theory is proven, as the urine, bacteriologically, was negative. In the cases of hydronephrosis studied clinically, the papillæ were found in the urine, and necrosis was noted during operation. This gives a new significance to the subject of hydronephrosis. Turner describes a case in which circumscribed areas of necrosis, with softening and partial disintegration and separation of portions of the pyramids, were observed. These lesions, he believes, were due to arterial thrombosis secondary to an arteritis associated with a recent endo-pericarditis. He reports another case in which there were circumscribed necrosis and separation of the apices of the pyramids—changes which resulted in blackish-brown, shrivelled sequestra. All the pyramids of both kidneys were affected. This patient was the subject of general tuberculosis. Loewenhardt records the case of an individual who expelled through the urethra a renal sequestrum; the patient had suffered from influenza prior to this occurrence, and the urine contained pneumococci. Attention was directed to the possible causal relation between them.

Gangrene of the Liver and Spleen.—Gangrene of both of these organs has been observed at autopsy after death from different forms of acute illness. In most instances they have been found greatly enlarged, with a few or many foci of suppuration or necrosis, the latter sometimes being associated with a distinctly gangrenous odor. In the case of the liver, the abscesses have been found to be in the portal spaces. The pus has contained numerous bacteria. A case in which both liver and spleen were affected was reported by Barker. A man, 22 years old, suffering from malaria, died after an accident that was associated with profuse hemorrhage. The spleen was found to contain many æstivo-autumnal parasites; there was focal necrosis of the pulp, very much like that seen in typhoid fever, and similar areas were found in the liver. The affected areas appeared to be the result of venous thrombosis.

Gangrene of the Gall Bladder.—Gangrene of the gall bladder is not very common, although acute phlegmonous inflammation, of which the former is the sequel, is not rare. Three causal factors are to be considered: (*a*) thrombosis of the nutrient artery; (*b*) infection; (*c*) tension from imperfect drainage. The

two latter factors exist in both gall-bladder and appendix inflammations, but the first factor is more common in inflammation of the latter structure.

Gangrene of the gall bladder is usually observed in patients with gall stones, but may exist without them; in this way, as in the case of the appendix, there may be gangrene without any concretion. It sometimes follows typhoid fever.

The *symptoms* are those of acute peritonitis, and usually come on suddenly with pain in the right hypochondriac region, rapidly becoming general. Rapid, feeble pulse; quick, thoracic breathing; high fever; intense general depression; marked tenderness, especially over the right side; rapidly increasing tympanites, persistent vomiting, and anxious expression are the symptoms observed.

The acute peritonitis, significant of the disease, may be local at first, but rapidly becomes general. Jaundice may be present or absent. Temperature is an inconstant and unreliable sign.

In the gangrenous form death occurs early unless relieved by operation. The indication is to remove the gall bladder if practicable; if not, to provide free drainage.

Gangrene of the Pancreas.—A number of cases of gangrene of the pancreas have been observed. Fitz believes that it usually follows hemorrhagic pancreatitis. The process may be of limited extent, or it may involve the whole organ, which may be almost completely separated from the surrounding tissue as a slough. Peritonitis develops, as a rule, and obscures the clinical picture.

Symptoms.—These appear suddenly, and usually while the patient supposes that he is in good health; they are violent epigastric pain, vomiting, and symptoms of shock. There is acute tenderness in the epigastrium, the area of which increases as the gangrenous process spreads to the peritoneum. There may be fulness and increased resistance in the epigastrium. Death may occur within two days, or the patient may survive for some weeks. Hemorrhagic and gangrenous pancreatitis are supposed to be due to impaction of a gall stone in the diverticulum of Vater.

Treatment.—During the earliest stages it will be necessary to control pain and to employ internal and external stimulation to overcome the collapse. As soon as the diagnosis is established, and the patient's condition warrants, an exploratory operation, which should also serve the purpose of drainage, should be done. If disseminated fat necrosis is observed during the operation, the diagnosis will be confirmed. The bile passages should be examined, and cleared of stones if any be present.

Some of these cases have recovered after drainage.

Gangrene of the Uterus.—Gangrene of the uterus during the puerperal period (metritis dissecans) is caused by the presence of germs in a uterus the tissues of which have not sufficient vitality to resist the infection.

According to Beckmann's observation, gangrene of the puerperal uterus is not an unusual disease. He has found it more often in private practice than

in maternity hospitals, because in the former puerperal septic infection is more apt to occur.

Young women are most subject to this complication, especially when they are subject to general disorders, or when labor is tedious and obstetrical interference is required.

Streptococcus infection is the sort usually present in these cases. This spreads through the deeper blood-vessels of the uterus and also through the lymph vessels, with the formation of thrombi. In a few cases saprophytes were found. Necrosis of the connective tissue results, and in severe cases the patient dies before the necrotic tissue can separate. Usually, however, dead tissue comes away with the free formation of pus.

The *symptoms* are fever, fetid and purulent lochia, and an ultimate discharge of the necrosed portion of the uterine wall. This pathognomonic symptom has been observed usually from the fifth to the seventh day; in rare cases, even later.

The *diagnosis* of this condition is not readily made. There are no definite symptoms by which it may be recognized. When, however, cases of septic infection are differentiated, the diagnosis is not so difficult. The enlargement of the uterus during the first few days of the disease, delayed involution, swelling of the inner surface of the uterine wall, and the expulsion of this tissue are the characteristic phenomena. The temperature curve is that commonly seen in pyæmia.

The *prognosis* depends upon the severity of the infection, upon the complications present, and especially upon the presence or absence of perforation of the uterus. Beckmann places the mortality at 27.5 per cent. Zaborowski found the death-rate to be 32 per cent. Uncomplicated cases usually end in recovery. The resumption or non-resumption by the uterus of its normal functions, after the patient has recovered from her illness, will depend upon the extent to which the uterine surface has been destroyed.

The *treatment* in the milder cases is expectant. In the more severe forms, hysterectomy may be called for. Curettage is dangerous on account of the liability of perforating the necrosed uterine wall. The pyæmic symptoms should be treated in the usual manner.

Gangrene of the Uvula and Pillars of the Fauces.—Gangrene of these structures has been reported after measles, the process extending to the larynx and causing death.

Gangrene of the Tonsils.—Gangrene of the tonsil has resulted in cases of tonsillitis, diphtheria and measles, and probably also in diseases dependent upon other infections. The condition is always serious, and especially if it depends upon a virulent infection. In the milder grades of the disease, a recovery may be looked for.

Gangrene of the Tongue.—Gangrene of the tongue has been met with, and, like the preceding, is due to some form of infection. The cases are extremely fatal, on account of the resulting œdema of the larynx.

XX. GANGRENE OF THE HOLLOW VISCERA.

Gangrene of the Œsophagus.—Gangrenous areas in the œsophagus, followed by perforation, have been reported by Dittrich and Chiari. These cases are explained by assuming a primary hemorrhagic infiltration, followed by erosion due to the action of gastric juice. They can scarcely be diagnosed until rupture has taken place. If an abscess follows, this might be detected, and, if so, evacuation would then be indicated.

Gangrene of the Stomach.—Gangrene of the stomach has been met with as a manifestation secondary to gastric carcinoma, after the ingestion of mineral acids and alkalies, in phlegmonous gastritis, and as a result of embolism and thrombosis. In the case of the stomach, the gangrenous tendency due to interference with the circulation is increased by the action of the gastric juice, which digests the devitalized wall.

Drummond and Morison state that certain of the hollow viscera—viz., the gall-bladder, the vermiform appendix, the cæcum, the urinary bladder, and the stomach—are subject to gangrene followed by perforation as the result of acute intravisceral tension. As regards gastric ulcer their view briefly is that excess of hydrochloric acid in the stomach, by producing pyloric spasm and acute gastric distention—for example, in an anæmic girl—gives rise to a small gangrenous patch or patches in the stomach wall, and that subsequent digestion of the dead or devitalized patch, if all the coats are involved, leads to perforation.

Cases have been reported after pneumonia, acute tuberculosis, acute yellow atrophy of the liver, and gangrenous stomatitis. Severe injury and septic emboli have also been responsible for some cases. Gastric ulcer will be considered in another article, in a later volume of this work.

There are no definite symptoms of gangrene of the stomach. There is profound prostration, and there may be shreds in the vomited matter. The latter, if present, constitute the most definite sign. As a rule, the symptoms are overshadowed by those of the primary disease.

Gangrene of the Intestines.—Gangrene of the intestine is frequently met with. The causes are: strangulation (as seen in hernia and as the result of pressure by bands), volvulus, intussusception, mesenteric thrombosis, and embolism. Cases are also met with which are due to traumatism, and to extreme distention caused by obstruction.

Gangrenous Hernial Sac.—The sac of a hernia may become gangrenous while the contents retain their vitality. In these cases the pressure of the hernial mass must interfere with the blood supply to the sac. These cases all require operation, the removal of the necrotic sac being imperative.

Gangrenous Omentum.—Gangrene of the omentum may occur from interference with its blood supply by constriction, as in hernia, and from injury.

The omentum, when strangulated, is first congested, then dark red or purple, and later infiltrated and matted. If it contracts adhesions to the sac, and if no gut is present, the acute symptoms may subside and nutrition be carried on through adhesions. When such conditions are not present, gangrene results. The omentum then becomes ashy gray or brown in color, and pultaceous and friable. It does not become offensive if intestine be absent, as it contains no germs. The sac becomes distended first with serum and then with blood-stained fluid, which finally becomes turbid.

These cases call for operation, the affected omentum being ligated and removed.

Gangrenous Strangulated Hernia.—When a portion of intestine is strangulated it assumes a dusky red, chocolate or claret color, due to venous congestion; the wall becomes thickened and stiff from exudation into its coats; the loop becomes distended by gas in the lumen, due to arrest of peristalsis and putrefaction of contents. The peritoneal covering remains smooth and glossy for a time, but, as exudation increases, the endothelium is lost, and the surface becomes dull and lustreless. Superficial capillaries may rupture, causing ecchymosis; occasionally the congested deeper vessels rupture—in some cases, in consequence of undue efforts to reduce it by taxis—and the hernial sac becomes filled with clotted blood. If the constriction be relieved at an early stage, the bowel rapidly assumes the natural appearance. If inflammation occurs, the surface is rough from the deposit of lymph, and entirely loses its polished surface.

Gangrene results from the prolonged stagnation of blood, but the process is aided and hastened by the action of the Bacillus coli communis, which, as soon as the integrity of the intestinal wall is impaired, migrate through it and cause inflammation which accentuates the gangrenous process. Corner found pyogenic cocci more common in the acute than in the chronic cases. The colon bacillus is by far the more abundant organism, occurring in 90 per cent of the chronic cases and 70 per cent of the acute, and is associated with staphylococci in 15 per cent of the acute cases, and with streptococci in 7 per cent. Staphylococci are rare alone; they are present to the extent of 1 per cent in the chronic form and 4 per cent in the acute. Streptococcus is exceedingly rare in the adult. Corner remarks that the colon bacillus is so common that it must overcome other organisms and that, therefore, the earlier the case is examined the more likely are we to find complicating germs. It is doubtful if the cultures in all cases represent all the organisms that have been concerned in the disaster. The colon bacillus has some bad relations, but it is not always the rule that its action is an evil one. There is every reason not to expect other organisms in an ordinary culture, as they have been generally killed off by the growth of the colon bacillus. As soon as gangrene is fully established, the intestine becomes of an ashy gray color or black, usually at one or several spots, which spread and coalesce; the lustre is lost, and the part becomes soft, friable, and offensive.

At the point of strangulation the gut is anæmic, and ulceration or even perforation is common.

Gangrene of the intestine is encountered very frequently in connection with strangulated hernia, and one should be prepared to deal with this complication in every operation for the relief of the latter condition.   The judgment of the surgeon will be most severely tried in deciding upon the proper course in the large number of borderland cases, in which the appearance of the bowel indicates marked devitalization, and yet absolute necrosis has not begun. Nothing but experience will avail in judging properly each case.   As a broad statement, when there is doubt as to the vitality of the strangulated bowel, all constriction should be relieved, and hot cloths applied to the affected loop.   If the normal color soon returns, showing restoration of the circulation, it may be assumed that the part will fully recover itself.

While no absolute rule can be stated as an invariable guide the surgeon will be expected to act in accordance with the lesions discovered, the condition of the patient, and those general surgical principles which are fully explained in the article on Hernia in one of the later volumes.

Gangrene in Connection with Intussusception.—Gangrene of the intestine occurs in both the acute and the chronic forms, but is more frequent and extensive in the former.   The whole mass of intussusception may be necrotic and may come away in one piece.   The amount thus passed has varied from a section of intestine only a few inches in length to one measuring several feet.   The process appears first and is most advanced in the middle layer; thus, when the separation occurs, the middle cylinder may be disintegrated and in part missing, while the entering layer, though dead, may still show its structure.   In Guy's Hospital Museum there is a specimen showing the cæcum and ascending colon, which was passed on the eleventh day of the illness.   The patient recovered.

The symptoms and treatment are described under Intussusception, in the article on Surgery of the Intestines.

Gangrene Due to Traumatism.—Gangrene of the intestine not infrequently results from traumatism.   A severe blow on the abdomen, such as the kick of a horse, is the usual cause.   The gangrene results evidently from injury to the mesenteric vessels.

The early symptoms may be mild, unless the blow be very severe, when the condition of shock may be pronounced.   As this wears off, abdominal pain, constipation, distention of the abdomen, and rapid pulse are noted.   If the condition be not relieved, the symptoms of general peritonitis supervene.

The only effective treatment for these cases is the opening of the abdomen as soon as it is patent that some severe intra-abdominal injury has occurred. Devitalized portions of intestine, if found, must be resected, and the cut ends of the bowel united by suture.

Gangrene Due to Torsion.—Gangrene of the bowel is observed as the result

of torsion, as seen in cases of volvulus, which occurs principally in the sigmoid. In rare instances a loop of small intestine may be similarly affected. Cases are also recorded in which a large portion of the small intestine has become gangrenous from a twist of the mesentery.

The early symptoms are those of intestinal obstruction. By prompt operative interference the bowel may be saved, but, if this be delayed until gangrene has set in, resection and suture will be demanded, and the patient's chances for recovery will thus be very much reduced.

Gangrene Due to Distention.—Gangrene of the intestine may result from extreme distention, caused by some form of mechanical obstruction. This is particularly apt to occur in the large bowel, and especially in the cæcum, which has the thinnest walls of all the parts of the entire large intestine. Distention of the cæcum causes a sharp curve at the hepatic flexure, one that is sometimes so sharp as to close off the transverse colon completely. Under these circumstances, the fecal matter being still fluid in the cæcum, decomposition occurs very readily. The valve between the cæcum and ileum prevents the gases from going in the direction of the ileum.

The symptoms are those of obstruction in the lower portion of the alimentary tract—constipation and distention. Early relief of the obstruction is imperative.

Bayer says: "There is a local meteorism of the cæcum, due to abnormal impediment of its contents through occlusion of the large intestine, and to the thinness of the walls of the cæcum; and the marked activity of the intestine to overcome the impediment heightens the condition. The collection of gas overdistends the cæcum; laceration of the serosa takes place; and gangrene results. The nearer the cæcum is to the obstruction, the more rapidly does the gangrene develop."

Operations.—Gangrene of the bowel may follow operations involving the alimentary tract if its blood supply be interfered with in any way—either from injury to the vessels or from undue tension or pressure.

Gangrene of Meckel's Diverticulum.—A number of cases of gangrene of Meckel's diverticulum have been reported, as well as of gangrene of the intestine due to strangulation by this structure.

Gangrene of the Appendix.—Gangrene of the appendix, and of adjacent portions of the bowel, as a result of the former, are well known. These cases are fully dealt with in the article on Appendicitis.

Gangrene Due to Thrombosis and Embolism.—Thrombosis of the portal vein resulting in gangrene of the intestine is probably more common than has been supposed. It undoubtedly results from infection, sometimes secondary to suppurating foci, and at other times no primary cause can be found. Either the main trunk or any of its branches may be affected.

Audistere reports an autopsy which showed partial thrombosis of the main

trunk of a portal vein, and complete thrombosis of some of the branches. The latter had resulted in gangrene of a loop of intestine. No primary cause could be discovered. The diagnosis was not made during life. Rixford reports a similar case due to thrombosis of a principal radical of the portal vein.

Fagge's case is very interesting. It is that of a woman who was suddenly seized with severe abdominal pain, one month after delivery, and died in a few hours. The bowel was affected from a point four inches below the duodenum to the middle of the small intestine. Thrombi were found in the superior mesenteric veins and they extended into the trunk of the vena porta, nearly to the point where it breaks up into its branches. At the upper part the thrombus was softened and adherent to the wall of the vein. Within the mesentery the veins were distended to an extreme degree by a solid and recent clot. The femoral veins were plugged with softened thrombi extending high up in the vena cava. There was no endocarditis, or peritonitis, or any cause for internal strangulation.

Elliot records a case of thrombosis of the trunk of the mesenteric artery, not at a bifurcation, nor was any part of it distinctly different from the rest, as would be expected in a case of embolism. It was regarded as a primary thrombosis of the mesenteric artery to which the thickening of the intima— chronic endarteritis—stands in a causal relation. The walls of the artery were thickened, the greatest change being in the intima, which was several times its normal thickness. Occlusion of the mesenteric vessels usually results in infarction of the intestine, but Virchow records two cases in which the mesenteric artery was obliterated and transformed into a cord without causing any change in the intestine. Tiedemann observed a similar case in which anastomosing branches were very prominent. This is, however, apparently exceptional. As a rule, there are very limited anastomoses between the branches of the mesenteric artery; hence the danger of gangrene of the intestine from any interference with the circulation.

Elliot analyzed 50 cases of occlusion of the artery. In most instances heart disease or atheroma was present. The embolus came from the left heart in 19 of 33 cases.

Thrombosis is frequently due to an extension of a primary lesion from the veins of the pelvis, kidney, or intestine. It is common after acute appendicitis, acute metro-phlebitis, pyelo-phlebitis, intestinal ulceration, etc., but very rare in typhoid fever, although the veins of the lower extremities are commonly affected. In the mesenteric veins there is observed a form of endophlebitis which corresponds with endarteritis; it is rarely met with elsewhere. There are on record several cases of mesenteric occlusion after thrombosis of the pulmonary veins.

Grawitz has shown how rapidly the intestinal walls break down when the blood supply has been cut off, and how readily bacteria penetrate the tissues under these circumstances.

Gallovardin believes that the most common cause of mesenteric embolism is mitral stenosis, and that arterial sclerosis stands next. Falk collected 17 cases of embolism of the intestinal arteries; in every one there were embolic disturbances elsewhere—an important point in diagnosis. The simultaneous occurrence of embolism and thrombosis must be remembered. Embolism must be followed by thrombosis in the artery, and later in the accompanying veins. Even the colon, sigmoid, and rectum may suffer in some of these cases. Gangrene of the rectum, including the anus and sphincter, has been described.

Pilliet thinks that mesenteric thrombosis is an ascending process. It has followed gangrene of the lower extremities. Cases are reported by Osler and Chiene where the origin of the artery was involved in a small aneurism.

Symptoms.—Park, in a very valuable article, gives the symptoms as follows: The more complete the occlusion of the mesenteric vessels, *i.e.*, the more extensive the area suddenly deprived of blood supply, the more sudden and more overwhelming will be the symptoms. Of these the most significant are as follows:

(1) *Sudden Onset.*—In the most severe cases this can usually be recorded by the watch, since patients indicate nearly the exact moment at which they began to feel severe pain, while the other symptoms follow so quickly as to make it a sudden and overwhelming affection.

(2) *Intensity and Character of Pain.*—This is sometimes paroxysmal, at other times continuous. It is nearly always severe and often agonizing, and scarcely to be quieted by any ordinary opiate. Sometimes it is spoken of as intense colic; even mild degrees of the lesion are aften accompanied by sufficient pain to present a prompt and very grave indication. On the other hand, rare instances are known in which the disease has run its course almost without pain.

(3) *Diarrhœa.*—This is usually an early symptom, the evacuations being profuse, and bloody after a few hours, if not at first. It is met with in from 30 to 40 per cent of cases.

(4) *Obstructive Symptoms.*—These are sometimes those of ileus, sometimes those of constipation, which may be followed by diarrhœa.

(5) *Vomiting.*—Usually occurs early, the vomitus being bloody or even after a few hours fecal.

(6) *Rapid pulse*, which will be rarely less than 110, and may run as high as 130 or 140.

(7) *Subnormal temperature*, which, though not constant, may be an occasional symptom.

(8) *Meteorism*, which begins early and becomes very marked.

(9) *Abdominal Rigidity.*—This, with the previous symptoms, prevents palpation or the discovery of anything which may ordinarily be made out by the sense of touch. These two symptoms constitute a most distressing feature and of themselves indicate the gravity of the situation.

(10) Later, and to the above, may be added, perhaps, evidence of the presence of fluid in the peritoneal cavity. In connection with the symptoms stated above, this can only be regarded as adding to the gravity of the situation. Yet a little later will be added the features of complete collapse, delirium, etc., which precede death. When the inferior mesenteric artery is involved it is said that tenesmus becomes a rather prominent characteristic, since the colon and rectum are partly supplied from this vessel.

The symptoms in 20 cases analyzed by Elliot were as follows: Pain 17; colicky pain 6; vomiting 13; hæmatemesis 3; blood in the stools 13; hemorrhage from the bowels 6; partial obstruction 3; complete obstruction 3; diarrhœa 9; abdominal distention 8; subnormal temperature 3; tumor in abdomen 3. All of these cases died.

Elliot also collected reports of 14 cases of thrombosis of the mesenteric veins. These were more rapidly fatal than the preceding, nearly all having died on the second or third day with symptoms of intestinal obstruction. The symptoms were about the same as those noted in obstruction of the artery, i.e., pain, vomiting, diarrhœa (often bloody), subnormal temperature, abdominal distention, etc.

Litten has called attention to the remarkable depression of pulse, loss of appetite, vomiting of blood, bloody stools, and meteorism which follow ligature of mesenteric vessels.

Meteorism is explained by Kader as due to the complete paralysis which follows such gastro- and entero-malacia. All experiments tend to show that obstruction of the mesenteric circulation is quickly followed by necrosis and infarct.

Tangle and Harley, as well as Kalisch, have observed glycosuria after experimental ligation, especially of the superior mesenteric artery. The urine should therefore be examined for sugar. The writer was unable to find a record of any case in which this symptom was mentioned.

Kussmaul stated that pain above the navel indicates a lesion of the superior mesenteric artery, while, if referred rather to the sacrum, it means involvement of the inferior vessel. Litten believes that the so-called tea-ground stool indicates involvement of the upper vessel, while fresh blood in the stools is likely to come rather from the branches of the lower. Of course, a distinction between occlusion of the artery and occlusion of a vein is most difficult to establish, and is practically impossible unless evidences of the embolic or thrombotic process be found elsewhere. And even upon autopsy the deeper parts may be so softened and disintegrated that the ordinary post-mortem evidences of one or the other may be lacking.

Acute abdominal symptoms, with the passage of blood, in a patient with hepatic cirrhosis or with some other lesion capable of causing obstruction to the portal vein, would be suggestive of thrombosis of the mesenteric vein.

When this condition is suspected, one should carefully search for similar lesions elsewhere; it would add to the certainty of the diagnosis should these be discovered.

The *diagnosis* is based largely on the occurrence of hemorrhage from the bowel, not otherwise explainable. It is generally only tentative and uncertain, and frequently it is impossible to make a diagnosis.

Prognosis is very grave, death usually occurring in from two to four days. The cases reported by Virchow and Tiedemann show that collateral circulation may, in rare instances, be established, and the vitality of the bowel be thus preserved. Pilliet thinks that some cases recover.

Treatment.—The treatment is operative. Only exploratory section will enable one to determine whether the case is absolutely hopeless or not. Mudd says that in any case in which occlusion of the mesenteric vessels is suspected, or in which for any reason operative interference is not resorted to, the heart's action should be stimulated in every possible way; it being borne in mind that our only hope in such cases rests upon the establishment of the collateral circulation, which may enable the affected parts to regain their vitality. He considers the estimate of Watson, that one-sixth of the cases are amenable to surgical intervention, as rather larger than the facts warrant.

If an operation is decided upon, the question will next arise, How much of the bowel can be safely removed. In answer to this question it may be stated that Kocher resected a portion that measured 2 metres 8 centimetres in length. The patient remained well, except that a diarrhœa was established easily by errors in diet. A great number of other cases in which portions of less length were removed have been reported. Grzebicky concludes that a resection of as much as 286 centimetres in man is perfectly feasible.

XXI. GANGRENE OF THE GENITO-URINARY SYSTEM.

Phimosis as a Cause of Gangrene.—Phimosis causes gangrene only indirectly. When the parts become the seat of a severe inflammation, due to infection, gangrene may result. This is due to the difficulty of exposing the inflamed surfaces for proper treatment, and from the extreme swelling that follows in consequence of retained inflammatory products.

Traumatisms of the penis, followed by infection, may likewise result in gangrene. All of these inflammatory lesions are more severe in the presence of certain constitutional conditions, such as diabetes and advanced albuminuria. Some of the most severe examples of gangrene with phimosis reported have occurred in diabetic subjects.

The diagnosis and treatment are identical with that described below, under Balanitis and Balano-posthitis.

Gangrene with Balanitis and Balano-posthitis. — Balano-posthitis, even if it be hyperacute, is not prone to lead to gangrene unless complicated by marked phimosis. In these circumstances the retention of the secretions greatly increases the inflammatory action, and hence the swelling, and the latter in turn interferes with the circulation and thus leads to gangrene. Venereal sores hidden by a tight phimosis may, in the same way, result in gangrene.

Balanitis and posthitis are said to occur as complications in diabetes. In very severe examples the inflammation leads to gangrene, by which more or less destruction of the prepuce or glans is produced. The cases of gangrene of the penis in diabetic subjects are sometimes very alarming in their extent, and call for prompt treatment. The truth probably is that balanitis and posthitis are not more common in diabetic subjects than in others, but, when they occur in conjunction with diabetes, they are apt to run a more rapid and serious course.

The special symptoms in a case of balano-posthitis that threaten to result in gangrene are a very high grade of inflammation, accompanied by severe pain and great swelling of the parts, with impaired circulation, manifested by lividity of the surface.

Treatment.—Prophylactic treatment should be instituted if possible. In the presence of the above symptoms, a free division of the prepuce, followed by thorough cleansing and keeping the parts clean by frequently repeated dressings, and warm antiseptic fomentations to restore the circulation, may result in maintaining the vitality of the tissues.

If gangrene has already become established, efforts should be directed toward the promotion of a vigorous reaction in order to limit the process. The circulation should therefore be encouraged by moist, warm applications. If any tension exists, it must be relieved by dividing the prepuce, and, above all, provision must be made for the free escape of the discharge.

When it is recalled that extensive tissue necrosis may result from the action of a virulent culture of certain bacteria and their acrid products, just as it would from the application of a strong caustic, the importance of an effective antiseptic treatment will become apparent. Necrotic tissue, at the temperature of the body, furnishes the most favorable conditions for luxuriant bacterial growth. Moreover, as the germs are distributed throughout the dead tissue, they are protected to a great extent from the action of antiseptic applications. Hence, the first step should be the removal of any devitalized portions, and the free exposure of every inflamed part. Undermining must be guarded against, inasmuch as considerable portions of tissue are thus sometimes unnecessarily lost.

Frequent cleansing of the wound comes next in importance. The wound secretions sometimes have a very irritating and devitalizing effect, and, if allowed

to remain, interfere with a healthy healing action, and frequently even cause the disease to spread. The use of strong antiseptics is not to be recommended, because they are not well borne in some cases. The free and frequent use of mild remedies will be found more effective than the application of stronger lotions at greater intervals.

Gangrene with Paraphimosis in Connection.—In paraphimosis the case is different; gangrene may result from this cause alone. As the preputial orifice is not very elastic, as soon as the penis reaches a certain degree of swelling, the circulation is arrested, and gangrene results if the constriction is not promptly relieved.

According to the degree of the embarrassment of the circulation, smaller or larger portions of the prepuce, glans, or urethra may be destroyed.

There have been reported cases in which a blood-vessel has been perforated, leading to severe hemorrhage. Among other complications described are phlebitis and lymphangitis.

The symptoms of such a condition would be a gangrenous discharge from beneath the prepuce, marked swelling, lymphangitis of the penis, and inguinal adenitis.

Treatment.—The prepuce must be divided or removed in such cases, preparatory to the routine treatment, which should be carried out as described above. As a rule, it is better practice merely to divide the constricting band of the prepuce on the dorsum, leaving the formal circumcision until the inflammation has subsided.

Gangrene of the Penis.—Gangrene of the penis occurs as a result of phimosis, paraphimosis, or injuries, such as the introduction of the organ into a ring, impaction of a calculus, wounds of the cavernous bodies, etc. It also occurs as a result of phagedenic ulceration, phlebitis of the dorsal vein, urinary extravasation, and in low fevers. Usually the prepuce only is involved, but occasionally the skin of the whole penis, or even the entire organ, is destroyed.

The disease may prove fatal from exhaustion, pyæmia, secondary hemorrhage, etc.

When gangrene is threatened, no time should be lost in relieving tension by incision, and promoting the circulation by hot antiseptic compresses. After gangrene has formed, support the patient and facilitate the removal of the slough by careful cleansing and the application of moist heat. These dressings are made by wringing several layers of aseptic gauze out of a *hot* 1 : 10,000 bichloride solution; they may be covered with wax paper to prevent evaporation.

All gangrenous tissue should be removed as fast as it forms, by cutting away with scissors, in order to expose all infected parts to the action of the antiseptics.

Emphysema is always a serious symptom, as it probably results from infection with saprophytic organisms in addition to those of suppuration. It usually calls for free incisions.

Urethra.—An example of sloughing of the urethra, from the constriction of a metallic ring, is recorded by Owen.

Gangrene of the Scrotum.—Gangrene of the scrotum is rarely met with. Allen says: "Among the causes of this distressing and often dangerous condition, aside from urinary infiltration, erysipelas, thrombosis, embolism, and, incidentally, influenza, we find reference to typhus, syphilis, gonorrhœa, diabetes, prostatic disease, pediculi pubis, ergotism, traumatism (faulty punctures and injections), and frost-bite."

Taylor has seen two cases—one in a diabetic patient, and the other in a man suffering from Bright's disease. The gangrene usually begins, particularly in cases that have been poulticed, at a dependent portion of the sac, as a black spot, which spreads and destroys more or less of the walls, laying bare the testis or testes, which, however, are not invaded. After the process is arrested the parts usually heal, and cover the organs again, unless the destruction has been very extensive.

Gangrene of the External Genitals.—According to Emery, this affection has been recognized as a separate entity, occurring especially in the young, in alcoholics, or in those run down from privations. A special germ seems to favor its appearance. It is possible that contagion with erysipelas may be the cause.

Three periods in its evolution are described.

(1) Period of inflammation. The initial symptoms are apt to mislead on account of their apparent benignity; there is first a pain in the penis, sometimes violent pain at the prepuce, and pain during micturition; then redness appears, marked in the preputial region, and this is followed, later, by swelling and œdema which lead to phimosis. Chills and fever appear after the first day.

(2) Period of mortification. *Suddenly* blisters appear, or there may be anæsthesia, with a lowering of the local temperature, and a change in the consistence, with discoloration. The gangrene usually appears on the dorsal surface of the shaft of the penis, sometimes on the lateral part of the prepuce or scrotum. It extends with extreme rapidity, and in one day may involve all the parts, including the scrotum. The general symptoms are very marked—intense fever, vomiting, sweats, and prostration.

(3) Period of repair. This also begins suddenly; the temperature falls and a line of demarcation forms. The loss of substance may be great in extent, but, as a rule, involves the skin only; usually the anterior preputial ring is spared. Repair is rapid, owing to the liberal blood supply.

Gangrene in this part of the body is diagnosed by the following characteristics which it possesses: the sudden explosion, the subacute evolution, the

absence of the usual causes of gangrene, and the rapid recovery. Thus it is distinguished from lymphangitis, diffuse phlegmon, infiltration of urine, syphilitic phagedenic ulcerations, gummata.

The *treatment* is identical with that described for the preceding condition.

Gangrene of the Spermatic Cord.—If the spermatic artery is injured, and particularly if the plexus of nerves supplying the testis is subjected to severe traumatism, gangrene may result.

Gangrene of the Testes.—Gangrene of the testes is a very rare complication of acute gonorrhœa. Bogdan reports a case in which both testes were destroyed by gangrene. Gangrene of the scrotum may follow gangrene of the testes.

Buschke has collected 17 cases of gangrene of the testicle that occurred after gonorrhœa. In the case which he personally observed, the gonorrhœa was mild, but the inflammation in the testicle progressed to gangrene. The patient was a robust man of 27 years. A bacillus resembling the colon bacillus was cultivated from the secretions, and Buschke believes that the gangrene was a secondary-process. Up to the present time gonococci have not been found in the gangrene. Trauma seems to afford a predisposition.

The disease has also been observed as a very infrequent complication of traumatic orchitis, occurring especially in debilitated subjects.

Exceptionally, gangrene of the testicle follows ligation of the veins of the cord performed for the cure of varicocele.

Gangrene of the testis may result from torsion of the spermatic cord. Rigaux has studied this subject very fully, and reports 52 cases. He says:

" 1. Spontaneous torsion of the spermatic cord is an accident that occurs most often in cases which present congenital malformations, the most important of which are: (*a*) An excessively large tunica vaginalis; (*b*) anomalous fixation of the testis; (*c*) anomalies in form of the organ.

" 2. Torsion may be of two kinds: (*a*) Generally the testis alone participates; it is intravaginal; (*b*) exceptionally the vaginalis participates in the rotation and accompanies the testicle; it is extravaginal.

"3. The immediate lesions following the torsion are characterized by hemorrhage, infarction, true testicular apoplexy, and by parenchymatous degeneration.

"4. The ultimate lesions depend on the state of asepsis of the organ: (*a*) If no infection exists, the gland disappears by progressive atrophy; (*b*) if infection exists, the gland disappears by sphacelation and suppuration. Of the 52 cases on record, in but 2 cases did this occur spontaneously, *i.e.*, without any surgical wound being the portal of infection."

Among the etiologic factors are adolescence, violent muscular action, and congenital malformations of the testes. The exciting causes are traumatism and physical exertion.

The *symptoms* of torsion set in suddenly, as a rule, and they resemble those

of intestinal strangulation: a tumor is present; spontaneous reduction may follow, or it may be effected by artificial means; an open incision usually results in sphacelation and gangrene of the testicles (perhaps because operation is done too late).

Diagnosis.—Conditions which may be confused with torsion of the cord are: 1. Strangulated hernia. 2. Acute inguinal adenitis. 3. Acute orchitis. 4. Acute peritesticular or scrotal suppurations. 5. Hæmatocele. 6. Periappendicular abscess. 7. Spontaneous gangrene of the testicle due to phlebitis or primary thrombosis of the cord. This latter condition gives symptoms and lesions identical with those of torsion.

Usually the diagnosis is not made until the parts have been exposed to view by operation.

Treatment.—If gangrenous, the testicle must be removed and the wound closed, after drainage of the vaginal cavity.

Gangrene of the Vulva.—Herrman reports a case of gangrene of the vulva in a woman, 37 years of age, whose habits were bad, but who had had no illness.

On the fifth day, after an acute otitis media, severe pain was felt in the " privates"; the labia were swollen; there was no ulceration nor any herpes. On the eleventh day a black, sloughing ulcer was observed on the vulva, involving the labia majora and vagina as far as the finger could reach. On the fifteenth day a slough, consisting of a large portion of each labium majus, a coat of the lower part of the vagina, the labia minora, part of the urethra, the skin of the perineum and the skin around the anus, came away.

Gangrene of the Bladder.—Gangrenous cystitis is characterized by sloughing of the mucous membrane and muscular coat of the bladder. It is occasionally observed in acute septic processes, in cancer of the bladder, and as a sequel to extensive trauma.

XXII. BED-SORES.

(Decubitus.)

The so-called bed-sores result from necrosis of the skin and subjacent tissues due to pressure received on bony points, as when a person is confined to bed. They are met with especially in certain classes of cases.

1. Old and feeble persons with arterial sclerosis, low vitality, and feeble circulation, who are obliged to remain in one position in bed for some time, as during the treatment for fracture of the lower extremity, or who are not sufficiently conscious to change their position, not infrequently develop bed-sores at points subjected to the continued pressure.

2. Patients of any age, whose vitality has been exhausted by a severe and prolonged illness such as typhoid fever, joint diseases, general septicæmia, pro-

fuse hemorrhage, etc., are particularly prone to acquire bed-sores. This class furnishes some of the most severe examples of the disease.

3. Certain affections of the nervous system, epecially such as destroy the integrity of the cerebro-spinal centres or peripheral nerves, favor the development of bed-sores. When the trophic centres are thus cut off, the tissues possess very little resistance, and necrosis occurs with amazing rapidity. This process is naturally much more rapid in subjects advanced in years, whose vitality is impaired.

Bed-sores may occur early in certain cerebral lesions, such as hemorrhage. In such cases the buttock of the paralyzed side is apt to be involved, rather than the skin over the sacrum. This is due, no doubt, to a combination of causes. The patient lies on the paralyzed side much of the time, and as there is entire absence of sensation, any unfavorable condition, such as a wrinkled sheet or garment, moisture, etc., that would lead a person under ordinary conditions to change his position, is not observed, and hence the irritation continues. Charcot believed that some of these cases were due more to trophic influence than to pressure.

In the last stage of spastic paralysis, acute bed-sores appear suddenly in those who have been bedridden for months and have not been nursed with sufficient skill and care. Every part pressed upon in turn becomes purple, so that within two or three days the buttocks, sacrum, and hips may be in a state of incipient gangrene. Pressure on any part, in such cases, tends to induce sloughing. For instance, pressure of the contracted lower limbs upon one another has laid bare the femoral artery and the tibia.

Bed-sores appear early in cases of acute myelitis, and also in those other forms of spinal-cord disease in which the integrity of the cord is destroyed.

Fractures and luxations of the spine, in which the cord is lacerated or is subjected to injurious pressure, are followed by marked trophic disturbances in parts below the lesion, and, as in acute myelitis, such injuries are usually complicated by bed-sores, in spite of every care.

Acute Post-operative Decubitus.—Vanverts describes this rare condition. It usually follows operations on the female genitalia. Vanverts' collection of cases includes vaginal hysterectomy, 17 cases; abdominal hysterectomy, 2 cases; abdominal salpingectomy, 2 cases; symphyseotomy, 10 cases; the lesion is not rare after sacral resection.

According to the theory advanced, the development of bed-sores presupposes an irritation or destruction of certain pelvic nerves, perhaps rendered specially susceptible by previous inflammation. This irritation is transmitted to the branches of the sacral nerves which supply the skin of the sacral or gluteal regions, and it rapidly gives rise to trophic changes. Vanverts does not accept this theory for all cases.

The most common site of bed-sores is the sacral region. This fact is readily

explained. The sacrum is a very prominent bone and is covered merely with skin. The continued pressure due to the weight of the body impedes the circulation, which is already barely sufficient to maintain the nutrition of the tissues. As a consequence, the capillary circulation is arrested, capillary thrombosis follows, and necrosis or gangrene results. Every grade of severity is met with, from the merest superficial abrasion to complete destruction of all the structures overlying the bone, and even caries of the sacrum has been observed. The extent depends upon the vitality of the individual and also upon the care, or lack of it, which the patient receives. The worst examples are seen in those patients who have incontinence of urine and fæces, due either to great physical or mental feebleness or to paralysis. In these cases the skin is macerated, and infection is soon added to the loss of vitality.

Pressure sores also occur over such bony prominences as the spinous processes of the scapulæ, the spinous processes of the vertebræ, the elbows, the great trochanter, the heads of the fibulæ, the heels, etc. In the more robust cases, a bed-sore will develop only after prolonged pressure and neglect, while in very feeble subjects it may appear with astonishing rapidity.

Treatment.—Bed-sores may be prevented in many cases by appropriate care. Their treatment, always troublesome, becomes especially difficult in cases of fracture of the spine or of the femur, in which the necessary attention to the sore may seriously interfere with the rest essential to the proper union of the bone. In addition, healing is always very slow. Therefore, when a patient belonging to any of the above classes comes under treatment, every effort should be made to prevent a bed-sore.

The following indications are to be met:

1. The patient's back must be examined daily; also all other points subjected to pressure, *i.e.*, scapulæ, elbows, trochanters, heels.

2. Change the position of the patient frequently, if this can possibly be done, so that the pressure on the prominent parts shall not be continuous. As a matter of course, this cannot be done in cases of fracture of the femur or of the spine. In such cases, the patient should be placed on a water bed or air bed, if one is procurable.

3. Cleanliness should be scrupulously observed. The skin should be bathed daily, or oftener if it becomes soiled, and rubbed with alcohol, dried carefully, and talcum powder freely applied. The skin must be kept dry. Maceration from perspiration, and especially from urine or fæces, as may occur in unconscious states or when the control of the bladder or rectum has been lost through paralysis, is to be prevented by constant watchfulness and care. For excessive perspiration, the use of a draw sheet, changed frequently, and the liberal application of talcum powder are indicated. In cases of involuntary evacuation of the bladder or rectum, sufficient cotton or other suitable material should be so placed so as to receive any discharges, and should be changed as soon as soiled so that

the moisture shall not spread about. When the skin becomes soiled, it must be cleansed, dried, and dusted before fresh cotton is put in place.

4. Every form of irritation of the skin subjected to pressure should be avoided. The sheet under the patient is to be kept free from wrinkles and also from bread crumbs and all other foreign matter. When the conditions are already unfavorable, the omission of such simple precautions may result in the formation of a bedsore.

In the daily examination of the patient's back, if any point is observed where the circulation is not good, the preventive measures recommended above are to be carried out with redoubled care. The condition of the skin circulation may be known by pressing with the finger any suspicious area. When the circulation is being properly maintained, points subjected to pressure, if at all changed, will appear of a bright red color, which disappears rapidly under pressure of the finger, and which returns promptly. If the color is a dull or dusky red, which disappears slowly and imperfectly at the point pressed by the finger, and if the color does not return promptly, the capillary circulation is impaired and the vitality of the part seriously threatened. All of the precautionary measures noted above should be employed with careful attention to every detail, but, especially, the skin affected must be relieved from pressure. This is readily accomplished if the patient may be moved freely, but if this is impossible the affected part may be relieved by the use of the inflated rubber ring or of suitably placed pads of raw cotton.

If the skin actually shows signs of breaking, rigid antiseptic measures must be employed to prevent infection. The sluggish circulation and low vitality present in such conditions present the most favorable soil for germs, and a small and simple abrasion may be converted into extensive sloughing by the addition of pyogenic infection. All abrasions should be kept dry, as moisture favors not only infection, but further breaking down and extension. A mild antiseptic dusting powder should be employed. The following will answer: Salicylic acid, gr. xxx.; powdered boric acid, $\mathfrak{z}$ ii.; sterilized talcum (by heat), $\mathfrak{z}$ vi. The part may then be kept covered by dry gauze or cotton. If suppuration or sloughing is present, the dry treatment must be abandoned and the wound kept thoroughly clean by the use of hydrogen dioxide and carbolic solution (1:100) or bichloride solution (1:2,000). Free drainage must be provided, undermining of the skin prevented, and sloughs removed as they form. When the wound has been properly cleansed, a dry sterile dressing should be employed. Extensive suppuration and sloughing still further depress the patient, already reduced by the primary trouble, and every effort should be made to limit the process. The frequency with which the dressings are to be applied must depend upon the amount of the discharge. It is desirable to change the dressing as soon as it becomes moist. A pus-soaked dressing causes maceration of the tissues and predisposes to extension of the process. A host of remedies have been recommended

for bed-sores. Most of them are probably without value, and none of them appears to the writer to have any advantage over an intelligent and thorough antiseptic treatment. A bed-sore is merely a wound caused, and perhaps kept up, by pressure. It requires the same treatment as a similar wound on any other part of the body, in addition to measures for the relief of the injurious pressure.

When the breaking down is checked and a healthy granulating surface is obtained, showing that the wound has a tendency to heal, the dry dressings may be continued if the granulations are active and healthy; but if they are deficient and of low vitality, gauze soaked in warm, sterile salt solution may be used. The wound may be touched with silver-nitrate solution (10 to 20 grains to the ounce of distilled water) to stimulate the granulations. When the latter are exuberant, the stick of caustic should be employed.

XXIII. GANGRENOUS STOMATITIS (NOMA; CANCRUM ORIS; WATER CANKER OF THE EARLIER WRITERS).

Gangrenous stomatitis is a destructive and fatal variety of gangrene, which attacks the cheek, mouth, throat, larynx, tongue, face, etc., of poorly nourished children, usually toward the close of some exhausting disease. Cachectic children are liable to inflammation of the mucous membranes, and this tendency is increased after some of the acute fevers, especially measles, typhoid, typhus, etc. Noma is usually observed between the ages of 3 and 8 years. It is rarely met with in this country, but is said to be rather common in the larger European cities, being especially prevalent in institutions devoted to the care of children.

The pathology is not well worked out, as the disease is so rapid that very limited time for study is afforded. It appears to be due to secondary infection, and is less common since hygiene receives so much more attention.

Herrman believes that the micro-organism which plays the most prominent part in the etiology of noma corresponds to the streptothrix of Seiffert-Perthes, and should be called the spirochæte of necrosis. It is identical with the organism found by Plaut, Bernheim, Vincent, and others in ulcero-membranous lesions of the mouth, and also with Spirillum sputigenum and Spirochæta dentium of Miller, found normally in small numbers in the mouth. The organism is probably present in the atmosphere in the form of very resistant spores, and may be introduced into the body with food and water. In order that a gangrenous process should result, there must be a preceding change in the tissues. Ulcerative and gangrenous stomatitis represent different stages of the same process. The presence of diseased teeth undoubtedly plays an important part in the etiology of these forms of stomatitis; hence in the infectious diseases of childhood particular attention should be given to the teeth.

As a rule, one cheek only is affected. The disease may advance so rapidly that in the course of a few hours the whole thickness of the cheek (if this be the part affected) becomes gangrenous. The advance is in the direction from within outward. At first the skin becomes tense, then livid, and finally black; blebs often form and perforation occurs.

For further information on this subject the reader is referred to the article on Surgical Diseases of the Mouth and Tongue, in a later volume.

SURGERY OF DISEASES OF THE SKIN.

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Introduction.—In the present article an attempt is made to furnish a short account of the treatment of diseases of the skin by surgical means. Those diseases of the skin which do not require surgical treatment have, with some exceptions, been omitted. For the general surgeon the treatment of diseases of the skin offers, as a rule, a field of comparatively small interest, and he is therefore apt to neglect it. The treatment of lupus may not be as dramatic as an abdominal section, but life is not made up of dramatic situations. A wart of the finger-tip may disable a mechanic almost as effectually as a broken leg. Then, again, this department of surgery includes some diseases of the skin which are of frequent occurrence, and which, if allowed to persist, may become an opprobrium to the man into whose hands they first fall. For instance, many cases of epithelioma are at first unimportant and are readily amenable to a treatment that is not too severe and can be easily controlled. If neglected, however, they develop into a severe affection. It is owing to the neglect of these incipient epitheliomas by the regular profession, and to the attention paid to them by the quacks, that people are driven into the hands of charlatans. The public is naturally timid about operations, and this timidity is a medical fact and has to be reckoned with as must any other fact. If a man having an epithelioma amenable to treatment by arsenic paste, consults a surgeon, the surgeon should be fully prepared to consider intelligently the question of applying arsenic paste. In other words, he should not narrow himself down to a single therapeutic measure as he does when he refuses to accept any other than operative treatment. Then, again, there are a great number of diseases of the skin which it is important for the surgeon to know from a negative point of view. It is important, for instance, for him to know that although in erythema nodosum the lesions may appear to contain pus, they in reality do not. It is also a matter of great importance, in many diseases of the skin, that the surgeon, who may eventually find it necessary to use the knife, shall be willing, before resorting to this step, to give full and fair consideration to the claims of medical treatment. Then, again, it may be necessary to incise a furuncle, but it is also necessary at the same time, if the advent of new furuncles is to be prevented, to treat the patient internally both as regards his diet and as regards the giving of medicine. Finally, in many diseases medical treatment should first be given before harsher surgical interference is resorted to.

FURUNCLE.

Etiology and Symptoms.—A furuncle is the result of the infection of a pilo-sebaceous gland by the Staphylococcus pyogenes aureus.

In a certain number of cases it begins as a deep, painful induration in the skin, which increases in size until it measures as much as one or two inches in diameter. On the surface this manifests itself as a rounded, red elevation that is hot to the touch. Pain and tenderness are present to such a degree that any movement causes great distress. We have here the classic symptoms of an inflammation, viz., heat, pain, redness, swelling, and interference with function. Shortly there appears on the top of the rounded surface a little pustule, or a vesicle that quickly turns into a pustule. At this stage the lesion looks like a pustule with a wide-skirted, red, conical base. On removing the top of the pustule a circular aperture is exposed, with a dark, dirty green, soft mass as its floor. The hole enlarges, the suppuration increases, the pain gradually subsides, and the green mass is seen to be a necrotic plug. This core, in the course of a few days, separates from the surrounding tissues, and can be pulled out. Then the hole fills with healthy granulations, and healing takes place, with the formation of a cicatrix.

In other cases the furuncle, instead of commencing as a deep induration, begins as a small pustule situated around the point of emergence of a hair. The inflammatory induration quickly extends into the depth of the skin, and the subsequent course of the affection is the same as that described above.

The pilo-sebaceous glands are not the only ones which may become infected and give rise to the formation of a furuncle; the sweat glands, the glands of the eyelids, the mucous glands of the mouth and vagina, and the ceruminous glands of the external auditory canal serve also at times as the starting-points for furuncular inflammation. These last give rise to a particularly painful affection.

The inflammatory process causes necrosis of the affected glands and the immediately surrounding tissue, and the necrosed parts form the core of the furuncle.

The direct cause of the furuncle is the Staphylococcus pyogenes aureus, but, for its successful inoculation, there must be contributory causes. These are:

(1) Erosions and irritations of the skin favoring inoculation, such as eczema, scabies, pediculosis, the inflammation due to poison oak, and small wounds from other causes;

(2) Bad hygienic conditions that act probably in two ways: first, by lowering the general health and thus diminishing the patient's power of resistance; and, secondly, by exposing him to decomposing materials containing the pyogenic bacteria;

(3) Diseases that lower the general health, such as diabetes, tuberculosis, and chronic Bright's disease. Anæmia, from whatever cause, predisposes to this kind of pyogenic infection. Constipation may act in two ways: by causing anæmia and by favoring the retention, in the body, of materials that ought to be excreted and that prepare the ground for the implantation of these bacteria;

(4) In many cases a diet which contains much sugar or starch favors pyogenesis and furunculosis.

The favorite location of furuncles is the back of the neck, but they may be situated on the face, forearms, legs or buttocks, or in the axilla. Usually there is only one furuncle, but they often appear in groups of from two to six or eight, or in successive crops, a new crop appearing as soon as a previous one is healed. This condition (furunculosis) may last for years unless proper treatment is given. Individual lesions take about two weeks to reach complete development, and another period of two weeks is occupied by the process of healing. Sometimes the furuncle can be reabsorbed by the organism before suppuration occurs (blind boils).

The *diagnosis* usually offers no difficulty.

Treatment.—If the present views in regard to the etiology of furuncle are correct, then the hygienic, dietetic, and medicinal measures to be taken for the cure of the disease are of the utmost importance, for they are the means by which we can influence the constitution and so change the ground in which the micro-organisms are planted. As for getting rid of the micro-organisms themselves, that is hopeless, for the ordinary pyogenic bacteria are too common and too widely distributed to permit of any such attempt being successful.

Success in treatment, therefore, often depends on elucidating the particular predisposing. cause in the case in hand, in order that we may apply to it the necessary correction. Inquiry should be made in regard to:

(1) The purity of the air breathed and the water ingested;

(2) The patient's personal cleanliness—a matter which may hardly be inquired into, but may be inferred from nasal or ocular evidence;

(3) The presence of any of the pruritic diseases such as pruritus, eczema, prurigo, scabies, and pediculosis;

(4) The diet, which for fat people may be reduced in the matter of starches and sugars, while for the lean and delicate it may be enriched. As a rule, the use of foods that easily ferment—such as starch, sugar, milk, butter, and cheese—should be regulated. The fermented drinks, such as beer, and all the alcoholic drinks should be stopped, except, possibly, in the case of thin, spare people, who need them as tonics;

(5) The debilitating diseases, such as rheumatism, gout, malaria, tuberculosis, diabetes, and the group in which albuminuria is a symptom;

(6) Constipation.

It has been suggested that a furuncle may be aborted by the employment

of a few drops of a strong carbolic-acid solution (1:30 or 1:40), which are to be injected under its base before the top of the tumefaction begins to soften. Another method put forward is that of injecting, in the same way, hydrogen peroxid. Still another method is to paint the skin, over and around the lesion, several times a day, with tincture of iodine or a caustic. All such attempts at aborting the furuncle are, however, quite likely to fail, and they are aside from the real aim of treatment, viz., materially to alter the physical condition of the patient.

As soon as the yellow point appears, showing that pus has formed, the top of the lesion may be incised, and the contents syringed out, a solution of carbolic acid (1:50) or hydrogen dioxide or some other antiseptic being employed for this purpose. This incision should be deep and free enough to permit the ready evacuation of the pus, yet not so free as to cut through the inflammatory surrounding wall, which would favor the extension of the infection. The cavity may be touched with pure carbolic acid or with tincture of iodine. A wet antiseptic dressing should be applied to the part and covered with oil silk; and these dressings should be changed, when necessary, several times a day until granulation is well under way, when they can be replaced by an antiseptic powder such as boracic acid. The moist antiseptic dressing mentioned above acts, of course, both as an antiseptic and as a poultice.

The contents of the boil should not be forcibly evacuated by compression, as this may cause the lesion to enlarge.

There is considerable difference of opinion in regard to the question whether heat or cold should be applied to a boil. To some extent the choice may be determined by the patient. During the first stages of the disease, when the inflammation is increasing in intensity, cold may be agreeable to the patient, and may relieve pain and decrease the intensity of the inflammation. When the pus is escaping freely, however, heat is usually preferable. Heat is best applied either in the form of a compress or possibly in that of an antiseptic poultice. Poultices, as usually ordered, are apt to encourage the formation of other boils around the original one.

A poultice is a mass of material kept warm by the heat of the body and favorable to the propagation of micro-organisms. It also renders the skin sodden and the glandular openings patulous and ready to receive the micro-organisms from the pus and from the poultice. In order to avoid these inconveniences, it is best to add to the poultice boracic-acid powder. Starch is a cleaner, nicer poultice material than linseed meal. In my own practice I recommend that the starch paste be made from ordinary laundry starch, but thicker in consistence than that used for laundry purposes. To a small bowlful of this is to be added a heaping teaspoonful of boracic-acid powder. The paste should then be enclosed in a cloth, applied to the affected part, and covered with oil silk. To keep these things in place it is necessary to apply a bandage.

In the case of a boil in the axilla, one can wring a small towel out of a hot saturated boracic-acid solution, fold it, place it in the axilla, cover it with oil silk, and hold it in place by tying a towel under it and up across the other shoulder.

Fresh brewers' yeast (one tablespoonful three times a day) often proves very beneficial; it probably acts as a laxative.

CARBUNCLE.

Carbuncle, like furuncle, is caused by infection with the Staphylococcus pyogenes aureus, but it is a much more intense inflammation, and is accompanied by more extensive necrosis.

Symptoms and Etiology.—It begins like a furuncle and is at first indistinguishable from one, but soon the induration and redness become more extensive. When suppuration occurs, sanious pus is seen to ooze out from several openings, giving the lesion a cribriform appearance. A single slough or several sloughs are formed, involving considerable necrotic tissue and causing an abundant discharge of pus. This slough is finally cast off, and there remains a raw, deep or shallow ulcer, which heals by granulation. The slough may either form under the cutaneous surface or it may incorporate this also into the necrotic mass. As regards size, a carbuncle may be as large as an average furuncle or may occupy an area of several square inches. The locations where a carbuncle is most likely to develop are the back of the neck, the back, and the thighs. The lesion is usually single, although two or three of them may coexist. The development of the lesion is often preceded and is accompanied by symptoms of general sepsis, such as fever, nausea, etc., which may be quite grave, and in old and debilitated subjects may even end fatally. The lesions of the face and head are particularly grave. The duration of the disease is from a few weeks to two or three months. It occurs chiefly in people of mature or advanced age, and like furuncle it has a symptomatic significance (see Etiology), and shows that the resisting power of the organism is lowered.

Diagnosis.—A carbuncle bears many points of resemblance to a furuncle, from which it is to be distinguished by the size and flatness of the induration, the large necrotic eschar, the multiplicity of the openings, and the greater severity of the general symptoms.

Treatment.—As in the case of a furuncle, care should be taken to improve the general health of the patient. Alcohol should be avoided, at least until suppuration begins. Lack of sleep should be remedied by the discreet use of narcotics. A generous diet should be advised, tonics given, and the surroundings, if necessary, changed. Quinine in full doses may be required.

Locally, antiseptic treatment (after the lesion has been incised) is sufficient in a large number of cases. The wound is syringed out once or twice

a day with a solution of carbolic acid, or sublimate, or peroxide of hydrogen, and then dusted freely with powdered boracic acid or other suitable substance. A wet antiseptic dressing may be applied, or in its place zinc-oxide or ichthyol ointment may be used. As much as possible of the pus and the slough should be removed, but this must be effected without compressing or squeezing the carbuncle. Taylor injects into the tumor and the surrounding tissues a saturated solution of carbolic acid with a hypodermic syringe, in order to check the development of the lesion. Some claim that a carbuncle can be aborted by injecting into the swelling a strong (1:30 or 1:40) solution of carbolic acid.

Curetting after incision is a method of treatment which is held in favor by many surgeons. It should be followed by the application of a wet antiseptic dressing. Some still practise deep crucial incisions, with or without curetting of the cavity in severe cases. The severe surgical methods of treatment for carbuncle are, however, practised less frequently than formerly, being supplanted by better and more modern antiseptic methods.

ACNE.

(Acne Vulgaris.)

Acne, or "pimples," is such a common disease, and the symptoms are so evident, that almost any one feels himself capable of making the diagnosis. In fact, the patients are not brought to us for diagnosis, but for treatment. Anatomically, we know the acne papule to be a folliculitis of the sebaceous or fat glands of the skin, but acne is only a disagreeable and unsightly symptom of a much larger disease called seborrhœa, which is probably caused by the presence, in the blood, of peccant matters—matters that arise from errors of digestion.

In size, the papules may be as small as a pin's head or even smaller, or as large as a ten-cent piece; large lesions are of a distinctly nodular or tubercular character. Retained fat secretion and secondary infection may cause pustulation, in which case a number of pustules are found scattered among a larger number of various-sized papules. The most common location of the eruption is the face, especially the cheeks, forehead, and chin; it often spreads over the shoulders, the upper part of the back, and the chest. Exceptionally, the eruption occurs only on the back, in which case it may reach as far down as the sacral region. The legs, the lower part of the thighs, the belly, and the arms are usually free, even in severe cases. These regions, however, are sometimes invaded in acne diabeticorum and in some forms of acne artificialis. The scalp is seldom involved. Usually, the number of lesions does not exceed fifty, but in severe cases it may be as high as several hundred. The eruption is accompanied by an oily, seborrhœic condition of the skin, with comedones or blackheads. The disease appears in young people of both sexes at the age of puberty,

and usually disappears entirely at the age of thirty. Exceptionally, it may persist after this age. Only a few cases have been recorded in which the disease has persisted into the sixth decade of life.

The course of the disease is essentially chronic, and if left untreated it may persist for years. The lesions appear, develop, and disappear in a succession of crops. They are painless, but occasionally there is some itching, especially in superficial cases.

While the course of the disease as a whole is chronic, that of the individual lesions is acute. The latter effect a complete evolution in the course of three or four weeks, or in even less time.

Etiology.—Acne is nearly always an indication of gastro-intestinal trouble, especially indigestion, and of dilatation of the stomach in the old. Constipation is nearly always present, and particular attention must be given to it in order to insure a lasting cure. Overeating or the use of indigestible or too concentrated (rich) food, and also the use of coffee, tobacco, and alcohol, even in slight excess, may serve to actuate the disease. Some kinds of food (even milk) cause an outbreak of acne lesions in predisposed subjects. Some drugs, for instance bromids and iodids, when taken in large doses, may provoke acne.

Puberty is not a cause of the disease, but only a highly predisposing factor. In girls and young women acne may be an indication of some uterine complaint, particularly of some trouble in the menstrual function, an exacerbation of acne taking place usually just before or during a period. Anæmia and chlorosis, and exhaustion, are important etiological factors.

Local irritation of the skin or mechanical plugging of the orifices of the sebaceous glands can aggravate or even cause the disease. Plugging may be due to particles of dust or to the use of improper cosmetics or of such substances as paraffin and tars. Strong soaps, cosmetics, petroleum, and even some strong drugs, such as chrysarobin, may act as irritants. Some forms of neurosis have a direct effect on the disease. The parasitic theory, according to which the disease is caused by a specific micro-organism, the acne bacillus, is not generally accepted, although the presence of micro-organisms is a circumstance that should receive particular attention in the treatment.

Diagnosis.—Although acne is such a common affection, and although its diagnosis is usually so readily made, it is sometimes a difficult matter to differentiate between it and some of the other papular and pustular diseases, and scientifically there is frequently no sharp boundary between acne and some of the other folliculitides. Any of the glands and follicles opening on the skin may become infected, or may through errors of secretion become irritated and give rise to different kinds of folliculitis, which may simulate more or less closely an acne.

In addition to the more superficial form of acne, which we have already described and which is classified by most authorities as *acne simplex* or *acne*

vulgaris, there are certain other forms to which special names have been given. These are: acne indurata, acne punctata, keloid acne, tar acne, acne cachecticorum, acne rosacea, and acne varioliformis.

Acne indurata is characterized by hard coniform indurations which are situated under the skin, and which, at their apices, are frequently pale, as a result of tension and the consequent emptying of the blood-vessels pressed upon. In *acne punctata* the initial comedo is usually present, and its nature should be distinguished from that of the tar plug of tar acne. *Keloid acne* is accompanied by hypertrophic scars.

It must be borne in mind that some drugs, such as the bromids and iodids, may cause an eruption of acne. The inhibition of these drugs should be insisted upon before treatment is instituted. In *tar acne* the papules bear at their apex a dark brown point.

Acne cachecticorum is distinguished by the livid purple color and the soft consistence of its papules and papulo-pustules.

Acne rosacea, or "red nose," is located only about the nose and anterior part of the face, while acne vulgaris occupies particularly the forehead, cheeks, and chin. Acne rosacea is markedly hyperæmic, and is often accompanied by dilated vessels. The age of the patient is also a diagnostic factor, acne rosacea occurring, in the majority of instances, after thirty.

Acne varioliformis arises as hard, brownish-red, rather deeply seated, more or less flattened infiltrations, a couple of centimetres in diameter. The whole lesion becomes flabby, and it is frequently the seat of capillary hemorrhages that appear as violet points through the yellow epidermal covering. Pustulation may occur, but it is not a prominent feature. On the other hand, dry necrosis does take place in the centre of the lesion, and forms a scab that adheres tightly to the skin. After this scab falls off, a deep scar, like a smallpox pit, remains. Acne varioliformis has a tendency to appear in groups, and is usually situated on the forehead and scalp, but it may appear on the neck and on the upper part of the chest. Acne vulgaris very rarely appears on the scalp. Variola, with which this form of acne might be confused, is an acute disease, always accompanied by general symptoms. Besides, in variola the forearms and legs are also involved in the eruption.

Syphilitic lesions form a generalized eruption, and the lesions show a tendency to peculiar groupings—characteristics which distinguish them from the discrete lesions of acne vulgaris. Tubercular syphiloderms are usually copper-colored. Papular syphiloderms form characteristic crusts.

Treatment.—We encounter one of the most difficult tasks in the practice of a rational system of medicine when we attempt to unravel the different causes of the seborrhœic state which forms the basis of acne. When these causes are fully known it will be found, as a rule, that they lie in errors of nutrition. For instance, in many sedentary occupations, such as that of the seamstress

or the telephone girl, the complexion assumes the dull yellow of Swiss cheese; the openings of the sebaceous glands, particularly of the cheeks and nose, become patulous like the pits in saddle leather; fatty secretion continues to collect in these wide openings until it forms plugs that are called comedones, and in these plugs infection is easily implanted, causing inflammatory papules that are called acne.   On the other hand, plenty of fresh air and an active outdoor life—both of which are conducive to good health and good nutrition—will often cure an acne.   For instance, a sedentary and stay-at-home girl, if given the zest and activities of travel, may presently see her complexion clear up.

Micro-organisms that infect the fatty plug are not to be considered the sole cause of acne, for those papules which in some people manifest themselves after the eating of cheese, butter, or some other article of food appear so quickly after they have been ingested that no reasonable doubt can be entertained in regard to the cause.   Therefore, it is an important part of the treatment of acne to pay attention to hygienic conditions—outdoor exercise, fresh air, and proper food.

Attention to diet is a very important matter, and yet it is extremely difficult to secure such attention on the part of the patient, especially if he or she be young and thoughtless, and blessed with the vigorous appetite of youth.   The point to be insisted upon is the reduction of those substances which readily ferment.

The use of sugar should be reduced to a minimum, and no candy of any kind should be allowed.   In some people sugar will produce a crop of acne pimples, just as butter and cheese will in others.   This is particularly true of confectioners' sweets.   The starches may be cut down by increasing the amount of green vegetables eaten.   As the bulk taken will probably remain the same, the amount of starchy foods would fall off proportionately to the increase of the green vegetables.   Potatoes, as being particulary rich in starch, may be cut out of the diet altogether.   Butter is a fat that easily grows rancid, and probably acts as a direct detriment by forming butyric acid in the stomach; it should, therefore, be reduced in amount or cut out altogether.   Milk also does not act favorably on the skin and readily ferments, and is therefore not a good food for acne patients.   Tea, coffee, tobacco, and alcohol, if taken, should be used in moderation.

Almost all those who have acne have at the same time some discoverable trouble in the alimentary tract, chief among which is constipation.   Barthelemy probably goes too far when he says, "When you speak of acne, you speak of the stomach."   There is no doubt, however, that many people having acne also have dilatation of the stomach, with fermentative processes going on there, and that when the stomach affection is cured or improved the acne either improves or clears up entirely.   For the relief of the constipation, the vegetable purgatives and laxatives are to be preferred to the salines, and their adminis-

tration must be kept up for a long time. Of these laxatives there are: rhubarb, compound extract of colocynth, cascara sagrada, and the pill of aloin, strychnia, and belladonna. The best of all these laxatives are the compound colocynth extract, and rhubarb. The others may be good for particular cases, but these two may be considered the best, and are of particular benefit in those who are overnourished, and such persons constitute a large class.

In some cases the acne is due to the lowering of nutrition or to anæmia. If the acne be due to some ascertainable malady, such as malaria or Bright's disease, or to loss of blood through excess of menstruation or from bleeding piles, then internal treatment resolves itself into a treatment of these maladies. If the cause of the anæmia cannot be ascertained, then it must be treated symptomatically. One of the best prescriptions for anæmia is the elixir of iron, quinine, and strychnia, to which may be added small doses (usually not over 2 minims) of liq. acidi arseniosi. This particular arsenical preparation is to be preferred under the present circumstances, because the alkaline Fowler's solution would cause a precipitate in the acid medium of the elixir. Blaud's pills, in combination with arsenic, afford another excellent mode of administering iron and arsenic. They may be combined according to the following formula:

    ℞ Pot. arsenitis .... gr. $\frac{1}{50}$.
      Pill. Blaud .... gr. x.
    M. et ft. cap. tal. dosæ No. xxx.
    S. One capsule after each meal, three times a day.

In cases of acne where the acne pustules are large and flabby and bluish in color, and where the patients are possibly anæmic, lymphatic, and puffy looking, with perhaps a history of tuberculosis in the family, cod-liver oil is frequently given with advantage. The brown oils are to be preferred. A good brown cod-liver oil is often better than one of the more refined amber-colored oils. Sulphur or sulphid of calcium may often be given with advantage in suppurative cases. The sulphid of calcium is given in one-quarter-grain doses three times a day. Sulphur may be given as follows:

    ℞ Pot. arsenitis .... gr. $\frac{1}{50}$.
      Sulph. præcip .... gr. x.
    M. et ft. cap. tal. dosæ No. xxx.
    S. One capsule after each meal, three times a day.

By far the best external applications for acne are those containing sulphur, and the sulphur lotions, as a whole, agree better than do the ointments. An excellent lotion is the following:

    ℞ Sulphur. præcip .... ℥ ij.
      Spts. camphoræ ...., ... ℥ i.
      Spts. lavandulæ... ℥ i.
      Aq ....ad ℥ iv.
    M. S. Rub in well at night.

If the skin is tough and resistant, and the acne deep-seated and indurated, a stronger lotion, like the following, may be advisable:

R̥ Sulphur. præcip.,
    Pot. carbonat.,
    Glycerini,
    Spts. vini gallici ....āā ℥ i.
M. S. Rub in well at night.

Next to sulphur the best applications are those made from resorcin, which is best incorporated in a paste, as in the following formula:

R̥ Resorcin 3.50
    Glycerin.. 2.00
    Zinc oxid 5.00
    Wax.. 1.50
    Lard 33.00
M. S. Rub in well at night.

It is best for the druggist first to heat the glycerin and then to add the resorcin to it before incorporating it with the other ingredients of the paste. Otherwise the resorcin may not mix evenly, and, because of the irregular strength of the paste, it may act irregularly. The massage of the face incident to rubbing in the paste is also of value in the treatment.

Surgical Treatment.—Curetting, for the purpose of removing the hardened sebaceous plugs (comedones) which obstruct the orifices of the sebaceous glands and thereby favor the formation of pustules and abscesses, constitutes a very effective local treatment. A blunt-edged curette should be used so as not to cause too much unnecessary pain. (Fig. 40.) By the proper use of the curette, not only are comedones removed, but pustules are torn open at the

Fig. 40.—Blunt-edged Comedo Compressor.

apex and their contents pressed out. At the same time an outlet is given to the blood, and the congestion is thus relieved.

Puncturing the larger papules and papulo-pustules is seldom absolutely imperative, but this little operation will at any rate materially help the treatment. A narrow and thin blade should be used, and the puncture should be made vertically to the surface of the skin and of sufficient depth. The few drops of blood which the patient will lose in the operation will relieve the hyperæmia, and, in the case of the larger lesions, bleeding should even be encouraged. The lesion should be gently squeezed between the fingers in order to evacuate its contents. It is not well to treat too many lesions at a single sitting. From ten to fifteen at a time would be sufficient, and one can easily, in the course

of two or three days, evacuate the contents of all the lesions on the face, even in severe cases. Inasmuch as the purpose of the operation is to prevent scarring and to accelerate the recovery, it would be unnecessary to apply this procedure to lesions other than those of the face. In order to insure good results, the skin should be properly prepared in advance. For several days the tissues should be softened by suitable ointments, and the operation should be preceded by thoroughly scrubbing the face with soap and water and then soaking the skin in warm water. A couple of towels wet in warm water will accomplish this in five or ten minutes. Some advise the introduction, into the tiny wound, of a droplet of some antiseptic such as carbolic acid, sublimate (1 : 100), or pure ichthyol, by means of a pointed wooden toothpick, but I do not consider this necessary. Likewise, I do not wash the face with strong antiseptics, nor do I use medicated soaps after the operation. I usually wait until the bleeding ceases, and then I simply wash the patient's face with a solution of boracic acid and let it dry.

Various instruments have been devised for opening the lesions of acne. I think, however, that a sharp, short, narrow-bladed bistoury is as good as any of them.

The surgical treatment is of especial value in acne hypertrophica. Discrete lesions may be destroyed by the thermo-cautery or by the knife without much trouble. In extensive and confluent cases which have deep, tumor-like lesions it may be necessary to resort to decortication. The operation is to be done under an anæsthetic, either the knife or the thermo-cautery being used for this purpose. If the former is used, there may be sufficient hemorrhage to require for its arrest the employment of hæmostatic forceps or cauterization. Recovery takes place rapidly, even when the wounds are extensive. The resulting scars resemble those of lupus, and subsequent trouble can be partially prevented by skin grafting.

Acne keloid is, of all forms of acne, by far the most troublesome, and special skill is required for its successful treatment. The use of the knife should be followed by cauterization, and the knife itself should be sterilized by dipping it in alcohol after every incision, in order to prevent reinoculation, for the disease is contagious. Cauterization is, therefore, in the majority of cases preferable. In the early stages of this form of the disease it is wise to open the individual lesions and to disinfect their cavities with corrosive sublimate or ichthyol.

In recent years the x-ray has become very popular in the treatment of acne. It certainly has the advantage of giving excellent results, in a large number of cases, without straining the endurance of the patient. Its only drawback is that considerable time is required if we aim at securing lasting improvement. But, on the other hand, it has many advantages: the treatment seldom fails, is absolutely painless, and above all leaves a minimum of scar, which, in a

disease that attacks chiefly the face, is of especial importance. I use a medium tube, set at a distance of about twelve inches from the face. The duration of a single treatment is ten minutes, but sometimes, when both sides of the face must be treated, I make it fifteen minutes, or seven and a half minutes for each side. I protect the hair roots of the scalp by covering them carefully with a conveniently shaped piece of sheet lead. The chest of the patient may be protected in the same way, or, if there are any acne lesions on it, it may be left uncovered. This treatment is given two or three times a week, while the distance between the tube and the surface treated is being gradually shortened to ten, eight, seven, six, and even five inches. After a certain number of treatments—say, from eight to twelve—a slight erythema makes its appearance, and then the treatment should be suspended for from three to six weeks. During this time the eruption usually clears away, but a new series of treatments similar to the first one should be repeated in order to prevent a recurrence. A third series of treatments is seldom necessary. Instead of the second and third series, a single treatment lasting for from twelve to fifteen minutes, at a distance of, say, four inches, might be given once a week. Treatment with such a long interval between the sittings may be kept up for a long time.

ACNE ROSACEA.

Acne rosacea, like acne vulgaris, is one of the manifestations of the large group of seborrhœic diseases. Unlike acne, however, which is practically confined to adolescence, acne rosacea is a disease of the decline of life, and usually appears at about fifty years or later. Its first symptom is usually redness appearing on the chin, nose, cheeks, and forehead, and, upon careful examination, it is found that this redness is due to dilatation of fine capillary blood-vessels. The red color may change later to purple or blue from capillary stagnation. The vascular lesion may constitute the only change, but, in a number of cases, there may be, in addition, sebaceous plugs with dilatation of the sebaceous gland openings, acne pustules, and oily seborrhœa, or a dirty-looking, greasy crusting of the skin. In still other cases, the connective tissue and the sebaceous glands of the skin involved may become thickened and irregularly hypertrophied. All these changes are capable of producing a most repulsive and striking disfigurement.

Treatment.—As in simple acne, one of the chief aims of treatment should be the correction of the gastro-intestinal troubles, which are even more pronounced in this form of disease than they are in acne vulgaris. The bowels should be regulated, and such a dietetic and medicinal course should be prescribed as will tend to improve the digestion.

Topical applications containing sulphur, camphor, resorcin, or salicylic

acid, such as are recommended for acne vulgaris, often do good, but they have to be used in a very mild form, for fear of causing overstimulation.

Periodical emptying of the overfilled sebaceous glands with Bronson's curette (Fig. 41) often reduces the redness and improves the appearance.

In many instances, obliteration of the capillaries will improve the color and the general condition of the skin. This may be done by electrolysis. The needle attached to the negative pole is forced through the skin and then depressed so as to run parallel to the surface and in or beside the capillary that it is wished to obliterate. A current of three or four milliamperes is allowed
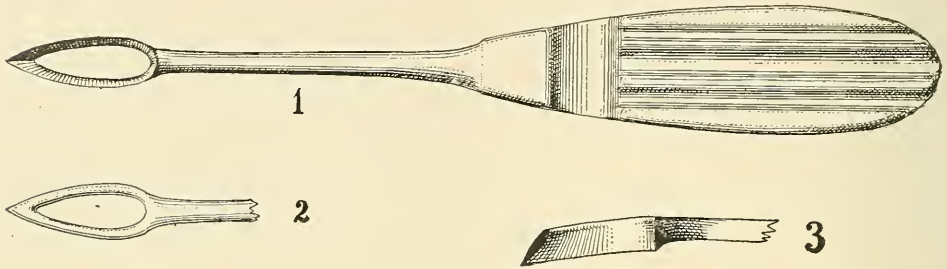
Fig. 41.—Dr. E. B. Bronson's Comedo Tool. 1, View showing cutting edge of curette and handle of the instrument; 2, the reverse side of the curette; 3, side view.

to play for five or ten seconds. A number of capillaries may be treated at one sitting. The tumefied lumps may also be reduced by this means.

Scarification is another means of cutting off the capillaries and reducing the swellings, and at the same time it empties the acne pustules and the overfilled sebaceous glands. The operation is performed by making a number of parallel incisions, about two millimetres deep, then cross-hatching them with similar incisions. A surface about the size of a nickel is thus treated at each sitting, and the sittings are held about one week apart, so that it takes a considerable time to go over the entire surface affected. After the scarification an ointment containing boracic acid should be applied to the part; no other covering is required. In nervous or timid persons one may, before operating, benumb the surface by applying a thin rubber bag containing mingled ice and salt.

The employment of the cautery secures the same result as that obtained by scarification. Thibierge uses the long thin needle of the galvano-cautery; he pushes it into the skin perpendicularly and deeply. The punctures are to be made close together, only three or four millimetres apart. After cauterization, a powder should be dusted over the part until the crust falls off. This treatment gives quick and excellent results.

Large nodes and tumors may have to be removed by excision.

LUPUS VULGARIS.

Tuberculosis of the skin appears in many forms, one of which, lupus vulgaris, is distinguished by its slow course and its superficial situation.

The primary element of lupus vulgaris is the lupus nodule. This appears first as a bright red spot, of the size of a pin's head and slightly elevated above the level of the skin. There is nothing characteristic about it, and it is only by observation that it is found to develop into a well-marked lupus tubercle. The fully developed lupus tubercle measures from one to four millimetres in diameter—that is to say, from the size of a bird shot to that of a buck shot—and is of a reddish or yellowish translucent color. It has been compared to a little mass of apple jelly lying in the skin. It is perfectly round, and is well marked off from the surrounding skin. It rarely projects above the surface, and it cannot be felt with the finger. The skin over it is thin, pellicle-like, and desquamates slightly, and the tubercle is quite sensitive to pressure. When the spot is touched with any pointed instrument, it will be found that the tissues are very soft, the instrument sinking readily a distance of a few millimetres. Lupus tubercles tend to form groups, and such a group of rusty-looking tubercles may exist for years—on the cheek, for instance,—giving rise to no discomfort, doing no harm, and not increasing either in extent or in number. Or each tubercle may undergo retrogressive changes, either with or without ulceration. In the latter case the lupus tubercle sinks in, because of the degeneration and absorption of the lupus tissue, and a little scar is left. A spontaneous cure is in this way possible, but very rarely occurs. These groups are of very variable size; sometimes they can be covered by the tip of the finger, and at other times they are much larger. Then, again, it is easily possible to distinguish the presence of several nodules in one of these groups. In still other cases there is so much redness that the nodules are hidden from sight unless the blood is squeezed out of the part by pressing on it with a glass or by putting the skin on the stretch. This mode of pressing the blood out of the tissues to be examined is an important method of diagnosis, for otherwise such a patch may be mistaken for lupus erythematosus, a totally different disease. The inflammatory reaction may be still greater, and the patch may swell up quite markedly above the surrounding skin, and be called lupus tumidus. The favorite location of such a group of tubercles is the face, as on the cheeks or about the nose. They can, however, exist in any part of the skin or on the mucous membranes. Each group tends to grow peripherally, and one can sometimes easily make out a slight circinate outline at the periphery of the patch, each such outline corresponding to a tubercle. As the patch spreads peripherally it cicatrizes in the centre, and then one finds a patch with a cicatrix in the centre and a red border, and in this border, or on its outer edge, the apple-jelly-like tubercles can be

made out invading the surrounding skin. Such a patch may readily be mistaken for one of syphilis, but it grows much more slowly, and it destroys the normal tissue much more slowly. Its tubercles are usually not perceptible to touch as are those of syphilis; they are more translucent and jelly-like, and appear more as if sunken in the skin; and, above all, the tubercles recur in the central scar, which never happens in the case of syphilis.

There is a form of epithelioma that is apt to be mistaken for this variety of lupus. The lesion is red and desquamating in its centre, and at its outer border there is an advancing, rounded, gristly ring of superficial epithelial infiltration. This ring or border is the positive distinguishing characteristic, and, of course, no lupus tubercles can be seen.

Some forms of lupus never ulcerate, but continue, throughout a period of years, slowly destroying tissue that is replaced by a scar tissue which resembles that which develops after burns. These non-ulcerating forms are more persistent, and are more difficult to cure, than the ulcerating forms of the disease.

The lupus ulcers result from the breaking down of lupus tissue; and lupus tissue may exist either in the form of tubercles, such as have been described above, or, more rarely, as a diffuse tuberculous infiltration that appears as a bluish-red or pale brown, low, flattened area not unlike that which is observed in lupus erythematosus, but smoother and firmer. The floor of a lupus ulcer is usually formed of red, rotten granulations that lie on a level with the skin or are elevated slightly above it. The surrounding skin comes sharply up against this granulating surface. The floor of the ulcer may, however, be depressed, and the edges steep or undercut and indolent looking. The edges of the ulcer are never hard and infiltrated as are those of a syphilitic ulcer, and it never has the kidney shape so common in lues. The lupus tissue, studded with tubercles, may spread peripherally, break down to form an ulcer, and then heal, so that one gets a central scar surrounded by a low shallow ring or ditch of ulceration, which in turn is surrounded by a ring of lupus tubercle or infiltration. This is sometimes called lupus serpiginosus. In some cases the granulations in a lupus ulcer may become very large, and form papillæ covered or not with epithelium—a variety to which the name lupus verrucosus is given.

Diagnosis.—Besides lupus erythematosus, syphilis, and epithelioma, the distinguishing characteristics of which have been already mentioned, there remain to be considered blastomycosis and granuloma coccidioides. As regards the former disease it may be stated that the infiltration at the edge of a blastomycotic ulcer is studded with minute pinhead-sized pustules, and the pus contained in these pustules, on being examined with the microscope, is found to be full of little budding spheres like the spheres of common yeast. Besides, in blastomycosis there are found, at times, below the eyes, characteristic crescentic ulcers, in which the horns of the crescent point upward. In granuloma

coccidioides there may be ulcers that simulate lupus verrucosus; but there will also probably be tomato-like tumors that are totally unlike anything seen in lupus, and the microscopical examination will show the presence of large double-contoured spheres filled either with granules or with smaller spheres—evidences which remove all doubt about the diagnosis.

Prognosis.—It is not an infrequent occurrence for some patches of lupus to heal spontaneously, but it is rare for all of them to heal in the same patient, although such an event has been known to occur. Good hygienic conditions and good general health are aids in bringing about this happy consummation.

Treatment.—The best treatment for a patch of lupus, where it can be carried out, is either to cut out the affected skin and sew up the defect or to fill out the defect with Thiersch grafts or with a flap taken from the neighboring skin. The technique, according to Lang, runs as follows: First clean the field of operation; but, in doing so, avoid rubbing the lupus tissue too vigorously, for fear of scattering about pieces of lupus tissue and tubercle bacilli. Make the circumscribing incision in sound skin, at least a centimetre beyond the border of the patch. If this be done after the parts have been benumbed by the employment of Schleich's method of cocaine infiltration, it will be well first to trace out the line of incision with fuchsin solution, as the infiltration tends to obliterate the boundaries of the disease. Then cut away the diseased tissue from above downward, so that the blood will flow away and not obscure the field. After the hemorrhage has been stopped through torsion, or by ligature of the bleeding vessels, or by means of compression, a thorough examination should be made of the under surface of the piece of tissue removed, and also of the floor of the wound, for the detection of disease foci. The defect may then be closed in one of the following ways: By sewing the edges of the wound together, if that can be accomplished; by laying in Thiersch grafts; by filling the gap with a piece of skin removed from some other region, and fixing it with sutures (Krause's plan); or by turning in a flap from the neighboring skin. If the Krause operation is chosen, the piece of skin to be implanted should be one-third larger in all its dimensions than the defect it is intended to cover. If Thiersch's method is adopted, the form of dressing advocated by Lang will be found serviceable. He applies over the part a sheet of perforated gutta percha, which is held down at the edges by treating it with chloroform, and then he places a mass of sterile gauze over all.

Excision can usually be more readily carried out on the extremities than on the face, where the proximity of the disease to delicate organs, such as the eyelids, may interfere. Then, again, the patient may object to such radical surgical measures for what often appears to him to be an insignificant disease that should be curable in some other way.

A sharp nitrate-of-silver stick is an excellent means of burning out the lupus nodules, and one can do a great deal with it if one knows how to search for

the nodules. The stick easily sinks through the diseased tissue. It is especially good for destroying the granulations on the floor of ulcers. It is, however, an exceedingly painful, bloody form of treatment, and, no matter how skilfully it may be used, many of the nodules are not destroyed by it. This is especially true of the nodules that occur in the hard cicatricial tissue.
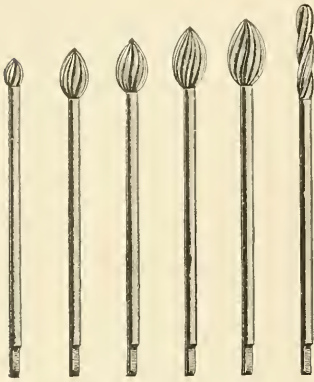
Dr. George H. Fox recommends a method of employing dental burrs dipped in carbolic acid. The burrs are sharp and fluted (Fig. 42), and the carbolic acid is retained in the fluting. The smallest visible lupus tubercle, situated in the toughest tissue, can be eradicated by this means. The steps of procedure are these: As soon as the presence of a tubercle has been discovered, there should be applied to the spot a droplet of carbolic acid, which acts as an anæsthetic. Then, after the acid has remained there undisturbed for a few moments, the burr should be inserted into the tubercle and twirled around several times between the thumb and index finger. As a means of rendering the lupus tubercle visible, it was my practice at first to use pressure with a glass, and then, on removing the glass, to guess at about where the lesion was. A better method still is to have an assistant put the tissues on the stretch, thus pressing out the blood and rendering the tissues pale. The tubercles are then easily seen and may readily be reached with an instrument.

FIG. 42.—Dental Burrs.

The sharp spoon can also be used for getting rid of soft infiltrations, but it is of less value in digging out the tubercles, as the surrounding sound tissue resists the spoon. It is a good thing to have different-sized spoons for this work: large ones for the large infiltrations, and small ones for the small lesions. (Fig. 43.) The ringed curettes are also good instruments for this work. The bleeding can be checked by compression with a sponge or with cotton. Tatters of tissue can be clipped off with the scissors. After the surface has been well scraped out, it is a good plan to go over it again with the Paquelin cautery, which

A B C

FIG. 43.—Different Patterns of Curettes. A, Unna's double curette; B, Piffard's curette; C, Hebra's curette.

stops the bleeding and at the same time destroys the tubercle bacilli. As the best form of dressing to employ after such treatment, Lang suggests

iodoform.   He warns the surgeon, however, to look out for iodoform poisoning, which is especially likely to occur in lesions about the face, because of the constant inhalation of the drug.   The Paquelin cautery and the galvano-cautery can also be used, but the objection to such use is that they afford no aid in determining when sound tissue is reached, and consequently the
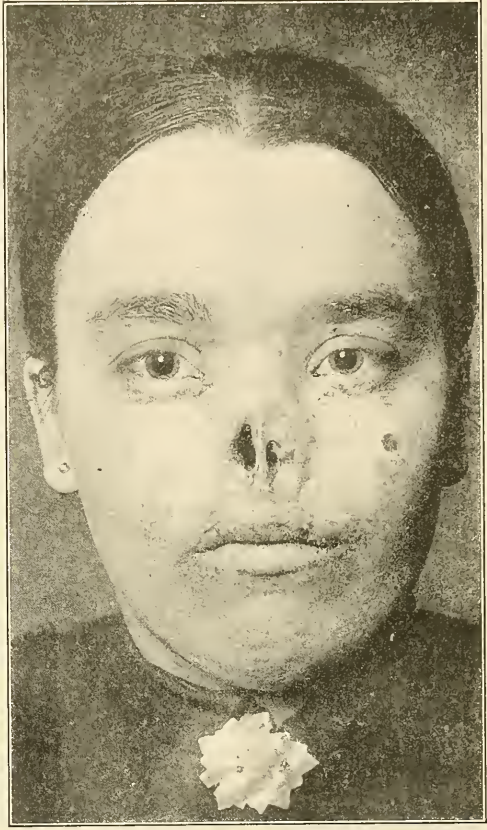
Fig. 44.—Case of Lupus Vulgaris of the Face, under Treatment with the Roentgen Rays. (Scholtz, in Neisser's "Stereoscopischer-medicinischer Atlas.")

Fig. 45.—The same case as that shown in Fig. 44, but at a later stage of the treatment. (Scholtz, op. cit.)

operator must use his judgment—an unreliable guide—in estimating how deep to go.

The *Hollander lamp* is an apparatus which enables one to force a current of air, heated to about 300° C., through a slender metal tube.   When this apparatus is employed in the treatment of lupus the tissues are burned and dried up by the current of hot air forced against them.   The objection to this plan of treatment is that it leaves tremendous scars.

The *pyrogallic-acid treatment*, as recommended by Jarisch, is carried out as follows:

It is best first to scrape the surface well, and then to swab it with a five- or even a twenty-five-per-cent solution of bichloride of mercury in alcohol. Then spread the pyrogallic salve on cloth and apply. This salve is made according to the following formula:

℞ Pyrogallic acid.. 5.00
   Lanolin 20.00
   Vaseline.. 30.00
M.

The dressing should be changed twice a day. From the fourth to the seventh day the surface will look swollen and discolored brown; and then an iodoform dressing should be applied until the slough is cast off and healing takes place.

Radiography.—There is no doubt that a marked amelioration of lupus can, in many instances, be attained with the Roentgen ray, and that it is a particularly welcome help where mucous membrane is involved. It usually, however, fails to effect a complete cure. (Figs. 44 and 45).

Phototherapy.—Niels R. Finsen introduced the light treatment for lupus vulgaris. At first, sunlight was used, but, later, the arc light displaced it, owing to the fact that it is stronger, steadier, and more efficacious. The light is collected with rock-crystal lenses, and is then passed through cool water to abstract the heat. As the blood hinders the light from penetrating the tissues, it is got rid of by pressure. After the sitting, the part treated appears reddened, and the inflammation reaches its highest point in from twelve to twenty-four hours. Blisters may form, but necrosis or other untoward results almost never occur. Whether it is the light or the inflammatory reaction caused by it that is the curative agent, is uncertain. The advantages of the treatment are its painlessness, its safety, its excellent cosmetic results, and the fact that the beneficial results are comparatively rarely followed by relapses. On the other hand, the wearisome length of the treatment, dragging on, as it does, for months and even years, constitutes a positive disadvantage. Of course, one is not bound down to light treatment alone, and any of the other methods of treatment may be used in combination with it. For instance, Finsen himself frequently began the treatment by using pyrogallic-acid salve, and then finished with the light treatment.

Multiple linear scarification, a modification of the Dubini-Volkmann method, was once claimed to have changed the prognosis of the disease. It is doubtful whether anything is to be gained by either a preliminary freezing of the part or the use of cutting instruments with many blades. The incisions may be produced with a delicate sharp-pointed bistoury held in the fingers like a pen. They should be made in parallel lines closely set together, and crossed. The cuts should extend completely through the depth of the lupus growth—a fact which can be determined, after some practice, by noting the cessation of the creaking resistance which the blade fails to elicit from normal tissue. Fur-

ther, these incisions should extend laterally beyond the borders of the lupus patch into the sound peripheral zone. The bleeding is trifling and may readily be arrested by firmly pressing small pieces of fine sponge, lint, or absorbent cotton over the part. The edges of the incision unite either by granulation or by first intention; and, in both these modes of healing, the incisions seem to serve as starting-points for the reparative process, the material for which, as already pointed out, seems to be supplied from the lupus nests themselves. Subsequent operations, when needed, require a previous freezing or benumbing of the affected part. In France and in some portions of the British Empire this method is still popular (Hyde and Montgomery). Undoubtedly good results can be gotten by this method, and it is especially useful in treating nodules on the lip and lower part of the nose.

SCROFULODERMA.

Under the term scrofuloderma are classed a number of tuberculous manifestations of the skin that follow tuberculosis of the deeper-seated organs. A nodule begins in the skin or, more frequently, in the subcutaneous tissue, gradually enlarges, and approaches the surface, and as it does so the overlying skin becomes livid red. Finally, the nodule opens on the surface and discharges dirty pus and cheesy masses, and forms a lazy ulcer or cavity with a small opening and overhanging edges. This cavity is lined with dirty, rotten, indolent granulations. The whole process is one of extreme slowness and torpidity. Scrofuloderma is particularly apt to follow tuberculosis of the lymph nodes, especially those of the neck, where it leaves characteristic deeply sunken, irregular scars.

The prognosis is not at all bad. The ulcers, after lasting a long time, may heal spontaneously, and, if they are well curetted and dressed with iodoform, they heal usually without incident. In some instances a lupus may take its origin from a scrofuloderma, and then the outlook for curing the affection is not so good.

In many respects resembling the above is an affection called

ERYTHEMA INDURATUM.

Symptoms.—In the beginning, erythema induratum consists of one or more indurated, pea-sized nodules that form deep down under the skin. As the induration grows and approaches the surface, the skin over it becomes livid red. The lesions are situated on the lower part of the calf and are rarely seen on the upper part of the legs, the thighs, or other parts of the body. The indurated patches, after a variable length of time (weeks or months), either undergo

absorption or break down into indolent sero-purulent ulcers, in which case the necrotic process involves the whole nodule. Usually there are only a few lesions, but occasionally they appear in larger numbers. The disease is of a chronic character, and, while some of the lesions may disappear, others are likely to come in successive crops.

This disease is seen chiefly in girls and young women who have to stand on their feet a great deal. It seldom attacks males or well-to-do people. It is believed by many to be of tuberculous origin.

Diagnosis.—Erythema induratum is to be differentiated from erythema nodosum by its indolence, its tendency to ulcerate, and its location upon the sides and posterior part of the leg; by its color, which never assumes a yellowish or bluish ecchymotic hue; and by its chronic course. It may be easily mistaken for a syphilitic gumma, from which it must be distinguished by the history of the case, the symmetry and multiplicity of the lesions and their slow chronic development, absence of pain, and the failure of antisyphilitic treatment.

Treatment.—First of all, the hygienic condition of the patient's life should receive careful consideration. Clean surroundings, fresh air, wholesome food, adequate clothing, and rest in a recumbent position are essential to insure a successful treatment. Tonics, such as arsenic, iron, strychnine, quinine, and particularly cod-liver oil, are needed in a majority of cases. Local applications are useless as long as there is no ulceration; but, after the tissues have commenced to break down, the ulcers should be washed, once or twice a day, with mild antiseptic solutions, such as boracic acid, or bioxide of hydrogen, to which Stelwagon advises the addition of resorcin (3 to 10 grains to the ounce). Before ulceration has begun, it may be well tightly to bandage the part, using compression upon the indurated patches; but, after ulceration has set in, the rules to be followed as regards bandaging and applications are not unlike those which are to be applied in the ordinary treatment of wounds.

TUBERCULOUS ULCER OF THE SKIN.

The tuberculous ulcer of the skin occupies about the same place in its relation to lupus as acute miliary tuberculosis of the lungs does to chronic phthisis. Furthermore, the patients who have a tuberculous ulcer of the skin are, as a rule, plainly suffering from advanced tuberculosis of the internal organs. The ulcer appears at or near the orifices of the body, as at the anus, vagina, vulva, or penis, where infection by passing bacilli may readily take place, while lupus occurs most frequently in people who otherwise enjoy good health, and is situated more decidedly on the free surface, as on the cheek or on the extremities. Tubercle bacilli, which are so difficult to find in lupus, are often readily found

in a tuberculous ulcer. An ulcer of this nature may come straight up through the skin from an underlying tuberculous bone or testicle, or it may spread by contiguity from a tuberculous ulcer of the mucous membrane, or it may occur independently on the free surface of the skin. The disease may appear as a flattened ulcer with little surrounding infiltration. The floor of the ulcer is covered with soft, reddish-yellow granulations, or with large papillæ. The edge is jagged and slightly undermined, and often one finds in it miliary tubercles that appear as little yellow nodules. The discharge is thin, scanty, and purulent. In other instances the infiltration is quite decided, forming a large, hard, raised border, and the floor of the ulcer is covered with large papillæ. The tuberculous ulcer of the skin is very painful and grows very slowly. It rarely attains any considerable size, principally because those so attacked die before the ulcer has time to grow large.

Partial healing is of not infrequent occurrence; spontaneous complete healing is rare, but may occur.

The form of treatment to be adopted must vary in individual cases. In instances of advanced tuberculosis it may be advisable only to still the pain by pencilling the surface with cocaine in 5-, 10-, or 20-per-cent solution. In other cases the ulcer may be burned out with the thermo-cautery or cauterized with lactic, carbolic, or pyrogallic acid. Under still other circumstances, especially when the general condition of the patient is good and the situation of the ulcer permits, it may be better to extirpate the ulcer with the knife, or to curette it well and then burn the base with pure carbolic acid.

CADAVERIC TUBERCLE.

(*Verruca Necrogenica.*)

Attendants in post-mortem rooms, or, more rarely, those who have to do with the bodies of animals, are subject to this disease, which occurs on the hands, especially on their dorsal surface. It is a wart-like infiltrated patch of a livid red color, and covered with thickened and fissured epidermis. It grows slowly and may reach the size of a half-dollar, but is usually smaller.

The affection should be well curetted and the surface burned with pure carbolic acid. It is also said to heal under emplastrum hydrargyri when applied for a long time (Lesser).

LUPUS ERYTHEMATOSUS.

The primary element of lupus erythematosus is a small, red, smooth, shiny papule. The papule is flattened at the top, and slowly and steadily grows larger, both from its own growth and by confluence with others. It may remain like this for a long time, forming more or less irregular patches. It may also,

after a time, fade away, leaving no trace, or it may leave a scar, or it may develop into some one of its other forms.

Instead of remaining stationary as a red patch, or fading away, the patch may sink in at the centre and spread at the periphery, and the sunken centre may become covered with a tightly adherent dry crust, while the mouths of the sebaceous glands become large and patulous, and fill with sebaceous plugs. The sunken centre often turns into a cicatrix, while the elevated, red peripheral edge, covered with a rough dry, tightly adherent crust, slowly extends, forming by confluence with other patches gyrate, irregular outlines which enclose a more or less cicatricial centre. Sometimes such a patch will spread from the nose out over the cheeks to form the well-known figure of a bat with outstretched wings. The disease is eminently slow in its progress. It is not spontaneously painful, but the affected part may be quite tender. It almost always occurs on the face, but may appear on any part of the body, and there is one rare form of the disease which is widely disseminated. Lupus erythematosus is not an infrequent disease in women, but is quite rare in men; it usually occurs in adults. In its course it is one of the most erratic of diseases, and one never knows when it is going to progress, to come to a standstill, or to clear up with or without scarring.

The nature of lupus erythematosus is unknown, but there is reason to believe that it is an angioneurosis. It has probably nothing whatever to do with either lupus or tuberculosis.

Diagnosis.—An erythematous lepride may simulate lupus erythematosus exactly, excepting that an erythematous lepride will almost surely have disturbances of sensation such as anæsthesia, analgesia, and insensibility to heat and cold, while lupus erythematosus is free from all errors of sensation excepting occasional tenderness. Psoriasis, especially of the face, may look strikingly like lupus erythematosus. By examining other regions, however, one almost always finds typical patches of psoriasis. Psoriasis of the face or scalp does not leave scars as lupus erythematosus does, and the scales are fluffy and not so adherent. A late syphilide is usually rapid in its progress, more infiltrated, and is apt to leave deeper scars than lupus erythematosus, and there is no implication of the sebaceous glands.

Treatment.—The vicissitudes of treatment are as marked as is the erratic course of this strange disease. At times, almost anything will cure it, and at other times nothing appears to exert the slightest beneficial effect. It can be asserted positively that no internal treatment, aside from paying attention to any existing disorders of the alimentary tract, has the slightest influence on its course. As regards external treatment, soothing remedies only are to be applied during the acute stage. When, however, the disease has slowed down to the chronic stage, stimulating remedies are often followed by the greatest benefit.

In the acute stage oxide-of-zinc ointment, with or without an addition of

two per cent of ichthyol, often proves beneficial.   Soothing lotions may also be applied, such as Hutchinson's, which is composed as follows:

℞   Liq. plumbi subacetatis 20.00
     Liq. carbonis detergentis 100.00
M. S. A teaspoonful in 500 c.c. of hot water, to be used as a lotion.

When the process has reached a more chronic condition, either mercurial plaster or mercurial ointment may be applied with good effect; and when the disease becomes thoroughly chronic, a still more stimulating line of treatment may be adopted.   Green soap may be used in the form of spirits of green soap, to be well brushed in every night; or, when a greater reaction is desired, green soap may be used as an ointment, by spreading it on flannel and applying it to the affected part.   The consequent reactive dermatitis is to be treated with mild salves, such as oxide-of-zinc ointment or boracic-acid ointment.

Good effects are sometimes obtained by cauterizing the surface with carbolic acid or trichloracetic acid.

The Finsen light is a good stimulant, and probably has no other action. It should be given in ten-minute sittings, ten days apart.   Sabouraud hopes more from the treatment by the x-ray than from any other method.   Some, including Sabouraud, think it should be given in large dosage, sufficient to cause a violent dermatitis that heals in from three to five months and leaves a scar.   Others advise a milder and more prolonged treatment.

BLASTOMYCOSIS.

Symptoms and Etiology.—The initial lesion in blastomycosis is a papule which, however, seldom comes under observation.   This develops into an ulcer, which may become quite extensive.   When the crust of the ulcer is removed, a deep red granulating mass is exposed.   This mass rises above the surface of the skin, has sharp elevated borders and a floor thickly set with small, deep abscesses, and exudes a sero-purulent secretion.   There are no general symptoms and no pain.   The beginning of the trouble is often the result of a traumatism (plus infection).

The disease is caused by a yeast fungus which is easily discovered by examining under the microscope either the contents of one of the abscesses or a piece of involved tissue.   It is necessary to macerate the specimen for ten or fifteen minutes in liquor potassæ before examining it.   The parasites are spherical, double-contoured, refracting bodies, from ten to twelve microns in circumference; they appear in pairs or in groups, and are seldom isolated.   Some of the organisms are seen budding.

Diagnosis.—The history and course of the complaint will dissipate any

thought of its being of a syphilitic nature. The morphological similarity between blastomycosis and lupus verrucosus, lupus vulgaris, or epithelioma, is at times so close that the diagnosis cannot be made without the aid of the microscope, cultures, or animal inoculations.

Prognosis and Treatment.—Potassium iodide administered internally may improve or even cure the disease. The lesions themselves may be curetted or cut away with the knife. The resulting wound should be treated on common antiseptic lines. It must be borne in mind, however, that the disease is of a very obstinate nature, and consequently the treatment is likely to act slowly, and occasional relapses must be expected.

The main part of the work on this quite recently discovered disease has been done by Hyde and Montgomery, of Chicago, and for a more detailed account of it, as shown in the cases reported, their articles should be consulted.

GRANULOMA COCCIDIOIDES.

Granuloma coccidioides has a very restricted field of interest, as the disease has been observed only in Buenos Ayres and in California. It is caused by a vegetable parasite which very probably is acquired by inoculation, and the effects which it produces on the tissues present the closest resemblance to what is observed in tuberculosis. The disease, however, affects the tissues more actively than tuberculosis does and it runs a quicker course.

On the skin it gives rise to flattened papules resembling somewhat the flattened papules of syphilis, for which the disease may be mistaken; or it may give rise to large tomato-like excrescences having rotten centres, rounded borders, and constricted bases—lesions resembling those of a vegetative character which are sometimes observed in poisoning by potassium iodide and in mycosis fungoides. These are to be diagnosed from the potassium-iodide lesions by the fact that the patient is not taking the drug, and from the lesions of mycosis fungoides by the absence of the itchy, eczema-like patches that precede and accompany the excrescences in this disease. (Fig. 46.) In the tissues themselves the fungus causes granulomatous tumors that break down in the centre into large abscesses with liquid contents. There may be many of these abscesses, below the skin, while the skin itself is perfectly sound and intact over them (Fig. 46); and, when this is the case, it is a very easy matter to mistake the lesions for the cold abscesses found in tuberculosis. In fact, when a diagnosis is attempted, tuberculosis is the one usually arrived at. In the internal organs the disease acts in the same way. In the lungs, for instance, it can exactly simulate tuberculosis with bronchorrhœa and the formation of cavities. The disease shows a great tendency to affect the lymph nodules. Its course is almost always fatal.

The treatment is entirely surgical, as no medicine has yet been found that exerts any influence on the affection. The lesions may be curetted and their bases burned with some caustic, such as carbolic acid. Dr. Samuel Gardiner secured a cure in one case by amputation of the affected foot. In this case the bones of the ankle were affected in such a manner as to give the clinical appearance of tuberculosis. Dr. Weil also secured a cure by treating the case

Fig. 46.—Case of Granuloma Coccidioides. (Original.)

just as he would one of actinomycosis. He curetted the lesions and then swabbed the cavities with tincture of iodine.

MYCETOMA.

The disease is usually seen on the foot, and begins as a papule or a subcutaneous nodule, which increases in size. Some œdema is present from the beginning, and soon the foot presents a tumefied mass studded with a large number of discharging nodules from which sinuses lead down into the deep tissues and into the bones. The discharge is red, gray, or dark-colored, viscid,

fœtid, and contains minute red, gray, or dark granules looking at times like fish spawn. Sometimes pustules, vesicles, bullæ, abscesses, and ulcers form on the tumefied organ as a result of secondary infection of various kinds. In cases of long standing, the bones are always involved and deeply eroded. Exceptionally, the seat of the disease may be the hand, knee, shoulder, toe, or other parts of the body. There is little or no pain. The general health is impaired only at a late stage of the disease. The course of the disease is essentially chronic and may end fatally.

Etiology.—The disease is caused by a fungus which has some affinities with the ray fungus or actinomyces. Inoculation takes place through traumatism, and, as a matter of course, those who walk barefooted are the usual victims. Thus, it is a disease of the poor classes, and is seen chiefly between the ages of twenty and fifty.

Treatment.—Mycetoma is an incurable affection. In early stages curetting may do some good, but in a fully developed case the affected organ (toe, foot, hand) should be amputated well up above the diseased area.

ACTINOMYCOSIS.

Actinomycosis is an infective disease common to man and the domestic animals, and is caused by the ray fungus or Streptothrix actinomycotica.

Actinomycosis occurs usually in the lower jaw, or in the neck as an extension from the lower jaw, or in the internal organs, and but rarely in the skin excepting as an extension from some of the deeper structures. In a collection of 1,094 cases reported by Ruröh, 56 per cent attacked the head and neck, 20 per cent the digestive tract, 15 per cent the pulmonary organs, and only 2 per cent the skin.

Actinomycosis of the skin may appear as an ulcer with a necrotic centre surrounded by a hard, firm granular zone, or it may appear in the form of tubercles, with central cicatrization and peripheral extension, as in lupus. Lesser thinks that many cases reported as lupus, in which the tubercle bacillus was not found, may really have been cases of actinomycosis. The board-like induration, the glossy nodules, and the absence of lymphatic involvement are striking characteristics. On the face the trouble may be mistaken for rodent ulcer. In actinomycosis the granulations have a small bleb-like appearance. The demonstration of the fungus clears up the diagnosis. The disease foci may form, in some cases, small abscesses that appear as papules countersunk in the skin. Some of these papules show a purulent top, and, when they are broken into by exploration, the sound sinks farther than expected into rotten tissue. This tissue may be dug out, hardened, and cut for microscopical examination, by which means the presence or absence of the fungus may readily be determined.

In the pus of actinomycosis are found small yellowish bodies, which vary in size from an object so small as to require a magnifying glass for its demonstration, to one as large as a pin's head. These are called the sulphur granules, and are an important diagnostic feature. The pus is usually greenish-yellow, glairy, and like mucus, and, if smeared upon a glass with a black background, the above-mentioned granules become more apparent. The granules crush easily and may be teased out in normal salt solution for microscopical examination. The actinomycotic body has often an irregular kidney shape, with a gray, granular-looking centre and lines radiating toward the periphery. It has been compared to a chrysanthemum or a daisy. These bodies stain with eosin or with picrocarmin. For careful study the Gram-Weigert method is the best. The bodies are best seen by far in the tissues, where they contrast well with the surrounding small-celled, inflammatory infiltration.

The prognosis of actinomycosis of the skin is good because the disease is easily reached for treatment, and because it has a tendency to spontaneous recovery which is common to all the forms of actinomycosis. Actinomycosis of the skin, when it is secondary to a deeper-seated disease, does not warrant so favorable a prognosis.

Treatment.—The one drug that seems to have a marked effect upon the disease is potassium iodide. In some cases a cure has been reported from the use of this drug alone, and it is therefore advisable to employ it in all instances. A large, seemingly inoperable infiltration will melt down under its influence, become much more restricted in its field, break down into an abscess in the centre, and so become much more amenable to surgical treatment.

Gautier reports a case which he cured by injecting a solution of potassium iodide and then passing the electric current through the tumor. Biegler used the bacterial proteids of the Streptococcus aureus in a case in which the neck was involved, and he cured it with twenty-four injections.

When the lesion is limited and well-defined, complete removal, followed by the use of the thermo-cautery, is the best treatment. When the lesion is diffuse or when the tissue attacked cannot be removed because the operation might endanger the life of the patient or might interfere seriously with some important organ, such as an eye, a thorough curetting and subsequent swabbing with tincture of iodine will be found an effective treatment. This procedure frequently has to be repeated several times before a definite cure is obtained. Everything should be done to put the patient under the best possible conditions in regard to food and environment.

GLANDERS.

Glanders, farcy, malleus, or equinia is an infective disease caused by the Bacillus mallei.

As this disease is almost always acquired from horses it is most frequently found in stablemen, jockeys, cavalrymen, and veterinary surgeons.

Equinia manifests itself in a great variety of forms. In the present article we have principally to do with the lesions and symptoms that are observed when the disease involves the skin. In many cases the part played by the skin is very unimportant, but in some cases the skin lesions are so marked that all other symptoms sink into insignificance beside them.

There are two forms of the disease—an acute and a chronic. The affection may be chronic from the start and may maintain this character through its whole course. Then, again, it frequently happens that the acute develops out of the chronic form. The reverse, however, never seems to take place—the chronic does not supervene on the acute.

In the form which is due to inoculation, the disease may commence as a local affection, and remain so, healing completely after a time; or it may become generalized. The first symptoms observed, however, may be those of generalized glanders, and this is especially seen when the malady is acquired by infection.

The point where inoculation takes place is frequently located in the skin, principally in that of the hands or face, where the virus enters through some wound. This wound may at first heal entirely, but, as the time of incubation is short (from three to eight days), the injured part swells and becomes painful, vesicles having sero-purulent contents develop, the tissues break down, and a ragged ulcer forms. This ulcer, as above indicated, may run a local course, healing in time and producing no general effects. Then, again, as the virus has an especial preference for the lymphatics, it may spread around in the connective-tissue interspaces of the skin which are the radicles of the lymphatic vessels, and cause a widespread redness and œdema of the integument, very much like what is seen in erysipelas. The virus, having entered the lymphatic radicles, may next run along the lymphatic vessels and cause them to swell until they resemble cords. Afterward, it may reach the lymph nodes, which then become enormous. The affection of the lymph nodes is so constant as to have given rise to one of the names of the disease—glanders. The generalized toxic effects of the malady now appear, viz., elevation of body temperature and sometimes chills. The dominant symptom, however, is usually extreme weakness, accompanied by headache, nausea, anorexia, and diarrhœa. If these symptoms appear in a patient in whose case the malady has been acquired by infection, they may be mistaken for typhoid fever. Sometimes

there are pains, in the muscles or joints, of such severity as to simulate acute articular rheumatism.

The mucous membrane of the nose is generally, but by no means always, affected. The affection of the mucous membrane occurs early in the course of the disease, and, when present, is an important diagnostic feature. There is at first an uneasy sensation in the nose and pharynx, accompanied by a glairy discharge and sometimes epistaxis. Soon the discharge becomes muco-purulent, and either streaked with blood or of an even brown color. It is viscous and sticks to the nostrils and to the lips, thereby excoriating them. The mucous membrane of the nose is red, excoriated, and sometimes even ulcerated, and the ulcerations may go on to the destruction of cartilage and bone.

Erysipeloid Malleoderma.—In glanders, or malleus, there are two forms of diffuse inflammation which bear a certain resemblance to erysipelas. There is, first, the diffuse erysipeloid inflammation, which follows shortly after the inoculation of the virus; and then, in addition to this, there is in acute glanders another form of diffuse dermatitis which also resembles erysipelas. This dermatitis occurs on the face and is accompanied by a hard œdema. It is not so well limited as is true erysipelas, nor has it the advancing border so characteristic of that disease. The nose becomes deformed and the cheeks tumefied. The eyelids become swollen to such a degree as to close the eyes, and a purulent fluid escapes through the eye-slits. The inflammation may run up on the forehead and even into the scalp. Vesicles, bullæ, and even gangrenous patches soon appear.

Pustular Malleoderma.—This eruption usually appears early in acute equinia—say, from the ninth to the twenty-fourth day. There are at first red macules that develop into whitish, acuminate, firm papules, and these in turn become pustules. These pustules are not umbilicated; they are generally discrete, but may become confluent and form large purulent patches. The favorite situations for this rash are the extremities and the face, particularly the conjunctivæ, the mucous membrane of the nose, the tongue, the palate, and the tonsils.

Furuncular Malleoderma.—These furuncles may appear on the sixth or seventh day of acute equinia. Sometimes they appear in the form of indolent tumefactions covered with a pasty, soft skin of normal color; at other times the skin is hard and violet-red. The tumefaction itself is painful, and contains blood or a red gummy substance. The furuncles may open and form ugly ulcers, with a necrotic floor. They comport themselves very much like the deeper and larger abscesses of chronic equinia.

Chronic Equinia.—Chronic equinia is characterized, in the first place, by the formation of abscesses. From three to five abscesses will appear, and afterward there will be an interval in which none are formed; then another attack will take place, and so on. Some of these abscesses form rapidly, while

others grow with exceeding slowness. Their favorite situation is on the limbs, especially near the joints. They may also appear on the face, and sometimes they show themselves, though infrequently, on the trunk. The abscesses on the face vary in size from that of a pea to that of a hazelnut, but on the limbs they are often much larger. After they have ulcerated through the skin they discharge their contents, which may be purulent or may consist of pus mixed with blood or a yellowish viscid fluid, often called farcy oil. The ulcers formed by the opening of these abscesses—or nodules, as they are called when small— may heal, or they may grow larger, and, uniting with others, form circinate figures resembling those of a syphilitic ulcer. The edges of the ulcer are violet-colored, ragged, soft, and velvety, and the floor is dirty and gangrenous.

The affection may go on slowly and without remission to the end, or there may be spells when the malady may seem to have come to a standstill or may even appear to be cured, only to break out again. It is even said on good authority (Babès) that the disease may remain latent, not only for months, but even for years.

In the cases which terminate fatally the disease, toward the last, advances rapidly, in the form of an acute glanders.

Diagnosis.—In acute glanders the rise of body temperature, the headache, nausea, chills, and diarrhœa may lead to a diagnosis of typhoid fever. If the muscular pains are very severe, as they are apt to be, it may be thought that the case is one of acute articular rheumatism. When the glandular swellings, the nasal symptoms, and the eruptions appear, the nature of the disease becomes clear.

Erysipeloid malleoderma may be mistaken for erysipelas; pustular malleo-derma for a pustular syphilide or for smallpox; and furuncular malleoderma for furunculosis. The chronic nodes, particularly when occurring on the face, are usually taken for a syphilide, or for a peculiar form of tuberculosis. When suspicion is aroused the physician is likely to make an examination for the bacilli, but the best test is to inject some of the discharge into a male guinea-pig, and then to look for the characteristic enlargement of the testicle from orchitis. The pus from the guinea-pig's testicle may be examined for glanders bacilli by staining with Gram's method, and also by making cultures on potatoes, on which they form honey-like, brownish colonies. So far as may be judged from the experiments on horses, the effects of mallein seem to be too uncertain to be useful as a means of diagnosis.

Prognosis.—The lesion that develops at the point of inoculation may sometimes be thoroughly eradicated by the active use of the thermo-cautery. Many of the instances in which recovery has followed closely on inoculation were probably not glanders at all, but simply wounds infected with some other poison while the patient was handling or dissecting a glandered animal. Acute generalized equinia is a uniformly fatal disease. Recovery from chronic

generalized equinia, while possible, must be rare. The knowledge that the disease may remain latent for a long time prevents us from positively predicting a cure in any particular case.

Treatment.—There is no specific treatment for equinia. The local manifestations are to be treated surgically by incision, the thermo-cautery, antiseptic douches, and dressings. The general hygiene of the patient is also to be looked after and tonics are to be given.

MALIGNANT PUSTULE.

Definition and Etiology.—Anthrax, the disease caused by the bacillus anthracis, arises from the entrance of anthrax bacilli or their spores into the body. When these organisms are implanted in any of the exposed surfaces of the body the primary lesion can be seen, and it is called either malignant pustule or external anthrax or inoculation anthrax. When the disease gains an entrance into the body through the walls of the intestinal canal or through the respiratory tract, it is called internal anthrax.

The lower animals get anthrax almost entirely from eating fodder containing anthrax bacilli or spores, or from snuffing up and drawing in with their breath dust containing these micro-organisms. Infected material is taken into the stomach of herbivorous animals, and the bacilli are killed by the stomach juices, but the spores are more resistant and pass along unharmed into the intestinal canal, where they flower out into bacilli in the warm alkaline fluids. It is not necessary that there should be a wound or ulcer of the intestinal mucous membrane in order to get a successful implantation.

As in the case of man the disease is practically only caught from the lower animals or from their products, it almost always occurs in those who have the care of animals, or who handle their products, and W. Koch has stated the question categorically as follows:

The immediate cause of infection can lie:

1. In association with infected animals or in contact with their bloody mucus or excrements (hostlers, farm hands, and shepherds).

2. In handling infected cadavers, as in skinning cattle, dressing meat, performing post-mortem examinations.

3. In working up industrially the raw products of infected animals, as in the case of tanners who work on hides, of upholsterers who work on horsehair, of wool sorters, of soap boilers who work on tallow, and of glue makers who handle hoofs, horns, and bones. In factories and packing houses, where raw animal products are handled dry, the micro-organisms may rise as dust, be respired, and produce internal anthrax of the lungs.

4. In contact with materials that have been made from infected animals— as with leather, for tanning does not kill the infection. In this way saddlers,

harness makers, and glovers may acquire the disease. In the recent Russo-Japanese war, Russian soldiers have become infected through the sheepskins, which, with the wool attached, were furnished as lining for their coats.

5. In eating infected meat, in drinking milk from infected animals, or in eating butter or cheese made from such milk. The infection in this class of cases can occur on the fingers or lips or in the intestinal tract.

6. In being either bitten or stung by insects that have been in contact with infected animals or their products—such as flies, horseflies, etc.

7. In rarer instances the infection can be conveyed from man to man, as from the patient to the nurse, or from the cadaver to the person performing the autopsy. A man may be the means of conveying the virus to another man without himself becoming infected. Infection, however, takes place more easily through a wound, no matter how small it may be, although experiment teaches that the germ can enter through the intact skin, as through the hair follicles.

Symptoms.—The time of incubation between the infection and the appearance of any symptoms is usually two or three days. It may extend, however, even to eight days (R. Frank). The first symptom is a small, red, itchy spot almost always situated on some exposed surface, such as the face, neck, or back of the hands. The patient thinks it is an insect bite, which it resembles. Shortly, in the centre of this red spot there develops a papule, which quickly turns into a flaccid pustule with yellow or dirty-reddish contents. This pustule itches and burns quite severely. It is rarely, however, seen by the physician at this stage, as the patient does not then attach enough importance to it to seek advice; he waits, as a rule, until the lesion has assumed the characteristic appearance of a malignant pustule. By this time there is a central necrosis that looks like a depressed black scab surrounded by a wreath of vesicles, the whole lying in a bed of intensely inflamed, indurated skin. These vesicles in their turn become pustules, which dry up and form a part of the central necrosis, and at the same time new vesicles continue to form in the periphery. In this way a malignant pustule may vary considerably in size, some of them being no larger than a pea, while others attain the dimensions of a walnut. Around the indurated bed of the lesion there is usually much œdema. This surrounding œdema is also of variable proportions, a very small pustule sometimes giving rise to very extensive œdema.

The lymphatic system is readily invaded by this disease. Thus, for example, there are often seen red stripes running from the lesion, and with these stripes, which indicate the course of the lymphangitis, there are associated swelling and tenderness of the nearest lymph nodes.

As a rule, there is only one malignant pustule, but there may be several, even as many as ten, and they may develop in such a way as to indicate the possibility of their being auto-infections (R. Frank).

Malignant pustule is at first a local disease, and may remain localized. In fact, the human being is so resistant to the virus that an abortive course is frequent, and by the third day the malignant pustule may cease to advance, and a line of demarcation form around the necrotic centre. The resulting slough is gradually thrown off by suppuration and the ulcer heals by granulation. This favorable turn of events may occur very suddenly; and even in advanced cases, where the swelling of the lymph nodes is marked, the inflammation may subside and the patient may recover. Malignant pustule is, therefore, hardly deserving of the adjective malignant, as contrasted with the other manifestations of anthrax; indeed, it constitutes the most benign form of this disease, much more benign than the internal infections.

As long as malignant pustule remains a localized disease it causes little inconvenience. The necrotic centre often does not give rise to pain, and there may be pain and itching only when the new vesicles appear. But toward the third or fourth day, if the disease tends to become generalized, constitutional symptoms manifest themselves. The whole lesion takes on greater activity, the necrotic centre becoming larger, the surrounding œdema and induration spreading, and the lymphatic involvement becoming more marked. The local affection may cause extensive sloughing and gangrene.

This advance of the local affection is accompanied by a rapid rise of temperature. The tongue becomes dry and hard. The thirst is insatiable and there is a burning skin. The pulse is small, feeble, and irregular, and the patient is affected with a horrible anxiety. Before death there are colliquative sweats, syncope and delirium, and the body temperature falls below normal.

Anthrax-œdema is another form of primary anthrax of the skin which gives a totally different picture from that described above. This begins most frequently on the eyelids, particularly on the upper eyelid. It may, however, arise on any other part of the face, on the neck, on the trunk, and rarely on the extremities. It is characterized by a soft, doughy, rapidly advancing, well-marked œdematous swelling of the skin and of the subcutaneous tissue, reaching down to and in between the muscles. At first, the skin is either quite pale or reddened (anthrax erysipelas, phlegmonous anthrax), but later it becomes bluish-red. The œdema is often translucent and tremulous, particularly where the skin is thin and the connective tissue is wide-meshed. After a time it becomes harder and the skin more tightly stretched. At the point where the œdema started there break out small flattened bullæ with serous contents, which cause intense itching, and in which large numbers of anthrax bacilli can be found (R. Frank).

When these bullæ break they sometimes expose a hemorrhagic cutis, which grows harder, dries down into a crust, and becomes surrounded by vesicles, so that, secondarily, the picture of a primary malignant pustule may be presented. In these cases the œdema spreads rapidly and the fever runs high.

In fact, the constitutional symptoms set in early and are severe, and the patients frequently die in about eight days, in collapse, and showing the symptoms of acute sepsis. The œdema may be followed by very extensive gangrene of the affected skin and by involvement of the lymphatic channels, as shown by the red stripes and swollen nodules of lymphangitis. Sometimes, however, a milder course is pursued, particularly where the disease attacks the eyelids, and in such cases the patient may recover either spontaneously or under treatment.

Anthrax-œdema may also appear in the mucous membrane of the mouth or of the pharynx or of the lungs. When it attacks the mouth or the pharynx there is interference with breathing and swallowing, and death quickly follows.

Along with primary anthrax of the skin there may also be coincident and independent primary anthrax of the lungs, of the stomach, or of the bowels.

In anthrax of the bowels, in the advanced stages of the disease, there may be secondary eruptions on the skin. These consist of small or extensive hemorrhages, of bullæ with serous and bloody contents, and of phlegmonous inflammations.

Diagnosis.—The first manifestation following the inoculation of the anthrax bacillus—the itchy, uncomfortable red spot—looks and feels like the sting of an insect. A little later it resembles a severe furuncle, and if one lived in an anthrax country or was passing through an anthrax epidemic one might readily suspect the true nature of the lesion. Otherwise, the diagnosis would probably be overlooked, for it is not always easy to bear in mind the fact that in anthrax there develops, at the apex of the swelling, a flaccid vesicle with turbid contents, whereas in furuncle the lesion at the apex is a pustule with rich yellow contents. If some doubt, however, should arise in the observer's mind, it is very likely that a correct diagnosis will be speedily made. The steps required are these: A little of the fluid of this vesicle should be spread on a glass slide, dried over a gentle flame so as not to burn it, stained with almost any of the anilines either in watery or in alcoholic solution, and then washed off. Next, a drop of glycerin or Canada balsam is to be added, a cover glass applied, and the specimen will then be ready for examination under the microscope. The diagnosis is easily made, as the characteristic bacilli are present in abundance at this early stage of the malignant pustule. The large bacillary bars (from 1 to 1.5 microns broad and from 3 microns to 20 microns long) are readily stained and easily seen, even with a dry lens of moderate power. If the suspected case should come under observation in the country, away from all conveniences, the physician can easily bring home a specimen between two pieces of window glass, and a staining fluid can be improvised by dissolving a piece of aniline pencil in water. When the malignant pustule develops still further, and has a black necrotic centre, surrounded by a wreath of vesicles, situated on an indurated base, and surrounded by widespread œdema, the pict-

ure is so characteristic as scarcely to be mistaken for anything else. One may make an error in being over-scientific. During the first few days the bacilli are easily demonstrable, then broken ones and involution forms appear, and in a short time no trace of them can be seen. It is therefore not unlikely that, after the disease has reached a certain stage, the anthrax bacilli may be sought for and only pyogenic bacteria or streptococci found.

In the effort to establish the diagnosis, it is very important to ascertain the occupation of the patient and also whether he may be living in an anthrax neighborhood. Then, again, as regards the likelihood of mistaking malignant pustule for furuncle, it is to be noted that the course of furuncle is much slower, and that the lesion is much more painful and also is frequently much larger than that of anthrax. The furuncle is not so œdematous, it has at its tip the characteristic yellow plug, and the examination for bacteria shows only cocci. There are furuncles, however, that look strikingly like malignant pustules.

The distinguishing features of carbuncle are the characteristic sieve-like openings, each with its necrotic plug, the very great pain, the finding of only cocci, and the much slower course of the disease. At the same time it must be remembered that, in some instances of carbuncle, where the centre dries down into a gangrenous crust, the lesion presents a striking resemblance to malignant pustule.

Anthrax œdema may simulate diffuse phlegmon. It usually occurs, however, on the face and trunk, whereas diffuse phlegmon does not frequently occur in these localities. Anthrax œdema develops in the first part of its course in the skin, while diffuse phlegmon quickly penetrates deep down between the muscles, and is much firmer than the œdema of anthrax. The œdema of the skin in anthrax is much more extensive and advances more rapidly. The formation of itchy and painful vesicles and bullæ, which is so characteristic a feature of anthrax, is not present in phlegmon. In the latter disease it is only in the later stages that the skin rises up in large bloody, serous bullæ, as a consequence of the great tension of the tissues. Phlegmon is much more painful and tender than anthrax, and gangrene of the skin does not take place so early, nor is it so extensive. On incising a diffuse phlegmon there is at first only a clear serous discharge; soon, however, this discharge assumes the character of a sero-purulent or a sero-ichorous fluid, whereas in anthrax only œdematous fluid is found.

Erysipelas differs from anthrax œdema in the following respects: Erysipelas begins with a chill followed by fever, whereas the high fever of anthrax œdema comes on only after the development of the œdema. In erysipelas there is the characteristic, slightly raised, bright red border. The accompanying œdema is much less in erysipelas than in anthrax œdema, and is confined to the reddened surfaces. In anthrax œdema the redness has no distinct border, and gradually fades off into the surrounding surface, while the œdema spreads far beyond the reddened skin.

The diagnosis between malignant pustule and glanders is at times diffi-cult, and the only way of deciding the matter may rest upon a bacteriological examination or on animal inoculations. In glanders ulcerations that develop early, and persist, are a much more prominent feature than in anthrax.

Prognosis.—In general, the prognosis of external anthrax is good, far better than that of internal anthrax. In internal anthrax, there are early con-stitutional disturbance and early generalization of the disease by way of the blood, whereas in external anthrax the disease is frequently capable of arous-ing such a high degree of reaction that it is stopped in its advance, becomes localized, and quickly burns itself out. Goldschmidt, for instance, has reported only three deaths in thirty cases of untreated malignant pustule, and it is the belief of R. Frank that the mortality runs from ten to twenty per cent. The prognosis in anthrax œdema is much graver than in well-marked malignant pustule.

The part of the body in which the disease is located has also not a little to do with the prognosis. The outlook for a malignant pustule on the extremities is much better than it is for one that is situated on the head, the neck, or the trunk. According to Nasarow's statistics, quoted by R. Frank, malignant pustules situated on the—

Head or face give a mortality of............................. 26.31 per cent.
Trunk give a mortality of................................... 22.73 "   "
Neck give a mortality of .... 18.52 "   "
Upper extremity give a mortality of......................... 13.88 "   "
Lower extremity give a mortality of......................... 5.12 "   "

Treatment.—In a disease which runs such an acute course and which may terminate in such a terrible fashion, but in which, nevertheless, the chances are in favor of the patient's spontaneous recovery, it is no wonder that opinions differ in regard to operative procedures, especially if the operations employed entail a lowering of the resistance of the tissues and an opening of new channels for the spread of the disease along the lymphatics. Operative procedures may be contraindicated by other considerations, such, for example, as the situation of the malignant pustule, or the age or strength of the patient.

Opinions differ in regard to the particular operative procedure to be chosen. Some advise the extirpation of the malignant pustule with the knife, the argu-ment being that it is a local disease, and that extirpation of this lesion would at least rid the body of a chief colony of the invading bacteria. There is no one, however, who would advocate carrying the incision out beyond the wide-spreading œdema, which is such a marked characteristic of this disease, and, besides, there are very few men who would resort to operative interference in the purely œdematous form of primary anthrax of the skin. If, therefore, an operation is to be performed, the cutting must not extend beyond the malig-nant pustule itself; and the more sharply circumscribed the malignant pustule is, the more satisfactory will be the operation. This, however, is the very

kind of case which, if left alone, is likely to get well spontaneously. Furthermore, in the malignant pustule itself the bacilli soon undergo involution, and on or about the fifth day disappear entirely, while the young fresh bacilli are to be found in the advancing œdema; and it is precisely through this œdema, and not outside of it, that the incision is almost always made for the extirpation of malignant pustule. Nevertheless, many surgeons operate upon malignant pustule, and even advocate the extirpation of swollen lymphatics, and they attribute the subsequent recovery of the patient to the operation. Their opinion must therefore be accorded due consideration.

If extirpation with the knife be determined upon as the proper mode of treatment, the incision should be carried well out beyond the induration and well down into the subcutaneous fat. The wound should of course be left open, and should be dressed with compresses wet with weak bichloride-of-mercury solution, or with carbolic-acid solution (1:40). After extirpating the malignant pustule, some surgeons swab out the wound with pure carbolic acid.

Instead of excising the lesion, some surgeons prefer to lay it well open with crucial incisions, and then to apply pure carbolic acid. Destruction of the lesion with the Paquelin cautery is employed by some, and, theoretically, this procedure should be preferable to excision, by reason of the fact that it does not involve the laying open of new lymphatic channels for the further spread of the disease.

Various mixtures have been recommended for injection into the tissues immediately surrounding a malignant pustule or into the outlying œdematous tissues. One of these is a preparation of iodine, either the tincture or Lugol's solution, several drops of which are to be injected into a number of different places. Another is alcohol—that is, the ordinary rectified spirits. Successful results have been claimed for both of these. Bichloride-of-mercury solution (1:1,000) has also been employed in this way. As one ordinarily injects in syphilis a syringeful of a one- or two-per-cent solution of this drug, ten such syringefuls of a one-per-thousand solution might be injected without fear of mercurial poisoning. The favorite remedy, however, is a solution of carbolic acid, of a strength of from three to five per cent. Here the danger of drug poisoning must not be overlooked. R. Frank says that these subcutaneous antiseptic injections undoubtedly act favorably on the disease, and that the œdema disappears under their use. In fact, these and antiseptic compresses are the only local means we can employ when the primary lesion in the skin assumes a purely œdematous character.

When the constitutional symptoms commence, internal treatment is of great importance, and it probably should be considered the main reliance. The administration of proper nourishment and the judicious employment of stimulants are the means we have of carrying the patient through the terrible

depression that comes on before a sufficient amount of anti-bodies is formed to destroy the bacilli floating in the blood and other juices of the body.

As Emmerich has been successful in curing rabbits infected with anthrax, by the use of injections of erysipelas serum previously freed of cocci, it has been proposed to employ this same serum in desperate cases in man (R. Frank).

POST-MORTEM PUSTULE.

Post-mortem pustule appears as the result of direct inoculation from cadavers, and is, therefore, an accident liable to occur to physicians and their assistants. Butchers may also become infected in handling animal carcasses. The name, "post-mortem pustule," is inapt. The affection is not due to any one virus, and ought not to be classified as a disease.

The infecting agent enters through a cut or an abrasion of the skin; inflammation then sets in, and a papulo-pustule is formed. In severe cases a red streak may appear upon the arm following the course of the lymphatics. There may be considerable swelling of the hand, and also well-marked constitutional symptoms.

Treatment.—The crust should be removed, the pustule opened, and the ulcer thoroughly disinfected either with a corrosive-sublimate solution or with hydrogen dioxide. In rare cases the ulcer should be treated with the actual cautery. Wet antiseptic dressings (sublimate or boracic-acid) should be applied, and they should be continued until the process of healing is sufficiently advanced.

FRAMBŒSIA OR YAWS.

There is little danger of mistaking the small, raspberry-like lesions of yaws (a disease of tropical countries), which are sparsely scattered over the surface of the body and are of a contagious nature, for any condition that requires surgical interference. The treatment, like that of syphilis, is to be conducted chiefly along hygienic and constitutional lines. In cases of obstinate ulcerations, curetting may be resorted to.

ORIENTAL BOIL.

Symptoms.—Oriental boil occurs in the districts bordering upon the Mediterranean, in Africa, in Central, Southern, and Western Asia, and in South America, and it bears a multitude of local names, which point to the localities where it is endemic—such, for example, as Aleppo boil, Biskra button, or Delhi sore. In the places where it is endemic, persons of all ages and races may be attacked. (Plate XIII.)

The disease is located on the face or limbs, seldom on the trunk, while the scalp, palms, and soles are scarcely ever attacked. It begins as a red, inflamed

EXPLANATION OF PLATE XIII.

This plate represents the first period in the development of Biskra Button, that of formation or induration. A small, erythematous papule, like the bite of a mosquito, makes its appearance upon an otherwise perfectly healthy portion of the skin. In the course of a few days this papule becomes converted into an indolent nodosity, over the centre of which is attached a small crust or scab, which in turn conceals the narrow outlet of a small collection of pus. In the immediate vicinity of the crust the skin is covered with desquamating scales of epidermis. In the near neighborhood of this single lesion there may also be found agglomerations of papules, each such agglomeration presenting the aspect of a plaque.

BISKRA BUTTON

(ORIENTAL BOIL ; ALEPPO BOIL ; DELHI SORE)

(FROM *La Pratique Dermatologique*, MASSON ET CIE, EDITEURS, PARIS.)

papule rising from an infiltrated base, and for weeks, sometimes for months, it gradually enlarges without ulcerating. Then purulent serum begins to ooze from a central opening, and a closely adherent crust is formed. Ulceration goes on under this crust. The mature sore is a large ulcer from one to two inches in diameter, with sharply cut edges and an irregular granulating floor which secretes ill-smelling pus. Other similar ulcers may form in the neighborhood, and several may coalesce to form large ulcerating patches. At the end of a few months, healthy granulations are produced, after which the sores begin to heal, forming extensive, ugly scars. The disease may last for years, breaking out commonly in the summer and healing in the winter. The lymph node sare usually not involved, and, unless complications take place, the disease is not accompanied by general symptoms.

Etiology.—The infection is contagious; it may be conveyed by clothing, insects, washing-water, etc., and by auto-inoculation. The period of incubation may have a duration varying from several days to a few months. The disease begins usually in the latter part of summer or in the autumn.

Diagnosis.—In view of the endemic character of the disease, the absence of general symptoms, and the definite appearance of the sore, the diagnosis offers no difficulty.

Treatment.—In the papular stage, cauterization or injection of carbolic acid (three-per-cent) may prevent further development of the sore; but it is seldom seen at this stage. The ulcer may be well scraped and the raw surface thoroughly cauterized with the thermo-cautery or with some caustic, or a thorough excision may be performed. The further treatment should be that of a simple wound. The Finsen light is said to have cured a case, leaving a supple, smooth scar (Petersen).

PHAGEDÆNA TROPICA.

This disease begins in the form of vesicles or bullæ which develop upon the site of a traumatism. In a short time a deep ulcer forms, with irregular borders, an uneven floor, an offensive discharge, and an adherent slough. This ulcer may heal at this stage (from the centre to the periphery), or the ulcerative process may invade the subcutaneous tissues, involving muscles, aponeuroses, and even bones, and destroying nerves, blood-vessels, etc. The issue is sometimes fatal. General symptoms, such as fever, prostration, and anæmia, may accompany the gangrenous process. Internal organs may also become affected.

The disease is common in tropical countries, and affects both natives and whites, the latter usually in a comparatively mild form. The onset of the disease is favored by a depressed state of the organism, resulting from malaria, malnutrition, or exhaustion from excessive work or from heat. The ulcer is usually situated upon the legs or feet, more rarely upon the thighs and upper limbs or other portions of the body. The disease is infective and contagious.

Treatment.—Particular attention should be paid to the general health of the patient. The ulcer or ulcers should be curetted, excised, or cauterized with thermo-cautery or caustics. At any rate, the wound should be thoroughly disinfected with some strong antiseptic, such as pure carbolic acid, iodoform, or corrosive sublimate, and then guarded against reinfection or recurrence.

PERUVIAN WART.

Synonyms.—Verruga Peruana, Oroya fever.

Symptoms.—When the eruption is fully formed, it consists of one or a multitude of tumors situated upon the face and neck, more rarely upon the limbs and scalp, and only exceptionally upon the body. The tumors run from the size of a split pea to that of a nut or even of an orange. They are hemispherical or conical in shape and sometimes pedunculated. They are red, soft, elastic, and tender. They often break down and ulcerate, with an offensive discharge. The eruption is preceded by prodromal symptoms consisting of fever, anæmia, and rheumatoid pains in the muscles and joints. The liver, kidney, spleen, and other viscera may become involved, and the patient often dies from this generalized infection before the appearance of the eruption. The prodromal period may last several weeks or two or three months. The disease is endemic in some of the South American valleys west of the Andes.

As the disease is due to a specific general infection, the treatment should be conducted accordingly. Surgical interference has no influence on its course.

HYPERKERATOSES.

The epithelium of the skin forms a horny resistant coating well designed to conserve the heat of the body and to protect it from external violence. In order to retain its efficiency, and to keep it resistant and yet pliable, it must undergo continual renewal. This is accomplished by the constant formation of new cells at the bottom, which shove up the older cells before them. These new cells are large, succulent, soft, and tender, and are capable of forming, inside of themselves, a substance called keratin. Through desiccation and the formation of this keratin, these cells become quite hard and tough. These young epithelial cells have yet another quality, viz., that of sticking together. As they grow older and slowly ascend into the horny layer, this capacity for cohesion increases, and then, as the cells grow still older and dryer, they gradually lose this quality and fall apart, and are cast off as the scruff layer. The three following affections—callus, corn, and cutaneous horn—are all characterized by an excessive formation of horn and a tardiness of the cells in falling apart. They are called hyperkeratoses.

Cutaneous Horn.

Cutaneous horns (cornua cutanea) are circumscribed hyperkeratoses in which the epithelial cells form an over-abundance of horn, and at the same time stick together with unusual firmness, instead of loosening up and being shed as they normally should. In this way they can form long twisted outgrowths resembling the horns of some of the lower animals, only softer and having a more crumbly, uneven surface. These horns most frequently develop over a group of long, stout papillæ, and thus resemble the cornified warts, from which they differ only by the massive production of horn. The skin around the base of the horn is frequently elevated into a kind of roll or fold resembling somewhat the nail fold.

Besides the horns that develop on papillæ, there are others that spring up from a hair follicle or from a sebaceous gland, or that form on the inner surface of an atheroma or wen, break through its upper wall, and then grow constantly outward as a horn.

Cutaneous horns grow most frequently on the scalp, forehead, and temples, but they may appear in almost any locality on the skin or on the neighboring mucous membrane. Not infrequently they have been found on the external genitalia. especially in the sulcus behind the corona glandis. Genital horns differ in many ways from those found on the general cutaneous surface. They are softer, especially while covered by the prepuce, and are frequently multiple, while those in the general surface are almost always single. They usually develop in youths under twenty years of age, while horns of the general surface appear in those past middle life. Cutaneous horns of the glans penis and prepuce give rise to pain, inflammation, and discomfort, while those situated elsewhere cause very little annoyance except by their appearance.

After cutaneous horns reach a certain size, which varies with each case, they are apt to fall off or to be knocked off. They, however, grow again. Cutaneous horns are of themselves benign growths, but not infrequently epithelioma develops at their base. This is a most important feature, and one which should always be borne in mind in the consideration of every case.

The best treatment consists in removing the horn in its entirety, with its cutaneous base, by an elliptical incision carried down into the subcutaneous tissue. Excision is particularly advisable in horny growths of the glans penis, because of the tendency of all such growths in this situation to become malignant. Horny growths of the lips may either be excised or well curetted, the base being burnt with some strong liquefying caustic, such as chromic acid or caustic-potash stick.

If the cutaneous horn becomes inconvenient in a person so old or weak as to make complete excision inadvisable, it may be either clipped down with bone scissors or sawed off.

CALLUS.

Callus, also called callositas, tyloma, or tylosis, may be looked upon as physiologic on the palms and soles, where the irritation of work causes an accentuation of the natural tendency these parts of the integument have to hyperkeratosis. It may, however, form on any part of the integument subjected to long-continued pressure.

Some occupations are particularly favorable to the development of callus, especially the rude laborious ones, but even less rude occupations may lead to its formation. Violinists, for instance, are sometimes plagued with callus of the finger tips rendering their touch less delicate. Some diseases of the skin favor the formation of callus: such, for example, as ichthyosis and pityriasis rubra pilaris, where the palms and soles are coated with great masses of thick yellow callus. Furthermore, in some people who do not work, masses of callus will, without any known reason, begin to form on the palms and soles, and after a longer or shorter time will disappear as mysteriously as they came.

Callus is chiefly interesting to the surgeon on account of what it may cover or hide. A wart or verruca may, as we shall see when we come to speak of these papillomata, cause the severest pains, and even give rise to the suspicion of the presence of malignant disease. People having callus of the palms are also frequently exposed to cuts and injuries that may become infected. Such an infection, running its course under the heavy callus of the palm, may undermine it extensively, and simulate a widespread phlegmonous inflammation. Ultimately, however, it may heal without causing any destruction of tissue or scar formation whatsoever.

Callus may be removed by soaking the affected part in water, either in a bath or by the application of a wet dressing. To increase the softening effect the water may be rendered alkaline by the addition of liquor potassæ. A more ready application is a salicylic-acid salve, like the following:

℞ Salicylic acid...2.50
  Lanolin..25.00
  Vaseline...25.00
M. S. To be spread on cloths.

Some prefer to use a five- or a ten-per-cent salicylic-acid plaster mull. These applications soften and make sodden and white the epithelium, in such a way that it can be readily peeled off in layers.

CLAVUS.

Clavus or corn is an anomaly of cornification brought about by pressure, usually from ill-fitting shoes or boots. It is at first a callosity, but two forces are at work to shape it into a cone-shaped mass with the apex pointing down-

ward. One of these forces is the upward growth of epithelial cells springing
from the papillary layer; the other is the pressure from without that holds
these cells down. This corn presses upon and finally between the papillæ
of the papillary layer of the skin, driving them asunder. As these papillæ
are the seat of highly sensitive nerves, the pressure from this sharp epi-
thelial cone causes exquisite pain. The continuance of this pressure not
only drives the papillæ apart, but causes them to atrophy. If the pressure
upon the connective tissue of the skin continues, its meshes will be separated
and will undergo atrophy. As a protection Nature sometimes develops a
synovial sac as a cushion beneath the corn. This sac may communicate with
the joint cavity (bunion) over which a corn frequently forms—a fact which
should be borne in mind in any surgical procedure, as infection of this sac or of
the joint may give rise to grave and extensive troubles, such as necrosis, phleg-
mon, and lymphangitis.

There seems to exist, in some people, a tendency to over-cornification of
epithelium, sometimes from no known cause, sometimes as a symptom of disease,
—as happens, for instance, in pityriasis rubra pilaris. These people easily
form callosities and corns, and their palms and soles may be thickly studded
with them as a result of the error in cornification.

Diagnosis.—It is easy to mistake a perforating ulcer for a corn or a callus,
and this is especially true if the perforating ulcer is small. Nature, in her
effort to heal and to protect this kind of defect, builds around it a thick wall of
callus, and, unless the significance of this is correctly understood, vain attempts
are apt to be made to obtain an unattainable cure. Another error, easy to
fall into, is to mistake a wart growing under the hard epithelium of the palm
or sole for a corn or callus. It is sometimes impossible to discover that such
a mistake has been made until the hard mass of callus covering the wart shall
have been removed.

Prophylactically, good, sensible, easy-fitting shoes should be worn. This
ideal, however, is scarcely ever attainable. Much can be done toward ameli-
orating the condition by shaving off the thickened epidermal callus and apply-
ing a corn-pad; the procedure contributes nothing toward the cure of the dis-
ease. In order to secure this result, the epithelial cone must be removed and
the pressure relieved until the parts return to a normal condition. As a first
step in the removal of the corn, the epidermis should be softened by applying
to the part an ointment made of salicylic acid. The following formula will
answer the purpose:

> ℞ Salicylic acid.. 5.00
>   Lanolin,
>   Vaseline...āā 25.00
> M. S. Apply on cloth.

If this ointment is found to be too strong and to cause irritation, it may

be further diluted by the addition of more vaseline. If the corn is on the forward part of the foot, the cloth spread with the ointment may be held in place by cutting a hole in it, and running one of the toes through the hole. Then flap back the cloth over the corn, and pull on the stocking, which will hold the dressing in place. The salicylic acid will soften the epidermis and make it white and sodden-looking like a washerwoman's hand. This softened, sodden epithelium may be cut off, and the ointment reapplied. This procedure may be repeated until the tip of the corn is reached and removed. Instead of employing the salicylic acid in the form of an ointment, we may incorporate it in collodion and apply it in this manner. The proper proportions are given in the following formula:

℞ Salicylic acid.. 2.00
    Collodion 25.00
M. S. Apply with a brush every four or five days.

When, by means of this application, the corn is sufficiently loosened, it can be pried out of its bed.

When corns become inflamed, it may be necessary to put the patient to bed, and in that case it will be well to wrap the whole foot in cloths soaked in boric-acid solution, and to cover the whole with oil silk, which can be drawn taut around the ankle, like a bag, with a puckering-string. The boric acid is for the purpose of preventing infection. This moist dressing, which is kept warm by the natural heat of the foot, forms a poultice, which softens the epithelium and renders easy the extraction of the corn. This softening of the epithelium may also be accomplished in other ways, as by the use of a bath composed of a weak alkaline solution, or by burning away the callus and corn with glacial acetic acid.

When a synovial sac is formed beneath the corn, the greatest care should be taken not to open it, or, if it has already been opened, to see that it is treated according to good surgical principles. The habitual sufferer from corns is apt to be careless, and does not see the need of treatment for the inflammation of the synovial sac. The following is the proper method of treating this condition. The foot should first be placed in an antiseptic bath (bichloride of mercury, 1 : 10,000). After it has been subjected to a thorough soaking, the patient may be anæsthetized, the corn cut out, the sac split open and, if possible, extirpated by dissection. If a joint be opened it should be closed again by fine sutures, and the wound treated with a most rigorous antisepsis. The patient should be kept in bed until the healing is complete.

Corns in elderly people, or in those affected with diabetes or arterio-sclerosis, are usually by these circumstances rendered the more grave.

ACANTHOMA ADENOIDES CYSTICUM.

Synonyms.—Epithelioma adenoides cysticum; Adenoma of the sweat glands; Multiple benign cystic epithelioma (Fordyce).

Symptoms.—Discrete, pinhead- to pea-sized, pearly whitish, yellow, bluish or pink-colored tumors, tense, solid, painless to the touch, round or coniform, are deeply embedded in the skin or project above its surface. The individual lesions are freely movable, shiny, translucent, suggesting vesicles, but if they are punctured no liquid, other than blood, oozes out. Some may have a central depression. They grow slowly and they do nót attain a size greater than that of a large pea. Ulceration may occasionally take place. The nodules are usually located upon the face, chest, or back, but may occasionally be seen upon the arms and other parts of the body.

Diagnosis.—The lesions may be easily mistaken for adenoma sebaceum cysticum. The latter, however, are usually more colored (red) and telangiectatic. Telangiectases may be present in acanthoma adenoides cysticum, but they are not such a prominent feature as in adenoma sebaceum cysticum. In colloid milium the lesions are of a yellow and peculiarly translucent appearance, but sometimes they cannot be differentiated from acanthoma adenoides cysticum without the aid of the microscope. Molluscum contagiosum is more often a disease of children, and is not quite so persistent as acanthoma adenoides cysticum. In hydro-cystoma, the lesions contain fluid and are not permanent.

Etiology.—Most of the published cases have occurred in women, and in a large proportion the disease was clearly hereditary. It seldom begins before the age of puberty. The causes of the disease are unknown.

Treatment.—The benign character of the lesions should not inspire too much confidence, as they may develop into true epitheliomas; and, as spontaneous involution is not be to expected, one should not hesitate to use the proper means for destroying them. No internal medicine nor external application is known to have any beneficial effect upon the disease. Treatment is purely surgical. In some cases the lesions may be split open and their contents squeezed out (Fordyce). Curetting, excision or scarification, electrolysis and cauterization have been successfully employed to remove these lesions. The operator must decide for himself which of these means he will use in a particular case.

ADENOMA OF THE SEBACEOUS GLANDS.

These little tumors appear usually in groups in and around the naso-labial folds and on the sides of the nose; less frequently they may be scattered over the forehead and other parts of the face and on the scalp. As a rule, they are

arranged in symmetrical order, but not necessarily so. They appear as pin-head- to pea-sized papules which sometimes are of the same color as the surrounding skin, but more often are of a more or less marked redness due to telangiectases. They may also be of a brownish hue, or waxy in appearance.

The persons who have this disease very often show also defective mental development. Females seem to be subject to it more than males, and the
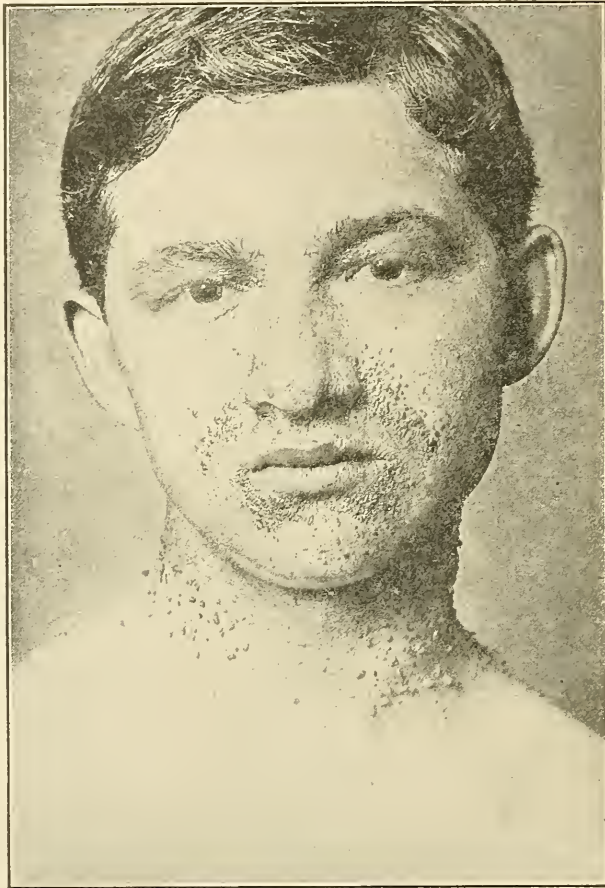
Fig. 47.—Adenoma Sebaceum (Nævus Sebaceus). (After Rau, in Neisser's "Stereoscopischer-medicinischer Atlas.")

unsanitary more than those living in more healthy surroundings. In regard to its nature it is undoubtedly a nævus. It is congential or occurs while the growth of the body is progressing. It is associated with, and in part made up of, telangiectases. It is also associated with fibromata mollusca that may form in rows down the front of the neck. The little rounded papules and agglomerations of tissue, when not telangiectatic, are waxy or buff-colored, or brown, as is often seen in moles and other nævi (Fig. 47).

Diagnosis.—The telangiectatic, convex appearance of the papules, their location in the naso-labial folds, and their long standing will differentiate the disease from acne rosacea. Epithelioma adenoides cysticum appears later in life than adenoma sebaceum; colloid milium is located chiefly upon the upper part of the face, while the location of adenoma sebaceum is the same as that of acne rosacea.

Treatment.—Spontaneous involution takes place in rare cases. The disease does not progress continuously, but remains stationary for long periods of time or indefinitely. The only successful treatment is surgical; and medical treatment, whether internal or external, is of no avail. The lesions may be clipped off with a knife or the scissors, and the wounds thoroughly curetted; recurrence is probable, and when this happens the operation should be repeated two or three times. Crocker has instituted the treatment of adenoma sebaceum by electrolysis, the needle attached to the negative pole being introduced once for the small nodules and several times for the large ones. This method of treatment is to be preferred when the lesions are not too large and do not form too voluminous agglomerations.

WEN.

The designation of this affection has given rise to a good deal of misunderstanding. It is frequently called sebaceous cyst, but probably the majority of these tumors are not retention cysts at all, but arise from embryonic displacements of cells that should have been external epithelium. At all events, there is formed a cavity which is lined with flat, stratified epithelium exactly like the epithelial covering of the skin. Inside this sac, lined with epithelium, there is a round, smooth, glistening, ivory-like ball, containing, in its centre, a mass of epithelial detritus of cheese-like consistency. The term "wen," the original meaning of which is never taken into account, is possibly better than "atheroma," because it is applied to no other pathological condition.

Although operations for the removal of a wen may be followed by disease of the wound, such as erysipelas, usually the healing takes place so quickly that surgeons have been again and again surprised at the quick results. This was especially noteworthy in the old days, when cleanliness was not so customary as at present, and when wounds of the scalp—the locality where atheroma usually occurs (Fig. 48)—were justly looked upon as being particularly dangerous. But, in these atheroma cases, one still hears men felicitating themselves that they can carelessly make large wounds in the scalp without anything serious following, and with remarkably rapid healing; the truth being, however, that they have made wounds of insignificant proportions. Then, besides, the real reason for the rapid healing can be easily appreciated if we reflect for a moment

upon the pathologic anatomy of the affection. Let the line A, in the accompanying figure (Fig. 49), represent the surface of the skin, while the circle B stands for the true connective-tissue capsule of the wen, and the circle C represents the hard, glazed, horny capsule of epithelium covering the central detritus. It is this inner circle that has given rise to misunderstanding, for men frequently teach that this is the outside connective-tissue covering of the tumor, whereas the real connective-tissue capsule is represented by the outer circle (B). The wen must be regarded as a globular cavity of connective tissue, lined with flat, stratified epithelium; it is, in fact, a piece of involuted skin, the connection of which with the outer surface of the body has become obliterated. The epithelium of this piece of skin is being continually thrown off, but instead of being shed, as it is on the outer surface of the body, it is heaped up in the centre, and there forms a mass of detritus.

FIG. 48.—Atheroma of the Scalp.   (Original.)

In operating, an incision is made over the most prominent part of the tumor, and an ivory-like, slippery ball is exposed, which readily pops out through the slit. There usually follows, as in all scalp wounds, considerable bleeding.

Now, what has the operator done? The slit he has made in exposing the ivory-like ball is positively the only wound that exists. The sac out of which he has pressed the ball is not a raw surface, but merely a piece of epithelium that has dipped down into the skin, and is as sound and healthy as the skin on the back of the patient's hand, and ready, like that of the hand, to continue to throw off its epithelium, which, in time, will form a new ball. Those who suppose that the inner surface of this sac is raw will say that it is red and moist, and that surfaces covered with epithe-

FIG. 49.

lium are neither red nor moist. This surface is, indeed, both red and moist, because it is the rete Malpighii, the covering of the ball being formed by the more completely keratinized cells of the granular and horny layers.
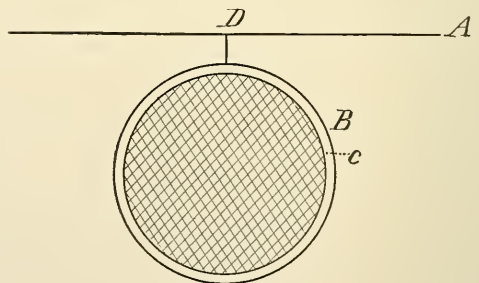
My attention was first called to the anatomy of a wen by examining a section of the wall of one of these glistening balls, and finding that it was not composed

of connective tissue lined internally with epithelial cells, but that it consisted entirely of epithelium, with some layers of flattened nucleated epithelial cells forming its external covering. This discovery settled its nature, and I then appreciated the fact that an operation, to be radical, must go outside the connective-tissue capsule. But whether or not it is desirable to take radical measures, to remove the sac entirely, or to permit it slowly to refill by retaining the whole or a part of the lining membrane, is a question which must be answered by the operator.*

After the cavity has been evacuated, curetting its walls or swabbing them with a caustic solution is sometimes practised, with the intention of destroying the capsule and preventing the return of the disease—*i.e.*, the refilling of the cyst.

In some instances, where there is an abundance of skin, a fold of the skin including the wen may be lifted up and cut off with scissors, and the wound then sewed up as an incised wound. This was the plan adopted by Dr. H. M. Sherman, of San Francisco, in a case of atheroma that occurred in the skin of the abdomen of an elderly woman.

The diagnosis of atheroma is usually easy, but sometimes difficulties in diagnosis may arise. I recall an instance where an epithelioma was mistaken for a wen. An open incision being made, the central portion of the mass did not shell out as readily as wens usually do. The operator fortunately examined a piece of the tissue, and so corrected the mistake. The growth, however, returned and caused the patient's death.

XANTHOMA.

Xanthoma is a yellow, superficially situated tumor that most frequently occurs on the eyelids of elderly women. Xanthomata are as a rule multiple and bilaterally symmetrical. They are usually soft and give no impression of a tumor to the touch, but they are frequently quite prominent to the view, and, on account of their position, are a source of much annoyance. At times they are much more widely distributed over the cutaneous surface, and they may be associated with diabetes or with icterus. When associated with diabetes they have been known to disappear under an antidiabetic régime and course of treatment.

As they are usually found on the upper lids they may not be so much of a cosmetic defect as the patient imagines they are; for they are under the shadow of the brow, and the lid when opened also hides them. Unless they are a cause

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* Cruveilhier ("Traité d'Anatomie path. gén.," tome iii., p. 346. Quoted by Virchow: "Die krankhaften Geschwülste," Band i., S. 227) long ago called attention to the great delicacy of the membrane lining these sebaceous cysts.

of a great deal of mental embarrassment, it is best to dissuade the patient from having anything done. If she insists, however, the tumors may be painted once a day with a ten-per-cent solution of sublimate in collodion. This should at first be used very carefully and over a small area, as the reaction may be lively and the pain severe.

These little tumors may also be removed by excision. If this method of treatment is determined upon, the lines of incision should run in the folds of the skin so that the scar may be less prominent. Care should be taken in excising xanthomata of the eyelids, not to go too deep, as ectropion may result, nor to go too near the canthus for fear of causing epiphora.

Electrolysis gives good results. The needle attached to the negative pole and carrying a current of from one to two milliamperes, is run through the base of the tumor in several directions. Bowen advises that the operation be done in several sittings, in order that the amount of destruction caused may be more perfectly controlled and thus better cosmetic results be obtained.

NÆVUS.

The term nævus was at first used for designating a tumor or discoloration observed at birth. It is now applied to any tumor or discoloration that has a congenital origin, whether it be apparent at birth or develops so as to be recognizable at some time after birth. When nævi appear later on in life their status as nævi is not determined by the time of their appearance, but by the general characteristics of the lesion itself. They therefore include an enormously large class of deformities representing all the structures of the skin and all possible combinations of them. The only way in which some idea of the nature of this class of deformities may be conveyed to the reader's mind is to describe the different types; it being understood, however, that nævi are in reality more intricately constructed than these types would indicate.

PIGMENTED NÆVUS.

A pigmented nævus is a localized increase of pigment that has taken place either in the epithelium or in the connective tissue of the skin, or in both, and that causes a discolored spot that may be light buff in color, brown, dark blue, or black. Some of these nævi have a dark centre and a lighter-colored periphery, thus presenting some resemblance to a dark nipple with the lighter-pigmented ring surrounding it. In size, they cover areas which have a diameter varying from a couple of centimetres to the breadth of the palm, or even more. In number there may be one or many, and in shape they are mostly oval, but they may have the strangest shapes—shapes that suggest fancied resemblances to many

objects and that give rise to many beliefs in maternal impressions. In fact, in size, shape, and number these lesions are subject to the greatest variations. They may occur on any part of the cutaneous surface, or at any of the orifices where the mucous membrane and skin meet. Like all other nævi they may be present at birth or they may not become apparent till many years after birth.

When these pigmented nævi are small they are called *lentigines;* and when only one or two of them are present on the face, and are placed in favorable positions, they may have a piquant effect; indeed, they are often looked upon as an addition to beauty. Not infrequently, a few stout, dark-pigmented hairs grow out of such a patch.

Sometimes these, like other nævi, appear to follow the course of a nerve, and they have then been called nerve nævi, and have been compared to herpes zoster. The idea that these nævi have anything to do with the nerves is groundless, and this peculiar distribution is due to an entirely different cause. The nævus is formed while the fœtal tissues are yet a plastic mass, and during the growth of the fœtus the nævus is stretched along the line of growth either around the body or out along the budding limbs. The nerves are also stretched in the same direction; hence the parallelism of nerves and nævi.

The congenital nævi do not ordinarily show any evidence of independent growth. They grow only in proportion as the body grows, and when the individual stops growing they also stop. They may, however, take on an abnormal growth, and develop into malignant tumors, a contingency that will be considered later on.

Pigmented birth-marks are to be distinguished from acquired patches of pigment that do not have a congenital origin and are due to other physiological or pathological causes.

Nævi Pilosi.

The hairy nævi have as their chief distinction a growth of hair. The skin involved is more or less thickened. The surface is elevated above the level of the surrounding skin, and is often warty, uneven, or cut up by deep furrows. The hair growing on this surface may either be stiff, coarse and crinkly, or soft and silky. Most of such birth-marks are either visible at birth or appear shortly after. Many of the extensive ones are bilateral, and, like the pigmented nævi, may appear to follow some nerve or to be bounded by the area of distribution of some nerve. This, however, as before mentioned, is apparent and not real.

To this class of nævi belong those which consist of clear or dark brown, club-shaped or rounded protuberances, and to which the name *nævus molluschiformis* has been given. They are composed of richly cellular pigmented tissue, containing islands of mucous tissue scattered throughout it, and covered over

by a few thin layers of more or less deeply pigmented epithelial tissue. Some-
times they contain a few large sebaceous or sweat glands or a few short stout
hairs; but frequently they are entirely smooth, and resemble the teat of a
female mammary gland.

Another form consists of hard, pigmented warts, which are hypertrophied
papillæ or true papillomata covered over with smooth or corneous or crumbly
epidermis.

In general, mother-marks are absolutely benign growths that do not cause
the slightest uneasiness or disturbance, except for their appearance, which
in some cases is decidedly disagreeable.

TELEANGIECTASES.

In all the nævi there is a marked tendency to the formation of dilated blood-
vessels, and in many instances angiomata exist apart from as well as com-
bined with them. The vascular nævi are formed in part or entirely of dilated
capillaries.

It is an important fact that melano-sarcoma and melano-carcinoma some-
times develop from nævi. This is much more frequently true of sarcoma than
of carcinoma; and the simple pigmented nævi are much more disposed to
malignant degeneration than are the fleshy ones. Furthermore, it is true of
the pigmented nævi, that the deep-colored ones are much more likely to undergo
this unfavorable change than are the light-colored ones. It must be looked
upon as an absolutely bad symptom when any of the pigmented moles begin to
grow at a rate faster than can be accounted for by the general rate of growth
of the body, or when they become succulent, or when they ulcerate.

Treatment.—The treatment of a nævus depends upon its situation and
extent; and, inasmuch as a cosmetic result is the aim usually kept in mind,
except in cases of threatened malignant degeneration, the question must be
considered whether the result is going to be a real improvement or not.

In some cases one can shave off a pigmented mole just as one shaves off the
skin for the Thiersch graft, and the surface may then be allowed to heal under
the scab. When, however, the birth-mark penetrates to a greater depth and is
more fleshy, it may be better to cut it out, and sew up the wound. In such a case,
one should, if possible, allow the scar to fall in one of the natural furrows of the
skin, in the hope that it may thus become hidden. If the surface is very large,
so that the edges of the wound cannot be brought together, Thiersch grafts
may be applied. Fox advises the treatment of such moles by electrolysis,
the needle being passed no deeper than the bottom of the epidermis, so as to
blister the surface of the black spot. All the methods which aim at relieving
the disfiguration by causing irritation of the epidermis and a consequent des-
quamation of the skin with its pigment, are of no lasting advantage, although

possibly they may produce some temporary benefit. Just as soon as the skin returns to its normal condition, the objectionable pigment reappears. The irritants which are used for this purpose are: Carbolic acid, which may be painted over the part in full strength, with the understanding that it may act much more strongly than is desirable; nitric acid, which may leave scars; and, finally, bichloride of mercury, which is used either as a one- or as a two-percent solution in alcohol or in collodion.

Patients frequently desire the removal of the long, stout black hairs that sometimes grow out from hairy nævi. Such hairs can be readily destroyed by the electrolytic needle, and it seems to me that they are more easily destroyed by this means than are ordinary hairs. The small amount of irritation that results from such a procedure would not be at all likely to give an impetus to malignant degeneration, because in the first place the irritation is slight, and secondly it is not long-continued. It is the long-continued irritations that may give rise to malignant degeneration. Not infrequently, in removing such hairs by electrolysis, one causes the destruction of the whole nævus if it happens to be a small one.

The cure of nævi by means of the Roentgen ray was accidentally discovered by Freund. In removing the hairs from a nævus by the aid of the x-ray, he noticed that the nævus itself was disappearing. Since then the x-ray has been used with considerable success by many operators. In fact, some claim that this constitutes the best form of treatment for nævus, especially for that variety which is known as port-wine mark. The treatment should be carried to the point of producing an acute dermatitis. The scars left are smooth and pale.

The removal of vascular nævi by *excision* constitutes one of the recognized methods of treating this disease. It might be thought necessary to mark out the line of incision before the operation, in the fear that the blood escaping from the tumor would make it impossible to distinguish the abnormal tissue from the normal. As a matter of fact, this precaution is usually unnecessary, for the abnormal tissue retains its peculiar look even when cut into. As in all such operations, judgment has to be exercised as to whether the operative removal of the nævus will or will not interfere with some neighboring organ. After the decision to operate has been reached, there will be other questions to which an answer must be given. What is the best method of procedure? Shall the wound be closed by suture or by covering it in with Thiersch films or with skin grafts? Shall a pedunculate flap of skin taken from the neighborhood be utilized for filling up the gap?

In the removal of hairs from hairy moles by the method of *electrolysis,* the whole lesion, as I have already stated, sinks down into a smooth scar. For the removal of small vascular nævi no better method can be found than that by electrolysis. In the case of large nævi, however, the results obtained by the employment of this method are not so good, and, besides, the treatment

is wearisome and painful. Some introduce the positive instead of the negative pole into the tissues, because it coagulates blood more easily; but, if this course be adopted, a gold or platinum needle must be used, as a steel one would deposit iron in the tissues and leave a black mark. When it is desired to cauterize the growth, the needle should be covered everywhere, except at the point, with shellac or gutta percha, to prevent its touching the neighboring skin and cauterizing it. It should be attached to the negative pole, and should bear a current of from fourteen to twenty cells. Some arm both poles with needles and introduce them simultaneously; others employ by preference Lewis Jones' instrument which is furnished with five needles, alternately positive and negative, fixed in a straight line in a handle. Even with this instrument many repetitions are necessary and the operation is very painful.

Many methods of ligating nævi have been devised; but it is difficult to see in what respects *ligation* is more efficacious than, or even as good as, excision.

As regards the *cauterization* of nævi, some advise puncturing the growth in many places with the galvano-cautery or with the Paquelin cautery, and good results have been obtained in this way. The cauterization can also be done with fuming nitric acid, or with trichloacetic acid, when the nævi are superficial.

The warts of the warty linear nævi may be removed either for cosmetic reasons or because—owing to their situation in the natural folds of the body, as in the axillæ—they become macerated, irritated, and foul-smelling. An excellent and easy way of removing them is to pinch up the skin into a fold between the thumb and forefinger, and then to trim the warts off the convex portion of the fold. It saves cutting clear through the skin, and at the same time the hemorrhage is controlled and the field of work is not obscured.

PAPILLOMA.

Papillomata are tumors that arise on free surfaces in many regions of the body, and consist of a connective-tissue core, that serves to carry nutrient vessels, and a covering of epithelial or endothelial cells. The striking differences observed between papillomata in various regions of the body are largely due to differences in their epithelial covering. This may be soft or hard, thick or thin, according to the nature of the epithelium or endothelium of the region affected, for papillomata may occur on the serous surfaces as well as on the skin and mucous membranes. It was formerly believed that the connective-tissue core was the essential part of the growth, and that each core was an exaggeration or hypertrophy of a papilla of the skin or mucous membrane. This view is not now generally accepted, and papillomata are regarded as epithelial formations with a consequent growth of the connective-tissue substances. The vascular and connective-tissue ramifications constituting the core of the

papilloma do not correspond at all to the papillæ of the surface from which they spring, as they are by far less thickly set, and they have not the same shape. Furthermore, papillomata may spring from scars that have no papillary layer whatever.

In this article only the papillomata of the skin and of the neighboring mucous membranes will be considered, and they may be divided into:

(1) Genital vegetations.
(2) Papillomata of the mouth.
(3) Verrucæ, or warts, or papillomata of the skin.

Genital Vegetations.

The striking growths called vegetations, genital vegetations, condylomata acuminata or cauliflower growths, are multiple tumors of frankly papillary appearance, situated on the mucous membrane or on the skin of the genital region.

These vegetations commence as a papule, one or two millimetres in breadth, and having a red, uneven, strawberry-like surface. On examining them with a lens, one can see a great number of red points, the top of each corresponding to one of the elevations of the strawberry-like surface. These points owe their redness to the fact that the comparatively large blood-vessel loop in each one of the papillæ is filled with blood. The whole papule grows out rapidly, and each little hemisphere on its surface elongates into a filament. In this way there is formed a bunch of thread-like vegetations springing from a small pedicle about one or two millimetres in diameter. The skin on which the pedicle sits is neither inflamed nor deeply indurated. These bunches of filamentous papillæ are almost always multiple, and are thickly set, giving them a solid appearance which in reality they do not possess, as one can readily separate the filaments down to their bases and isolate the bunches from one another. The vegetating masses are either rose-colored or pale, and are soft. Sometimes they are moist and secrete a turbid, foul-smelling fluid, and then at other times they are dry and apparently of a firmer consistence, in these respects corresponding to the degree of humidity of the region in which they are situated. They are not at all sensitive and may be crushed between the fingers, giving a sensation of crepitation and at the same time bleeding freely (Dubreuilh).

In men they often occur as small isolated vegetations in the sulcus behind the corona glandis, or in the neighborhood of the frenum, or, less frequently, in the meatus, or even in the fossa navicularis. They do not, however, always occur as small isolated vegetations; they may, instead, cover a large surface, not alone on the sulcus, but on the whole inner lining of the prepuce, and may give the impression of a papillary epithelioma—or, as has been observed in some instances, they may hide an epithelioma.

The cause of these warts is not known, but it would appear that an acrid

discharge may give rise to them. Thus, for example, the pus of gonorrhœa may furnish such an acrid discharge, a fact which partly justifies the name most commonly given to the growths—"venereal warts." And yet, on the other hand, they frequently occur when no gonorrhœal virus is present. Probably the irritating nature of the discharge in gonorrhœa excites the growth of epithelium, which, as we have seen, constitutes the essential element of this tumor. It sometimes happens that in gonorrhoea there occurs a phimosis, and under the phimosis a luxuriant growth of these papillomata takes place, necessitating splitting of the prepuce and circumcision before the fungating mass can be cleaned out. These growths may occur on other parts of the penis besides those just mentioned, and they also sometimes arise on the scrotum.

On the private parts of the female the warts sometimes grow with extraordinary luxuriance, and may become pale and sodden and resemble a cauliflower; hence the name "cauliflower growths." Here also they appear almost always as an accompaniment of gonorrhœa. If they become inflamed there oozes from their surface a turbid, foul-smelling secretion that flows away together with the vaginal discharges. Under such circumstances they may become tender and painful and impede walking. Although they are almost always an accompaniment of gonorrhœal discharges, they are not always so, and it ought to be especially kept in mind that women in pregnancy are particularly disposed to them. I know of a case where lack of this knowledge, and an indiscreet tongue, got a practitioner into serious trouble.

When condylomata acuminata occur in the anal opening, they are usually small and numerous, and may extend quite a distance up into the intestinal tube. These anal condylomata may be a consequence of the extension of the disease from the genitalia, which is especially the case in women, and is probably due to the circumstance that the discharges from the vagina flow down along the fold between the buttocks. They also occur independently in the anal opening, and are said to be due to indecent practices or to sodomy. They can, however, occur independently of either of these causes, and I think that those afflicted with seborrhœa or seborrhœic eczema are particularly prone to them. Sweating would appear also to be a cause. Sometimes the condylomata that occur just outside the anal ring are shaped like thorns with a sharp point and are quite firm.

A marked distinction should be made between condylomata acuminata and condylomata lata. These latter are almost pathognomonic of syphilis, as they occur in only one other disease, viz., in pemphigus vegetans. Condylomata lata are syphilitic papules growing in a situation where they are kept moist and where they are exposed to pressure as in the fold between the buttocks. They are quite different from the acuminate growths, for they are flatly approximated to the skin by a broad surface. They are usually about a centimetre in diameter. They are circular, and their borders rise up steeply from

the skin to the top, which is either depressed in the centre or flattened. They present, therefore, as they lie on the skin, a button-like appearance. The flat plateau-like top is usually covered by a moist, purulent coating, from which they get their name of moist papules. Not infrequently both the acuminate condylomata and the broad papules are present at the same time.

Papilloma of the Mouth.

The papillomata of the mouth may be excised and the base touched with nitrate of silver, which serves both to stop the bleeding and to prevent the recurrence of the growth. An excellent plan of treatment is to touch the growth with trichloracetic acid, which causes it to turn perfectly white, as if it had been frozen, and after a time to drop off. In Rasch's case there were many recurrences of the growth.

Papillomata are far less apt to occur in the mouth than on the genitalia, and, when they do occur, there are, as a rule, only a very few of them. I have never seen more than one wart in the mouth at a time. They may, however, occur in any region of the mouth, and they may appear in great numbers. They are indolent and painless, excepting when, by reason of their position, they are exposed to being bitten. Although they are said to occur most frequently in children and young adults, they are also observed at times in older people.

The occurrence of papillomata in the mouth in conjunction with papillomata of the larynx in one case (Freudweiler), and with verrucæ of the hands in two cases (Rasch and DeVariot), supports the idea that warts are infective.

Papillomata of the mouth must be differentiated from fibromata of the mouth. The latter form little, rounded, pedunculate tumors which have a smooth surface and are seen under the microscope to be fibrous growths with a thin epithelial covering. A papilloma may also be mistaken for a lymphangioma, especially on the tongue, where it forms a circumscribed salient tumor with a surface composed of a great number of little rounded eminences like the stones of a cobble-stone pavement. Lymphangioma rests on an infiltrated base, is larger in extent, and is never pedunculate (Dubreuilh).

Verruca.

Verrucæ, or warts, are papillomata that develop upon the skin. As might be expected from the physical differences which characterize the two localities, cutaneous warts are harder than those which are found on the mucous surface, and their epithelial covering is coarser, harder, and more horny than that with which the latter are covered. There are two kinds of verrucæ—the true warts and the flat or juvenile warts. True warts occur usually on the face and on the hands, especially on the back of the hands and fingers and

around the nails. They are very rarely found on the upper part of the limbs or on the trunk (Dubreuilh). Like the papillomata in other regions, they appear at first as small elevations or papules which have the same color as that of the surrounding skin, and present a surface that is made up of little rounded elevations. As the individual papilloma grows, its surface becomes smooth or rounded or flattened, or it becomes cut up by a network of deep fissures that separate the papillæ from one another. In these fissures the dirt settles and gives to the growth a black appearance.

Warts differ a great deal from one another according to the region where they are situated. Those of the scalp have a fatty coating, and have hairs growing out of them at different angles. They may give rise to much discomfort, and readily bleed when the comb strikes them or when they are struck by the nails in scratching.

As regards the origin of warts, there is now no doubt that they are caused by a contagium, but it has not yet been discovered what this contagium is. Jadassohn has succeeded in transmitting them, but they have a long period of incubation, viz., from three to six months. The laity has always held to this belief, and many facts, besides direct transmission, speak for this view. There is very often a mother wart, a larger wart surrounded by a great many smaller or daughter warts. Warts often appear suddenly, and in great numbers, and they may disappear just as suddenly and capriciously as they came. They appear in localities particularly exposed to contagion, as on the hands and face. We know, from the examples furnished by syphilis and tuberculosis, that the back of the hand is more liable to contagion than the palmar surface, and this is just where warts appear in greatest abundance. Cases have been reported where warts were present at the same time in the mouth and on the hands, and we all know how frequently the hand travels to the mouth.

Juvenile Flat Warts.

These constitute a sub-variety of warts, and they differ from the above in their size and in the smoothness of their surface. They are small, pinhead-sized, well-circumscribed growths that have steep, slanting borders and a smooth, flat top. They therefore resemble low, truncated cones. They appear suddenly on the forehead, along the sides of the face, and on the back of the hands. They usually occur in large numbers, but there may be very few of them, and these few may appear in any of the localities mentioned. Like the ordinary warts they are undoubtedly contagious, although the contagium has not been discovered. Sometimes these warts, instead of being irregularly scattered, will be arranged in lines as if they had been sown in a scratch, or they may be arranged in festoons and in slung lines as if they had spread peripherally from a centre, both of which facts also speak for their contagiousness.

Warts that Occur under Hard, Horny Epithelium.

Warts that occur under hard, horny epithelial surfaces, as on the palms or soles or under the nails, deserve special mention, as they may give rise to particularly disagreeable symptoms. When a wart occurs under a nail, the latter must be removed, and the wart treated radically, either by curetting or by cutting it out and burning the base with some acid, or by burning it out with the thermo-cautery.

Warts that occur under callous surfaces may be so rebellious to treatment, so enduring, and so painful as to give rise to the suspicion of malignancy. In the case of a wart which was located under the hardened surface of the pulp of the index finger, and which I treated in the regular routine manner, the growth repeatedly recurred until I finally removed it by the radical method. In this instance the patient, a mechanic, was completely incapacitated for work for a period of several days. A wart which had developed on the side of the index finger of a surgeon, as a result of the injury done to the part by the thread while he was ligaturing arteries deep in the abdominal cavity, threw him out of active practice for months and caused much anxiety. An affection that can disturb the course of life to such an extent is not to be looked upon as a trifling matter.

The essential difference between these warts and those located in other parts of the surface of the body is to be found in the hard, thick epithelial covering under which the wart grows and by which it is repressed. The lesion may at first look like a rather prominent, painful callus. Little by little the wart grows through this callus and may form a fungous plug appearing through a well-rounded hole. This fungus, on attaining the surface, may flatten out over it like the head of a tack. By chiropodists they are called "rose corns." In trying to currette it the instrument meets with a tough, elastic resistance unlike that of epithelium. Usually in these cases the best course to pursue is to soften and thin down the hard, thick epithelial covering, and then to peel and scrape it off. This lays bare the wart, which then may be treated just as one would treat an ordinary wart on the free surface.

Treatment.—(a) *Papillomata.*—The usual treatment of papillomata is simply to cut them off and to touch the base with nitrate of silver. In cutting them off, care has to be exercised, for it must be remembered that they are often of a venereal nature, and the patient may have syphilis. One of my friends, in removing some of them from the vulva of a prostitute, snipped with his scissors his own finger, and inoculated himself with syphilis.

Frequently acuminate papillomata will fade away on dusting them with calomel powder. This treatment is particularly applicable to papillomata on the genitalia. Sometimes even stout, fleshy papillomas will disappear under

this treatment. A patient once consulted me for several such, which were situated in the sulcus penis, and which I thought would surely have to be cut off. He could not have the matter attended to just then, and accordingly I prescribed the application of a twelve-per-cent calomel ointment. My preference for an ointment instead of a powder was due to the fact that, in this particular case, the growths were not moist, but dry, and it therefore seemed to me that the medicament would act better in the form of an ointment. In about three weeks all trace of the vegetations had disappeared. In women, with papillomata of the vulva, calomel powder frequently answers very well. For some reason calomel does not act as well on condyloma acuminatum of the anus.

(b) *Verrucæ.*—There are many treatments for verrucæ, all of them aiming to destroy the growths by topical applications; for we know of no internal medication that has any effect on them.

Nitric acid may be used, but it must be carefully applied or it will leave a scar. A drop should be placed on the top of the wart with a glass rod, care being taken that none of it shall run down over the skin outside of the wart. After this drop has penetrated into the wart, some of the dead, burned tissue should be scraped away, and another drop put on the denuded surface; and so on until it is assumed that the treatment is complete.

The wart may be shaved off and the base touched with nitric acid, or the wart may be removed by the use of the curette. In the latter case the fairly deep hole which remains should be treated with pure carbolic acid. The horny layer may be removed with salicylic acid, which should be used either in combination with collodion or in the form of an ointment. The formulæ for these are as follows:

> ℞ Salicylic acid 2.00
> Collodion... 20.00
> M. S. Apply with a brush once every two days. Before the application is made a second time, the preceding film, together with the softened epithelium, should be removed.

> ℞ Salicylic acid 1.00
> Simple ointment... 20.00
> M. S. Spread upon a cloth and apply.

The sodden, softened epithelium should be removed each day and the ointment reapplied until the wart is denuded sufficiently; then a drop of trichloracetic acid may be applied to the top of the stump in precisely the same manner as nitric acid is applied. Electrolysis affords an excellent method of removing warts, especially when they are located on the face in women, in which locality it is particularly desirable not to leave a scar. The needle attached to the negative pole of the battery is made to traverse the wart at the level of the skin in several directions, so as completely to destroy the circulation. The wart now

lies as a dead mass on the skin, and in the course of time falls off, leaving a smooth surface.

The high-frequency current, as applied with the large conical carbon point (Fig. 50), affords one of the best methods of removing warts on the scalp. The electrode should be held a short distance from the wart, and the spark allowed to beat on it, until the tissue looks like a soft, greasy lump that may be readily pushed off with the nail (Bulkley). This method of treating warts in other situations does not, for some unknown reason, seem to answer so well.

(c) *Juvenile Flat Warts.*—Juvenile flat warts of the face are easily scraped off with a curette, and then the surface may be treated with glacial acetic acid.

Fig. 50.—Electrode with Carbon Point, for single spark. (C. W. Allen: "Radiotherapy and Photo-therapy.")

Do not use nitric acid, as it is apt to leave scars that form a constant reproach to you. As a general disinfectant for the surface, a three- or four-per-cent salicylic-acid ointment may be prescribed.

CICATRIX.

Wounds in epithelial tissue heal by division and growth of the neighboring epithelial cells, and the repair is absolute and by a tissue that resembles in every respect the injured tissue. In the affected region the vegetative processes are slightly accelerated, and consequently there may be some tumefaction, redness, and desquamation, but after a time everything returns to the normal and conditions become as if no injury had occurred. In wounds of the other tissues of the body—of connective tissue, of muscular tissue, and of nerve tissue—the repair is made by what is called scar tissue, a tissue that resembles white fibrous tissue. While it resembles white fibrous connective tissue, yet it never is exactly like it, and its presence indicates a marked difference between the process of repair in epithelial tissue and that which takes place in the other tissues of the body. As the process of repair has already been thoroughly discussed in the preceding volume, we may pass on at once to the consideration of other matters.

Scars are usually recognizable, as they differ from the surrounding skin in color and in consistence, as well as in the absence of hair, of gland openings, and of the markings of the surface of the normal skin. They are not at all likely to be mistaken for anything excepting possibly false scar and keloid. False

scars, or lineæ albicantes, differ from scars by their great number and by the fact that they form long parallel lines of about the same length.

Scars may demand treatment because of their disfiguring character, because of their interference with function, or because of their being spontaneously painful. They may cause a feeling of formication, burning, or cold, which is usually intermittent, and which is frequently found to be dependent on some change of the weather, such as an approaching storm. Some cicatrices are exquisitely hypersensitive even to the clothing, and if such a scar is on the hand the patient may not be able to grasp anything because of the pain. A cicatrix that appears to be in perfectly good condition may be spontaneously painful, or pain of a neuralgic character may radiate from it. These painful scars are especially frequent after infected wounds, such as post-mortem wounds. The pain, in such cases, is thought to be due to the continued presence of septic materials, the elimination of which is followed by a disappearance of the pain. Sometimes, in such cases, an energetic cauterization will completely cure the pain (Winiwarter).

The consideration of those scars which give rise to other nervous symptoms —such, for example, as fibrillary twitching or contraction of muscles or groups of muscles, or the phenomena which constitute the starting-point for an epileptic aura—comes under the head of nervous diseases. On the other hand, the scars which, by exerting pressure on blood-vessels, give rise to venous stasis and to interference with arterial blood supply, as well as those which interfere with voluntary motion, as of the limbs or digits, are treated of in general surgery.

Scars may also, by their contraction, obstruct the ducts of the glands of the skin. Thus, for example, they are frequently the cause of comedones, of wens, and of retention cysts in the sebaceous glands or in other glands of the skin.

Hypertrophic Scars.

If it be assumed that a normal scar is one that fills out a solution of continuity and causes no particular disturbance, then there are scars that are evidently too large for the work they were intended to do. They are the hypertrophic scars. They differ from keloids in these respects: they tend, after a time, to recede and to look like normal scars, and they do not return after excision. The distinction between a keloid and a hypertrophic scar is, therefore, not very well marked.

Treatment of Scars.—One sees at times wonderful effects from massage as carried out by the patients themselves. It is usually well to prescribe for use, in the performance of massage, a smooth, soothing ointment, such as benzoated lard or a mixture of equal parts of lanolin and vaseline. A pinching,

pulling movement, by catching the scar between the thumb and index finger, is the best. Women who have a disfiguring scar in some exposed situation are likely to be very successful in their employment of this mode of treatment; they persevere with untiring energy.

Scarification is one of the oldest methods of treatment for hypertrophic scars and its allied disease, keloid. It has been practised as far back as the sixteenth century. In modern times it was introduced by Vidal. It consists in making a number of parallel incisions over the surface of the scar, and crossing them by other incisions at right angles. The depth of the incisions and the distance between them must depend upon the size and thickness of the scar or keloid. For instance, if the mass measures 4 or 5 mm. in thickness the first incisions should be about 2 or 3 mm. deep and 3 or 4 mm. apart. This procedure should be repeated at intervals of one week, and, as the hypertrophied tissue gradually shrinks, the incisions should be more superficial and the distance between them should be less. The incisions should extend entirely across the scar and a distance of 4 or 5 mm. into the healthy tissue on each side.

After the treatment, the scarified surface should be carefully protected against irritation by the application of a suitable dressing. Mercurial ointment has been found to be especially beneficial. It acts as a protection and also as an antiseptic, and it probably exerts a specific effect of some sort.

The first result of scarification, in painful keloids, is the disappearance of pain. Even in the worst cases this takes place after two to three treatments, and is doubtless due to the destruction of nerves. The reduction of the size of the tumor, however, requires a much longer time—probably several months. While scarification almost invariably brings relief, it seldom causes the growth to disappear entirely, unless it is coupled with some other method of treatment, such as electrolysis.

The employment of *electrolysis* in these cases was first inaugurated by Hardaway. A current of from five to eight milliamperes is required. Strong steel needles should be selected. There is some difficulty in penetrating the tumor, but this can be partially overcome by rotating the needle, or by closing the circuit while it is being introduced. The growth should be transfixed in a number of places at a single sitting, and at each introduction the current should be made to play for from fifteen to thirty seconds. The treatment should be repeated at weekly intervals.

Excision is not advisable in true keloids, as the operation may lead to the formation of a larger tumor. In the case of hypertrophic scars, however, the excised growth seldom returns. No cauterization of any kind should be tried on keloids, as the irritation may stimulate their growth.

The *x-ray* seems to afford the most successful method of treatment for keloid and for hypertrophic scars, and has been credited with a number of cures.

As soon as one method of treatment seems to lose its beneficial effect in a given case, it should be abandoned, as perseverence would be worse than useless. Another method should be adopted in its place. In conclusion we must say that, while hypertrophic scars are curable and sometimes shrink to normal proportions spontaneously, keloids are curable only in exceptional instances. As a rule, a treatment that succeeds in preventing them from enlarging should be considered successful.

KELOID.

A keloid is a scar-like tumor, and, like a scar, it can be moved freely on the subjacent tissues. It also resembles a scar in another respect: it is let firmly into the skin itself, and is only movable with it. It is harder than the skin, and often has prolongations which stretch out from it in the same manner as claws extend from the body of a crab; hence the name "keloid," or crab-like. (Fig. 51.)

Some keloids develop deep down in the substance of the integument itself, while the surface of the skin, with its markings, its gland openings, and its projecting hairs, remains intact. Even the color of the skin may be preserved, and the presence of an oval or elongated tumor can be made out by touch, by a slight saliency, and by the above-mentioned claw-like processes that are usually particularly well marked at each of its ends. This kind of keloid is apt to lie across the sternum and is called spontaneous or true keloid in contradistinction to false or scar keloid, that develops out of a scar. Some observers are inclined to look upon true keloid as being possibly of embryonal or congenital nature, and therefore a sort of nævus. It is rarely painful or otherwise troublesome, and, as it is usually covered by the clothing, its unsightliness is not a cause of worry. Inasmuch as it shares with the other forms of keloid a marked tendency to recur when cut out, it is the part of wisdom to leave it alone.

False keloid is indistinguishable from hypertrophic scars, but when it is removed by excision it almost always returns. On the other hand, hypertrophic scars may not return after they have been removed. False keloid also tends to remain stationary, while hypertrophic scar gradually becomes paler, flatter, and more supple, and finally assumes the appearance of what one calls a normal scar.

The false keloid differs from the true keloid in that the skin, like a cicatrix, contains neither glands nor hairs, nor does it show the normal markings found on the skin; and, instead of occurring over the sternum, it appears where its antecedent wound was inflicted.

False keloids, like hypertrophic scars, are raised, smooth, red, firm, and are fixed in the skin and movable with it; and, also like them, they are more

apt to follow suppurating wounds than those that heal by first intention. They
may be either painful or intolerably itchy, and their subjective symptoms are
apt to be most marked before some decided change in the weather or before a
storm.

Diagnosis.—The diagnosis of keloid is usually easy, as its appearance is
so characteristic. A patch of morphœa is also smooth and hard, and let into

Fig. 51.—Keloid. (Original.)

the substance of the skin; but it tends to be round and flat, and has a lilac
ring around an unusually pale centre. Some of the lesions of tubercular lep-
rosy constitute the nearest mimicry of keloid that I have ever seen. This leads
up to another interesting feature of keloid; I refer to the fact that some observers
have, by inoculating pieces of keloid into guinea-pigs, got as a result tuber-

culosis, and it may be that cutaneous tuberculosis, like cutaneous leprosy, may cause lesions indistinguishable from keloid.

Treatment.—The treatment of keloid is eminently unsatisfactory. This is particularly vexatious, as the disease may spring from a wound made by a surgeon, and in this manner there may be created an evil possibly greater than the malady for which the operation was performed, and one which the surgeon may find himself helpless to relieve.

Treatment may be directed either to relieving the pain and itching, or to the removal of an unsightly deformity, or to the correction of a functional disability. A keloid of the hand, for example, may interfere with the movements of the fingers.

The Roentgen ray is one of the most efficient agents in the treatment of keloid. It may either relieve the subjective symptoms alone, or it may also cause a decided decrease in the size of the tumor and at the same time diminish its high color. It should be administered in about the same way as for epithelioma. Sabouraud believes that a high dosage producing an erythema gives the best results.

A small quantity of mercurial ointment rubbed in daily for a long time has been found beneficial in some instances.

Many advocate scarification as a useful mode of treatment. It should be carried out in the following way: Cocaine is first to be injected under the tumor, the needle being slowly withdrawn as the injection is being made. Then wait three full minutes before commencing the scarification. The bistoury should be carried clear down through the tumor; and in doing this it should be remembered that the keloid lies as deep in the skin as it projects above the surface. The parallel cuts should be made as close together as is compatible with not cutting out slices of the tumor.

Dermatitis papillaris capillitii (keloidal acne) has been mentioned in the section on acne. We may add here that it sometimes gives rise to an irregular prominent tumor, bulging out like a cushion at the nape of the neck, and with the hairs sticking out of it at all angles. It may come under the care of a surgeon as a tumor, and, if its true keloidal nature is not recognized, it may be excised—with, of course, the usual relapse in an aggravated form.

FIBROMA.

Fibromata, or connective-tissue tumors, of the skin are of two kinds, hard and soft.

Hard Fibroma.—The growths of this variety consist of firm, sharply circumscribed, smooth nodules situated in the tissue of the skin. They are usually small, either the size of a pea or somewhat larger. Generally they are solitary, but there may be a few of them.

Diagnosis.—A hard fibroma may be mistaken for a deep keloid—for one of those keloids, for example, that occur in the lobe of the ear as a result of piercing the ears. It may be simulated also by one of the dense cystic tumors of the skin, like that of cysticercus. The fatty tumors of the skin differ from the hard fibromata by their doughy, soft consistence, and by frequently being lobulated. They differ from sarcomas by their slow growth and by the normal color of the skin over them. The skin over a sarcoma is frequently violaceous and highly vascular.

Treatment.—If they cause no trouble they may be left alone, and this masterly inactivity is sometimes wise, because fibromas after being extirpated may recur, and also because it is sometimes impossible to distinguish them from deep keloids that will almost certainly recur.

Soft Fibroma.—This variety of fibroma of the skin—also termed *molluscum fibrosum*—presents a totally different picture from that of the hard fibroma. It looks more like a prominence of the skin produced by a simple growth of the integu-

FIG. 52.—Multiple Fibromata of the Chest, Abdomen, and Arms. (Original.)

ment; its appearance being that of a soft, wrinkled prominence or a pendulous bag-like growth, of a size varying from a very small tumor up to the dimensions of a pear or an even larger object. It sometimes has a lobulated, corrugated, or puckered surface, and, when dirt fixes itself in its recesses, it may give the tumor a dark or black color. Usually the color is that of the surrounding skin. Sometimes these growths form large flaps of skin, a condition to which the term *dermatolysis* has been applied.

In many instances they are undoubtedly nævi, and they frequently occur, as in the accompanying illustration (Fig. 52), in association with pigmented nævi or lentigines. They also are an accompaniment of adenoma sebaceum, which is undoubtedly a nævus formation.

Treatment.—They are easily snipped off with scissors, and, as they are eminently benign growths, they rarely recur. The larger flaps of skin, constituting dermatolysis, sometimes require a more extensive operation, but rarely a difficult one.

MOLLUSCUM CONTAGIOSUM.

It is not for what they are, but for what they may be thought to be, that these little tumors are of importance. They themselves rarely cause any inconvenience and never any damage.

The tumors of molluscum contagiosum look like little unpigmented moles or warts. They are small, fleshy, rounded, prominent tumors, that vary in size from that of a pin's head to that of a pea, and they rarely attain a larger size. (Plate XIV.) They have usually the color of the skin, and are smooth and waxy-looking, but they may be pink or even red. They may sit on the skin on a broad base, or the base may be constricted. At first glance, they present every appearance of being prominent fleshy moles, but on closer inspection it will be found that they possess one well-marked feature that distinguishes them from moles, viz., in the centre of the top of each of the tumors a hole can be seen, either open or plugged, with a friable crust, and, if one squeezes the little tumor, a cheesy mass can be forced out through this hole, the tumor itself being left flaccid and collapsed. If more evidence of the real nature of the tumor be needed, some of the detritus may be spread on a microscopic slide, a drop of glycerin added, a cover placed over it, and then an examination made with a lens of moderate power. This will disclose a number of molluscum bodies consisting of round or oval, capsulated objects larger than an epithelial cell and having contents that look like colloid. Finally, if still more evidence is required, one of the little tumors may be snipped or removed from the skin, by means of the curette, put in alcohol, and afterward mounted, sectioned, and stained for microscopical examination. A characteristic and interesting picture will be seen. The tumor will be found to consist of compartments separated by connective-tissue partitions, all emptying into a central cavity that communicates with the opening at the top. The appearance presented is that of a fruit or of an acinous gland. The cells lining the walls of these compartments are the ordinary epithelial cells of the skin. These cells, in growing older, do not undergo cornification, as do those on the surface of the skin, nor is there a fatty change such as takes place in the epithelial cells of the sebaceous glands; but gradually they fill up with a homogeneous translucent substance, like amyloid substance or colloid, but differing from amyloid substance in this respect, viz., it does not give the characteristic reaction with either iodine or methyl violet.

There are many reasons for considering molluscum contagiosum a contagious disease, but no direct proof, as through inoculation, has yet been furnished. For instance, patients will, on inquiry, frequently admit that shortly before the appearance of the disease they had taken a Turkish bath. One is tempted to infer, from this circumstance, that the moisture, the warmth, and the maceration of the skin had favored inoculation. Another circumstance

EXPLANATION OF PLATE XIV.

Fig. I represents the typical, discrete, umbilicated lesions of Molluscum Contagiosum.

Fig. II represents the beginning of a confluent form, the conglomerate mass of raspberry-like lesions simulating nævi and to be distinguished from the latter by the presence of discrete tumors— each one possessing the typical umbilication—about the periphery of the mass.
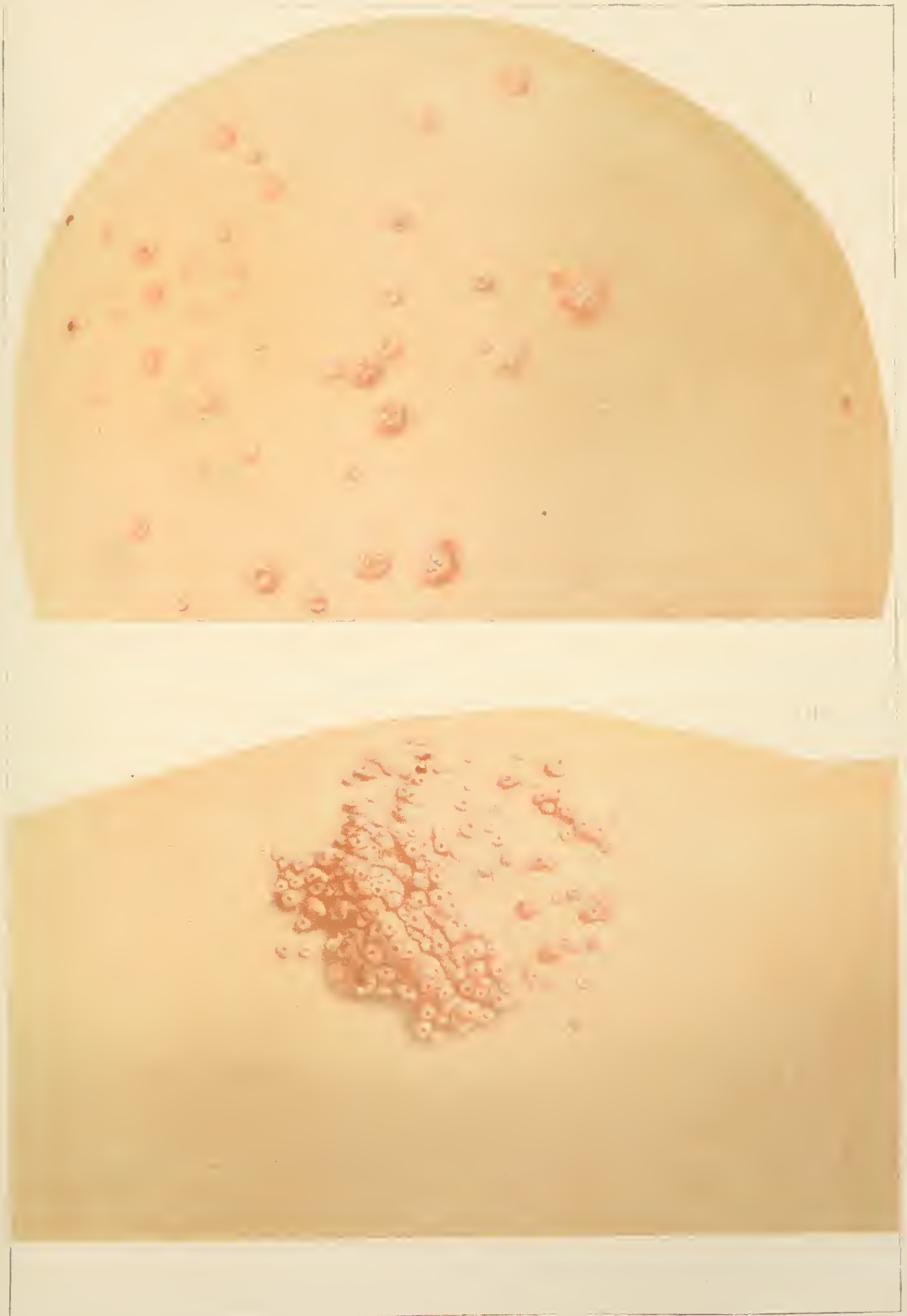
MOLLUSCUM CONTAGIOSUM

From *La Pratique Dermatologique*. Masson et Cie, Editeurs, Paris.

which may be mentioned as favoring the view that it is contagious is the frequency of its appearance in situations exposed to contact with the hands or skin of others—such as the breasts in nursing women, the face and neck in children, and the genitalia in men and in prostitutes. Furthermore, the disease has been remarked as occurring in groups of closely associated people, as in members of the same family, and in children in asylums and in schools. According to my experience, however, by far the most important of the above considerations is the one which refers to Turkish baths.

As before mentioned, these tumors cause no inconvenience and no damage, but they sometimes give rise to a great deal of worry. From the fact that they often appear after the patient has frequented some bathing establishment, he is very likely to fear that he has acquired a dangerous disease. Then, again, as the growths often appear on the genitalia and after illicit connection, the patient can readily, especially in the presence of a bad conscience, persuade himself that they are syphilitic. Fortunately, it is not a difficult matter to make an absolute diagnosis.

One or several such tumors may last for years without undergoing any particular change. They may either wither and drop off or be accidentally knocked off, or they may become infected and be destroyed by inflammatory reaction.

The treatment is very simple. The contents may be simply squeezed out, after which the capsule withers and falls off, or a small slit may be made across the top of the little tumor to enable the contents to be squeezed out more readily. A wooden toothpick dipped into tincture of iodine may be introduced into the opening at the top and twirled around; after which the tumor will wither. The little tumor may be removed by the employment of the curette, this operation leaving a shallow bleeding surface. This surface may then be burned with some acid, such as carbolic acid, which does not leave a scar. It is indeed very desirable that no procedure should be adopted which is likely to produce a visible scar. When a large number of these little tumors occur together, as is sometimes the case, it has been suggested that soft soap, spread thickly upon a piece of lint, should be applied every night to the area affected. This variety of soap acts as an irritant and solvent, and leads to a cure of the infection. Personally, I have never had occasion to use this mode of treatment, and I cannot speak from experience in regard to its efficacy.

EPITHELIOMA.

Epithelioma and carcinoma constitute a pathological group both members of which have one feature in common, viz., the errant and infiltrating growth of epithelial cells. The epithelial cells in such cases act like parasites, and grow down into the subjacent tissues, driving them asunder and robbing them

of nourishment. They can also, like independent micro-organisms, follow the course of the lymphatics and form metastatic growths; or, travelling by way of these channels, they may, as some believe, eventually reach the blood-vessels and so be generally distributed.

The name "epithelioma" is commonly restricted to the malignant growths that spring from flat, stratified epithelium.

The change in the life of an epithelial cell, by reason of which it manifests the characteristics which we call malignant, is probably effected by long-continued irritation. Frequently these irritations give rise to changes, usually of a chronic inflammatory character, that may precede for years the actual formation of an epithelioma. These conditions have therefore received the name of precancerous diseases. The precancerous diseases are:

(1) The senile or seborrhœic patch;

(2) A rough atrophic condition of the skin met with in men who are much exposed to the weather, and called "seamen's skin";

(3) Xeroderma pigmentosum, which is probably a hereditary hypersensitiveness of the skin to the irritation of light.

(4) Paget's disease, which exists for a long time as a refractory eczema before any malignant change takes place in it;

(5) Leucoplasia of the tongue and of the cheeks.

Besides the above diseases, in which the development of cancer may be looked upon as a more or less natural consequence, there are other conditions in which cancer occurs occasionally. Such are, for example, cicatrices, in which epitheliomas develop frequently enough to show that it is a predisposed tissue; old patches of lupus vulgaris; old tertiary syphilides; long-existent patches of psoriasis; obstinate patches of lupus erythematosus; and, occasionally, sebaceous cysts. Arsenic, when it has been given for a long time, and has caused keratosis arsenicalis, is also said to predispose to cancer (Hutchinson).

The nævo-carcinomas which are derived from birth-marks have been considered under Nævi.

Fig. 53.—Epithelioma, Showing Rolled Border. (Original.)

Males are more frequently affected with epithelioma than females, and this is probably due to their greater exposure to irritations. As examples of such irritations we may mention senile seborrhœic patches, resulting from ex-

posure to the weather, and leucoplasia of the tongue, which is attributed to the effects of tobacco smoke.

Some families are more disposed to epithelioma than are others. This may be due to some inherent weakness of the skin, that renders it more liable to the formation of senile patches, which in turn sometimes give rise to epithelioma.

Fig. 54.—Epithelioma of the Lower Eyelid.   (Original.)

Xeroderma pigmentosum—an affection which is apt to occur in families—may be only a highly exaggerated instance of this inherent weakness.

The great majority of epitheliomas occur on the face, and there are two principal reasons for this. In the first place, senile patches occur most frequently on the face, and out of these, as before mentioned, epitheliomas readily develop. Then again there are many orifices in the face, such as the eyes, the nostrils, and the mouth, and around these, as localities having a comparatively delicate covering and much exposed to irritation, epitheliomas tend to spring up. (Figs. 53 and 54.)

For clinical purposes one may divide the epitheliomata of the skin into:

(1) Superficial epithelioma;

(2) Deep or nodular epithelioma;

(3) Papillary epithelioma.

These divisions are not absolutely distinct, as they may run into one another;

but they do form a basis on which to build clinical descriptions in a disease the symptoms of which are remarkably diverse.

Superficial epitheliomas do not always begin in the same way. For example, an epithelioma may begin by changing, in an insensible manner, from one of the before-mentioned precancerous diseases, or by stealthily developing in one of the lesions mentioned as affording a good ground for the development of a cancer. Then, again, it may first appear as a common wart that little by little gets an indurated base, with an elevated, rolled, limiting collar about it; or it may commence as a hard papule no larger than a pin's head. This papule possesses considerable importance, and I will therefore describe it separately.

The cancroid body or papule, to which I have just referred, is rounded, prominent, hard, smooth, glistening, and waxy-looking, and has minute capillaries running over its surface. All these characteristics are dependent upon the fact that the epithelium grows down into the skin. These epithelial cells are hard and yellowish in color, and in growing down they lift up the outer layers of the skin, putting them on the stretch and so obliterating the natural furrows of the surface—a change which gives to the skin a smooth, glistening appearance. As the epithelial cells composing the chief tissue in the nodule are hard, the resulting nodule is indurated; and as they are yellow in color, the nodule, as seen through the translucent skin, has a yellow, waxy appearance. As the nodule is composed of cells that dip down into the connective tissue of the skin, below the papillary and superficial layers, these layers are lifted up over it and cover it, and it is in these layers that the capillaries run that are seen coursing over the nodule. In fact, as capillaries cannot run in epithelium, we are warranted in drawing the inference—in those cases in which they are seen coursing over the waxy-looking epithelial nodule—that the epithelial infiltration has taken place into the true skin. As these characteristics persist throughout the subsequent growth of the small cancroid papule, no matter how large the epithelioma derived from it may become, it will readily be appreciated that they have an important bearing upon the diagnosis. The small papule may develop into a large ulcerating surface totally unlike, in its gross appearances, the above-described cancroid body; but the border of this ulcer will be rounded, prominent, hard, smooth, glistening, and waxy-looking, and will have minute capillaries coursing over its surface.

After the formation of such a cancroid body an erosion takes place on its top. The erosion occurs in this particular spot because it is the point farthest removed from the nutrition supplied by the blood-vessels, which must run up from the bottom, and this erosion is, as one would expect it to be, cup-shaped or crateriform.

The blood-vessels of this cup-shaped surface easily bleed, because the epithelium that should protect them is cancerous epithelium, and, therefore, degenerate and friable. It is this epithelium, also, together with a little serum, that

forms the scanty secretion of the cup-shaped cavity. As this secretion is sticky, resulting as it does from horny epithelium,—and therefore containing a considerable amount of keratin or glue,—it readily forms a tightly adherent thin scab, the dark brown color of which is due to the fact that a little blood is mixed with the secretion.

When this crust is pried off, there is exposed to view a light or dark red, smooth surface that glistens as if varnished. This varnished appearance is also due to the glue. As the ulcer grows, the rolled edge may become more pronounced and the floor more irregular, but it retains its primitive characteristics, although they may be exaggerated.

Usually such an epithelioma starts, not as a single cancroid papule, but as a group composed of several papules, the general appearance being exactly like that of a wart. With a low-power pocket lens, however, one is enabled to distinguish each individual papule and to make the diagnosis. When such a group of papules breaks down, they go to form a common ulcer with scalloped edges, each scallop corresponding to a primary papule. An epithelioma formed in this way grows very slowly, and constitutes one of the ulcers that are known as "rodent ulcers."

Another form of "rodent ulcer," although in reality an epithelioma, is formed somewhat differently from the above and is still slower in its growth. It consists of an extremely slow persistent ulceration, that advances by a serpiginous border. As Darier says, there is so little tumor formation either about it or under it that one must know of the existence of the type in order to make a diagnosis of epithelioma at all. The ulcer grows on one side while it heals on the other, and the advancing border is steep, but neither undermined nor rolled. The floor of the ulcer is either rosy or yellow, but it is neither granular nor does it easily bleed; it is either perfectly dry or secretes very little moisture. The ulcer is always partially healed, and on the side where cicatrization has taken place it either rises gently to the level of the skin or it terminates in a rolled border. This ulcer is found exclusively on the eyelids, on the forehead near the hair line, or around the nose. It is most persistent as a local disease, and tends to return again and again after being apparently destroyed, but it never forms metastases.

Histologically, it is a small-celled epithelioma, associated with the formation of a great deal of cicatricial tissue.

As regards its mode of commencement, the superficial epithelioma generally begins as an erosion under a senile patch. Senile patches have already been spoken of as one of the precancerous affections of the skin. They occur most frequently on the face and on the back of the hands in elderly people, whose skin has already undergone atrophic changes. (Fig. 55.) It frequently appears on that desquamative, oily type of skin that is called seborrhœic, and the patch has therefore received the name "seborrhœic patch." Senile patches may, how-

ever, appear on other parts of the body besides the face and the back of the hands, and the people having them are not all old, nor do they all show symptoms of senility. The patches themselves are so common as hardly to require description. They may be slightly reddened, or the inflammatory reaction in them may be of such low grade as not to cause any reddening beyond the borders of the crust. They are round or oval and usually about one or two centimetres in diameter. The epithelium is roughened and slightly raised above the

FIG. 55.—Senile Patches and Epithelioma, Showing Epitheliomatosis. (Original.)

surrounding surface, and it may be hard and horny or soft, friable, and greasy. It may be white and glittering, as it frequently is in the hard, horny senile patches, or it may be buff-colored, dark-brown, or almost black, as in the so-called "moth patches." These patches may exist for a long time, or always, as harmless disfigurements, for they do not necessarily undergo cancerous degeneration. They frequently, however, do so, and, when this occurs, one can sometimes recognize the beginning of the graver trouble by the presence of a rolled waxy border, or of cancroid bodies at the edge of the patch. Often enough, however, there are no external symptoms to indicate the change, and it is only after scraping off the top crust, and exposing a rotten, easily bleeding base, that one

becomes aware that malignancy has commenced. The further course of the disease may be that described as arising from a cancroid body. The patch may have either a rolled waxy border or a border studded with waxy nodules. It may, however, have a border level with the surrounding skin and terminating abruptly at the edge of the ulcer.

Papillary Epithelioma.

Papillary epithelioma may make its appearance in the papillary form, or it may develop out of an antecedent senile patch. When fully developed it
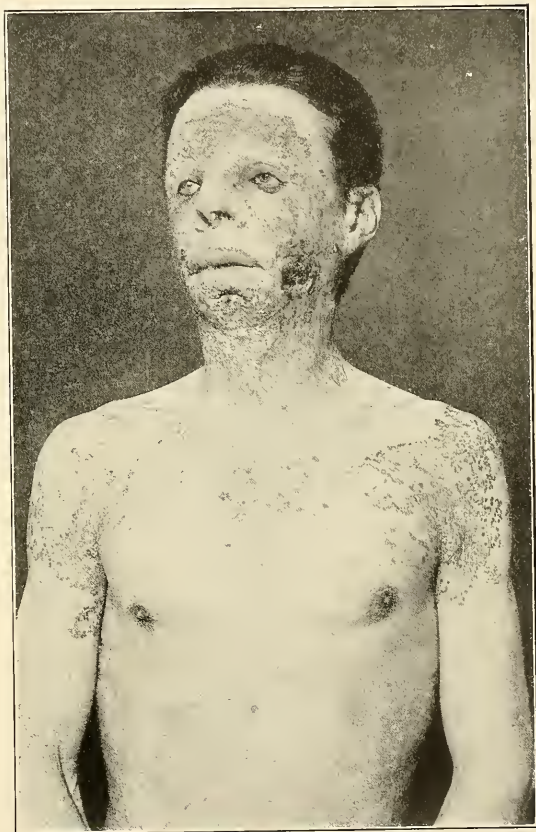
Fig. 56.—Lupus and Carcinoma of the Skin. (After Ashihara, in Neisser's "Stereoscopischermedicinischer Atlas.")

consists of a slightly elevated disc bounded by a rolled border, which encloses a surface covered by wart-like excrescences. (Fig. 56.) After a time these warty growths may be eaten away by the progress of the cancerous ulceration, and the ulcer may then resemble in all respects an ordinary superficial epithelioma of the skin. Besides appearing on the skin, this kind of epithelioma

also occurs on the lips, especially at the commissures, on the tongue, and on the glans penis.

Deep-Seated Nodular Epithelioma.

Deep-seated nodular epithelioma commences in the form of rounded or conical lumps located well down in the substance of the skin. There may be only one such lump, but, more usually, there are a number of them closely packed together. These gradually increase in size until they form a reddish or purple prominence on the surface. As the prominence grows still larger the color of the infiltrating epithelium asserts itself, and the tumor becomes waxy yellow with capillaries coursing over it, like a gigantic cancroid nodule. The oldest central epithelial cells may undergo atrophy and be absorbed, causing the centre of the tumor to sink in, and giving it an umbilicated appearance. Finally, ulceration may take place, giving rise to an ulcer with large rolled edges.

Senile Multiple Epitheliomatosis.

Senile multiple epitheliomatosis is a name given by Darier to a condition of the skin that sometimes occurs in aged people. It consists of a great number of all varieties of senile patches scattered over the face, ears, neck, and back of the hands. Besides this there are atrophy of the skin, and a dirty, greasy coating over quite extensive areas. There may be many epitheliomas present, in all stages of development, from those just evolving out of senile patches to those that have formed characteristic ulcers. Any of the several varieties of superficial epithelioma may develop in this affection, and several kinds may be present at the same time and in close proximity to one another.

Treatment.—In the first place, it is important to recognize the fact that much may be done toward the prevention of epithelioma. The patient should be advised that it is wise to have all senile patches treated, and that the fear of having them disturbed lest they should develop into cancers is not justified by the facts. The medical profession itself is not a little to blame in countenancing this negative attitude toward senile patches. In fact, it is as necessary to remove senile patches in order to prevent cancerous degeneration going on under them as it is to clean the tartar from the teeth in order to prevent erosion of the enamel.

There are several means of accomplishing this. The greasy coating of the skin of old age may be removed by wiping it off with glacial acetic acid. Senile patches may be scraped off, and an ointment composed of the following ingredients may be prescribed:

℞ Salicylic acid............... ....gr. x.
  Precipitated sulphur......................... .... ℨ i.
  Lanolin,
  Vaseline..of each ℥ ss.
M. S. Rub in every night.

In many cases one can keep down a senile patch for years with this application alone. Years ago a physician called on me with a senile patch on the left temple, that was so eroded as to bleed easily. This was absolutely controlled, although never entirely cured, by the daily application of the ointment for which the formula is given above. Patches that are very hard, and therefore are not reached by this ointment, may easily be removed by an application of trichloracetic acid. This is an admirable remedy, as it exerts upon epithelium the same dissolving quality that is possessed by acetic acid, and is much more energetic than glacial acetic acid.

The x-ray itself is an excellent remedy for this senile change, and in treating an epithelioma it is well, for the first few sittings, to expose a much larger area than that occupied by the cancer. In instances of multiple senile epitheliomatosis, I regularly expose the whole face, with the exception of the eyebrows and eyelashes, to the influence of the x-ray, and with benefit.

Medically speaking, the cure of a disease consists in restoring the affected part to the normal—or to the normal, barring some injuries wrought by the disease itself. When a disease occurs in a limb and the limb is amputated, we cannot term this "curing the disease"; it is simply removing the diseased member. So it was with epithelioma until a short time ago; annihilation was the only treatment possible. At the present time, however, it is possible, by means of the x-ray, to effect a real cure in many cases.

In place of the peccant material, there is left, after the employment of this treatment, a cicatrix representing the destruction of tissue which existed previously to the accomplishment of the cure. The x-ray is, therefore, the ideal non-operative cure, and, fortunately, it is available in quite a large proportion of the cases which present themselves for treatment.

The most important advantages of this method of treatment are its painlessness, and the beautiful smooth scars that follow the healing of the ulcer. It should, therefore, whenever such a course is possible, be given a fair trial before we resort to other more heroic and disfiguring methods of treatment; and this statement is especially applicable in the case of patients who have lesions situated upon the face, or in nervous or debilitated subjects. The proper conduct of the treatment is a delicate task requiring care, skill, and good judgment, as many accidents and failures are due to the lack of one or all of these qualities in the operator.

The patient should be well protected by lead sheets, which should have an opening so shaped as to leave exposed the whole of the lesion and a narrow band of skin around it. A twelve-inch coil and a six-inch tube should be used with

a current of from five to six amperes. The tube is held at a distance of six inches from the surface of the skin. This distance, in the course of six or seven exposures, is gradually reduced to two inches or less. The duration of a single exposure is ten minutes, but exceptionally malignant growths, which need to be checked immediately or even burned, can be exposed for from twelve to fifteen minutes. At the end of a course of sittings it is not an unusual thing to see no evidence of improvement; but, after a further lapse of time, the reconstructive action may begin and may steadily advance until the epithelioma either entirely disappears or is reduced to insignificant proportions. It is important to remember that there is very little danger of burning an ulcerating surface. The treatment should be suspended as soon as a slight erythema appears, and, in case the lesion does not in the mean time disappear, the treatment may be resumed later on. Even when the epithelioma disappears, it is usually well to give a later course of x-ray sittings to make sure of the completeness of the cure.

In my experience, x-ray treatment of epithelioma is almost always followed by some degree of apparent improvement. In many cases the growth of the neoplasm is checked, and the discharge and pain disappear after the first few exposures. In a certain number of the cases the ulcer heals over entirely, with little danger of recurrence.

Epithelioma may be extirpated in many ways, and the choice of the mode must be determined by the good sense of the operator. No educated man should bind himself down to one plan of treatment.

Prompt, wide, deep, repeated excision of all diseased areas is the most reliable procedure, and should unquestionably be adopted in treating deep-seated, nodular epithelioma. Papillary epithelioma, when it occurs on the tongue, lips, or glans penis, should also be treated in this way. It may be advisable to extirpate epithelioma of the external auditory canal with the knife or cautery if the x-ray fails, rather than use any of the chemical caustics, as they are apt to block the canal and cause inflammation and subsequent otitis media.

The thermo-cautery and the electro-cautery are valuable means of treatment for epithelioma in almost any situation. One drawback to their use is the danger of secondary hemorrhage in five or six days after the operation.

Arsenic pastes are of great value when properly used. Their employment, however, requires some practice, and the destruction caused by them is often very much greater than one anticipates. At the same time this destruction is, in all probability, no greater in any case than it should be for the proper extirpation of the disease, as the arsenic seems to exert a selective action on the diseased tissue. In using this remedy one must always remember that, no matter what combination is used, the arsenic is the active agent, and it should be sufficiently strong. The weak pastes, if they act strongly, cause as

much destruction of tissue as the strong ones do, and, if they act inefficiently, they merely irritate the tissues and do harm. Arsenious-acid powder may be poured into either gelanthum or common mucilage, in which excipient it sinks to the bottom in the form of a thick paste. This paste may then be spread like butter upon the lesion, and no further dressing applied, as it is better that it should dry in the open air. It is of no use to mix the paste with cocaine or morphine, as sometimes advised, because the severe pain does not usually commence till the second or third day, and then no local application is of any avail against it. The pain thus excited is severe and often enduring, and morphine injections may be necessary to relieve it. As above indicated, the application of this paste is followed by the formation of a slough, covered by a scab, which it takes some weeks to throw off. I have never yet known such a cauterization to be followed by the development of a hypertrophic scar that endured as a keloid, but I am quite ready to admit that such a result may sometimes occur.

The Czerny-Truneck treatment is another method of applying arsenic. A raw surface is first obtained either with the curette or with the cautery. Then the raw surface is pencilled with the following solution of arsenious acid:

R Arsenious acid.. . ... 1.00
    Rectified spirit of wine.
    Water...of each 50.00
M.

This solution is applied to the part with a brush and allowed to dry in the free air without applying any dressing whatever. The application is to be repeated every day or every second day. The crust comes away spontaneously, from the fifth to the eighth day, and if all the epitheliomatous tissue has been destroyed the surface will appear white, but if some diseased tissue still remains the surface will present a variegated gray and red aspect. In the latter case, a new series of applications should be made, until finally a surface of a more satisfactory character shall have been obtained. It must also be said that, as a matter of fact, those who use this method often apply the arsenical solution in a much stronger form and repeat the applications several times on the same day, allowing each one to dry before applying the next. In this way a considerable precipitate of arsenic is obtained, and this acts in very much the same manner as does the paste formed with mucilage.

Besides arsenic, which is the favorite, there are quite a number of caustics that are used by different operators, and almost all of them are those that burn deeply, liquefying the tissues as they act. It is best, however, before applying them, to curette away everything down to a solid basis (see Fig. 43, B and C), and then to wait until all bleeding has ceased before applying the caustic. In the case of chromic acid, which is one of the best of these caustics, it is particularly important to secure this dryness of the wound; for when

the acid is put on a wet surface all its energy is taken up in combining with the moisture, and none is left to cauterize the tissues. When it is applied to a dry wound and a very little cotton is put into the liquefied mass that forms as a result of the application, the whole dries down to a hard, black, tightly adherent crust, that makes an excellent impermeable dressing.

Another very good caustic is caustic potash in stick form. It cauterizes and at the same time readily liquefies the tissues, and, when the stick is vigorously pressed in, a deep, efficient cauterization will be produced.

XERODERMA PIGMENTOSUM.

Xeroderma pigmentosum, which is a most rare disease of the skin, was first described by Kaposi in 1870. It is mentioned here because it inevitably leads to the. formation of malignant tumors, either epitheliomas or sarcomas. The operations which are called for in these cases are not undertaken with any hope of curing the disease, but simply as a means of ameliorating the patient's condition or of prolonging life. The disease begins in infancy, even as early as the second or third year of life, and it has a tendency to occur in families. The first symptom to attract attention is an unusual number of freckles occurring on the exposed surfaces of the body, such as the face, neck, hands, and arms. This freckling becomes more and more marked, and many of the freckles enlarge and deepen in color until they assume the appearance of lentigines or pigmented moles. There will also be noticed in these lesions a great number of dilated capillaries. In many instances the lesions begin as groups of dilated capillaries and afterward become pigmented. At the site of these groups the skin begins to atrophy and sink in, the capillaries disappear, and white spots with a slightly desquamating surface are left. The skin next assumes a characteristic mottled look, in which there are all varieties of the lesions— little groups of dilated capillaries, hyperpigmented patches, and white, sunken, atrophied areas. According to Kaposi, the atrophy commences in the epithelium, involves the cutis later, and leaves sunken areas that may reach down even to the subcutaneous tissue. These processes all go on with the utmost slowness, and, after years have elapsed, the skin, by shrinking, becomes too small for the surface which it has to cover. The mouth and nasal openings become narrowed, and atrophy of the lower lids, with xerosis of the cornea, occurs. Superficial lesions also develop. (Plate XV.)

Epithelioma, sarcoma, and, more rarely, angioma develop in the affected skin.

Very little is known of the etiology of this disease. Light seems to play an important part in its development, as it occurs only on those parts that are
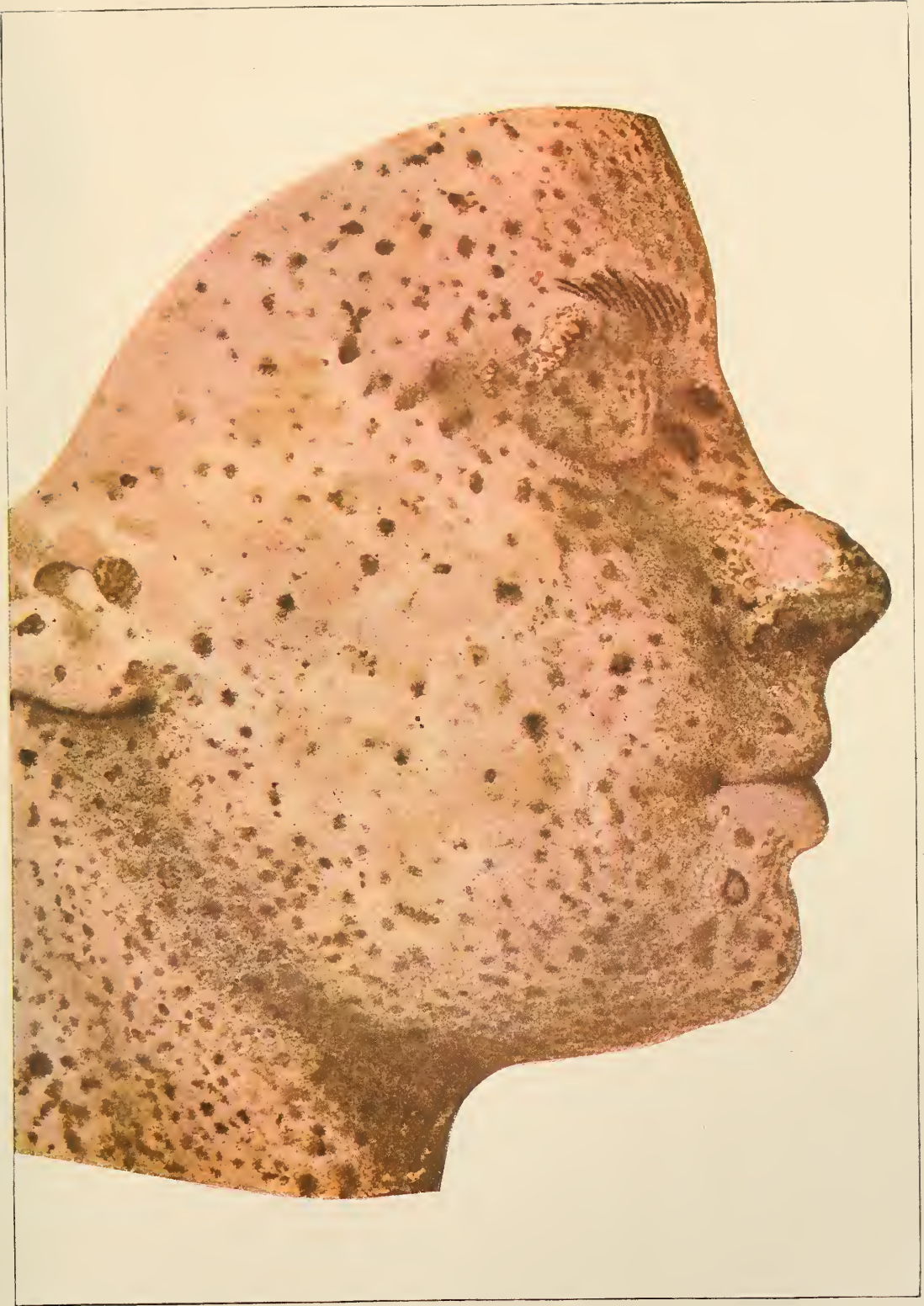
XERODERMA PIGMENTOSUM

(From *La Pratique Dermatologique*, Masson et Cie, Editeurs, Paris.)

exposed. In a little girl whom I saw some years ago, and who, as I thought, might be suffering from a light grade of this disease, the affection was on the face, neck, hands and arms, and on the legs. She lived in Arizona, where the sunlight is intense, so intense as ordinarily to cause browning of the skin of the legs through the stockings. The occurrence of the disease in families would indicate a hereditary affection. The diagnosis is not at all difficult. The
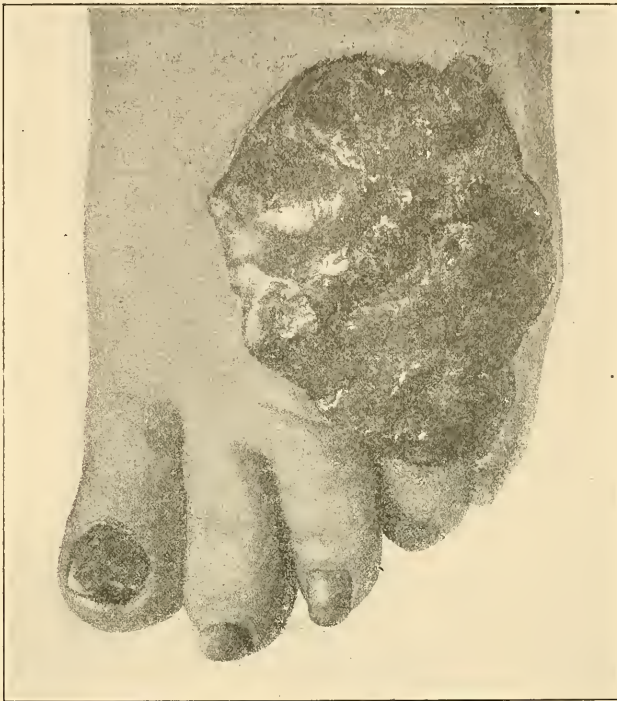
Fig. 57.—Fibro-Sarcoma of the Foot. (Sabouraud: "Dermatologie Topographique.")

only affection it might be mistaken for is pigmented nævus, as both are associated with patches of dilated capillaries.

The wearing of veils and gloves to shield from the sunlight, and the application of soothing ointments to make the skin supple, are the only preventive measures available. When malignant disease develops, an operation should be performed early.

SARCOMA OF THE SKIN.

Sarcomas are malignant tumors of the connective-tissue type. The tissue in them is embryonic and has a tendency to indefinite growth, but the rate of growth, and therefore the malignancy, differ widely in different sarcomas. Sometimes, for instance, it will form a sharply defined tumor of slow growth that when cut out does not return even locally, and has therefore not the malig-

nancy of a keloid; and yet, on microscopical examination, it will be found to consist of well-marked, richly cellular embryonic tissue. In another instance a tumor that is not nearly so richly cellular, and microscopically may be designated a fibroma, will obstinately return after extirpation, and may finally give rise to metastases. This all goes to show that we cannot ascertain the principle of growth simply by the aid of the microscope, and that malignancy is an aberration of growth. The diagnosis of sarcoma is often as uncertain as its course, for the inflammatory growths also frequently consist of richly cellular, round-celled tissue, in many instances indistinguishable from sarcomatous tissue. It may be that the erratic course described in some cases of sarcoma is due to the fact that they really are not sarcomas, but anomalous inflammatory growths. Actinomycosis, for example, used to be called osteo-sarcoma.

The clinical forms of sarcoma of the skin are so various that it is almost impossible to classify them; they have, however, this characteristic common to them all, viz., they form smooth fleshy tumors that grow either in the skin or under it. (Fig. 57.) Usually the disease commences as a single tumor, followed by other smaller satellite tumors. Many of the sarcomata have a rich blood supply, which gives them different shades of a red color, and many of them form a pigment which gives to them a deep brown color or an inky black. They are usually painless and easily movable.

Prognosis.—Nothing could be more certain, as a general proposition, than the prognosis of the sarcomata. Although their rate of growth is variable, and although they may cease growing and remain stationary for years, still the tendency of this disease is toward a fatal issue. Their disappearance has also been observed under the influence of erysipelas, of the x-ray, and of large doses of arsenic; and then, again, none of these agents may have the slightest effect on them.

Among the different clinical types of sarcoma there are some that are characteristic.

Melanotic Sarcoma.

A nævus, frequently a pigmented one, begins to show signs of activity, to enlarge, to grow more fleshy, and possibly to ulcerate. Such a nævus is particularly apt to be situated on the extremities, where it is exposed to irritation—it may occur even under a nail. The growth becomes indurated, and slowly increases till it reaches possibly the size of a hickory nut, but scarcely ever a larger size. The tumor is often deep black. It is usually movable on its base, and may be attached or not to the overlying skin. It may now take either one of two courses. It may invade the lymphatic system without any further implication of the skin. The next-lying lymph nodes enlarge, and the tumor spreads by metastases throughout the system, and the patient dies from invasion

of the internal organs. Or, instead of the lymphatic system being first invaded, other metastatic tumors may appear in the skin, where an enormous number of them may develop, all of them having the same characteristics as the mother tumor. Some of them may ulcerate and discharge a black fluid that stains linen. Other tumors may sink in at the centre and finally disappear; but the general course of the disease is onward, and finally, as in the former case, the viscera are implicated and the patient dies.

The disease has an inevitably fatal ending in at most two or three years, and, after visceral symptoms appear, death usually occurs within six weeks.

Nævi may also give rise to non-pigmented sarcomas, and the metastases are not always all pigmented. Some of them may be partly black and partly flesh-colored, while others are entirely flesh-colored and frequently look like rabbit flesh.

It follows from this that any nævus that shows signs of growth, or becomes succulent or begins to ulcerate, should be promptly and thoroughly extirpated. Malignancy is especially likely to occur when the nævus is exposed to any continued irritation.

Another well-marked type of sarcoma of the skin is that described by Kaposi as

Idiopathic Multiple Pigmented Sarcoma.

It begins at the same time on the dorsal, plantar, and volar surfaces of both hands and feet. From the hands and feet it slowly spreads up the limbs toward the trunk, taking two or three years to reach the body. It begins as moderately firm, round nodules the size of a shot or a bean, and of a reddish-brown color, which changes, as the tumor grows older, to a bluish-red. The tumors may stand out alone, or become confluent, or they may exist as extensive infiltrations. The hands and feet become markedly thickened, and the fingers stick out like sausages; and, as the growths are painful to pressure, working with the hands and walking are seriously interfered with or rendered impossible. The older nodules may, after some months have elapsed, sink down or fade entirely away, leaving dark, pigmented, cicatricial furrows. Whole groups of nodules or extensive infiltrations may so fade away, yet the disease progresses without being influenced in the least by any drug or any mode of treatment.

Enlargement cf the lymphatics is never a marked feature, but the malady ends by implication of the internal organs. The course of the malady covers a long period—from three to eight years.

The prognosis is absolutely bad, even when the diagnosis is made early and the nodules are extirpated.

The diagnosis is particularly difficult. At first, the disease is usually mistaken for a papular syphilide, and, later on, it may be mistaken for lupus or leprosy.

The treatment is symptomatic, and is directed to relieving the pain and swelling by means of softening bland ointments, by baths, or by lotions. Ulcerations and necroses must be treated according to general surgical rules.

ACANTHOSIS NIGRICANS OR DYSTROPHIA PAPILLARIS ET PIGMENTOSA.

Acanthosis nigricans is a rare disease of the skin that is principally interesting because of its being a symptom, as it indicates the presence of some internal disease, usually malignant disease, of the organs that have to do with the great nutritive processes of the body. It therefore is usually indicative of malignant disease of the abdominal organs.

Anatomically, the disease consists of a pronounced hypertrophy of the papillæ of the skin, a marked deposit of pigment in the papillary layer and in the suprabasal rete cells, and a hyperkeratosis. The name, dystrophia papillaris et pigmentosa, proposed by Darier, is, therefore, more appropriate than acanthosis nigricans. (Plate XVI.)

The papillary hypertrophy may be slight and may amount only to an accentuation of the natural furrows of the skin, or there may be warty growths which make the skin feel like that of a pachydermatous animal. The warty hypertrophy may pass over into the neighboring mucous membranes, as from the lids to the conjunctiva, where it appears as a fine granulation; from the lips to the mouth and tongue or to the nostrils; from the anus to the rectum; or from the vulva to the vagina.

The hyperpigmentation may be a light brown, a dark brown, or a deep black. The mucous membranes are never pigmented. The pigment may appear with the papillary hypertrophy, or it may occur before it, sometimes a considerable time before it. The pigmentation is usually confined to those parts which are affected with papillary hypertrophy or are about to be so affected; but sometimes it is more widely distributed. In some cases a generalized pigmentation has been observed, and, when this is light-colored and associated with anæmia, it can give the appearance called cachexia, and when the coloring is dark the skin may resemble that of Addison's disease.

In some situations the hyperkeratosis is very marked, as, for example, on the back of the neck, where the skin may feel as dry and as rough as a file, while in other situations it may not be perceptible clinically, although demonstrable in microscopical sections.

Changes in the hair and nails are not constant symptoms, and in any case they are apt to appear late. The nails may become dry and brittle, and split, while the hair also becomes dry and is apt to fall. The alopecia may even become general and very marked.

EXPLANATION OF PLATE XVI.

This plate represents the left side of the neck and the upper part of the back of a man, forty-two years of age, who was affected with Acanthosis Nigricans. Note the exaggerated folds and creases of the darkly pigmented skin and the presence of numerous disseminated papillomatous elevations some of which retain the form of isolated rounded eminences, while others are grouped together in cauliflower-like masses.

The patient, during the previous three years, had lost considerable flesh. The abnormal pigmentation of the skin had first been observed about five months before the time when the cast from which the picture was taken had been made by Baretta. Simultaneously with the appearance of the skin lesions, evidences of a cancer of the left lobe of the liver were discovered. [For further details consult the *Annales de Dermatologie et de Syphilographie*, 1896, p. 276.]

ACANTHOSIS NIGRICANS

(FROM *La Pratique Dermatologique*, MASSON ET CIE, EDITEURS, PARIS.)

The disease is usually symmetrical, and among the favorite situations for its development may be mentioned the back of the neck and the contiguous portions of the scalp, the mammary region, around the navel, around the privates, including the anal region, and the axillæ.

Treatment.—If the disease which interferes with the great nutritive organs can be cured, the dystrophy of the skin will disappear, as happened in a case of Spietschka's, where the acanthosis nigricans cleared up after the removal of a malignant deciduoma. When the affection is due to alcoholism it may clear up when the use of alcohol is stopped. In one instance the disease improved under the use of epinephrin (Boeck). Frequent bathing, with the use of salicylic acid, resorcin, menthol, phenol, or naphthol soaps, may do much to clear off the hyperkeratotic epithelium and relieve the itchiness from which the patient often suffers (Janovsky).

No operative treatment should be instituted for the removal of the acanthosis except when the warts cause discomfort. In such a case, curetting, clipping, and burning off the warts in the situations where the discomfort is felt are the only suitable methods of treatment.

AINHUM.

Ainhum is a rare disease of the dark races. One or both little toes may be affected, although in rare cases other toes and fingers may also suffer. A furrow appears in the digito-plantar fold and slowly creeps around the toe, gradually deepening. Little by little it compresses the toe at its base. The constricted toe swells to two, three, or more times its usual size and hangs helplessly, attached by a thin pedicle. The tissues of the tumor-like mass are subjected to atrophic changes, and eventually gangrene sets in. The mass may become accidentally detached or it may be cut away by the patient himself. The course of the disease is slow, and may last for a number of years before the useless member is removed.

No treatment has been successful in markedly improving the disease. It has been claimed that scarification or incision of the constricting band, if practised in the earliest stages, may prevent the further development of the disease —a view which is hard to verify, as the subject has not been adequately studied. Early amputation of the offending member is the best way of preventing subsequent trouble.

ERYTHEMA NODOSUM.

Erythema nodosum is a disease of the skin that is interesting to surgeons only in a negative way.

The eruption consists of nodes that vary in size from that of a pea to that

of a walnut or even a larger object, and that give the impression of being in the skin and not on it; that is to say, of being deeply rather than superficially situated. The comparison of the lesions, as regards their size, to a walnut is particularly happy, as most of the characteristic ones are of about this size and oblong and prominent. The color of the skin over the efflorescences is at first a bright red, afterward becoming bluish, and the color may run through all the shades of a bruise—hence one of the names of the disease, erythema contusiformis.

The severe pain and tenderness of the lesions, as well as their favorite situation on the legs below the knees, also favor the idea of the lesions being bruises and not the result of a general disease. There may be many or few of these nodules, and on one leg there may be a few infiltrated, red, œdematous-looking patches, while on the other there may be characteristic oblong contusiform nodules. The lesions may appear, not only on the highly characteristic situation over the flat surface of the tibia, but also about the knee, on the thigh, on the forearm, especially over the ulna, on the upper arm, on the trunk, and even on the face.

The affection begins with fever, with an evening temperature of from 39° to 40° C. (102.2° to 104° F.), and attendant chilliness or chills and constitutional disturbances, such as usually accompany a rise of temperature; and, on about the third or fourth day of the illness, the eruption appears. With each fresh outbreak of eruption, and there are usually several such, there is a corresponding rise of temperature.

The general, constitutional symptoms are usually marked, and the patients feel quite ill. They complain of prostration, sleeplessness, headache, and loss of appetite, and have a dry coated tongue. They have pains throughout the body, but suffer particularly from aching and heaviness in the limbs, the seat of the eruption.

The disease runs along, with a succession of new crops of eruption, and lasts in all for from four to six weeks. It usually attacks young females, and is far less common after twenty years of age than before that period.

The outcome is usually a happy recovery, even when the disease is complicated, as it occasionally is, with pericarditis, endocarditis, pleurisy, pneumonia, or diarrhœa.

The diagnosis is usually not at all difficult if the possibility of the presence of the disease be borne in mind. The appearance presented by the lesions and their favorite location on the shins render it easily possible to mistake them for bruises. They have also been mistaken for gummata. They frequently look and feel as if they contained pus, but no matter how marked the fluctuation of the nodes may be, they should never be opened, as absorption invariably takes place.

Probably, until we know more about the nature of the disease, the salicy-

lates and the alkalies will continue to be given, because of the pains that simulate rheumatism. The alkalies may even do good on account of their general effect on fevers. Rest in bed should be enjoined as a means of mitigating the pain, and also for its general effect on the circulation and on the fever. It also acts favorably in mitigating any of the cardiac, pulmonic, or other complications that may arise. Locally, the affected limbs may be enveloped in cotton or flannel. Soothing lotions, such as the lead-and-opium lotion, may be applied on cloths under oiled silk.

HYPERTRICHOSIS.

Hair may develop abnormally on any part of the integument excepting on the palms or soles. When there is a dense growth of hair and this abnormal growth covers a large surface, the question of the removal of the hairs must rest with the operator; a partial removal may leave the patient looking as unsightly as ever, while a total removal may leave a scarred surface. When, however, the abnormal growth is represented by a few hairs or tufts of hairs growing in an undesirable location, so that they are a source of serious worry and humiliation, removal should be advised.

We will not speak here of the many pastes and salves which have been used from time immemorial for the removal of hairs, beyond saying that no compound has been devised which will remove hairs permanently by destroying the hair bulb. On the contrary, such compounds, acting as irritants, often stimulate downy hairs to grow into coarse pigmented ones.

The employment of the x-ray in the removal of hair is still in the probationary stage, as its action on the hair bulb has not yet been elucidated, and electrolysis still remains by far the best method of permanently removing superfluous hairs. A battery consisting of from twenty to twenty-four cells should be used, and an amperemeter and rheostat are necessary. The needle should be extremely thin and made of gold, or, still better, of platinum, but steel needles are also quite satisfactory. Brocq advises having the needle bent at an angle of 45° at a distance of 6 mm. from the point, in order both to mark the depth to which it has been introduced into the skin, and to facilitate its introduction at the desired angle.

The needle, having been connected with the negative pole, should be introduced along the hair shaft to the bottom of the hair follicle, and then the circuit should be completed. To this end the other pole is connected with a suitable holder covered with chamois skin, which is to be soaked in a weak salt solution or in ordinary water. The circuit is completed by the patient's grasping this holder. This is the simplest modus operandi, but not the least painful, as the patient experiences a sharp twinge at each opening and closing of the current. This discomfort may be avoided by using the rheostat. The

needle attached to the negative pole is introduced as before, and the patient grasps the holder connected with the positive pole. Now, with the aid of the rheostat, the current is gently turned on and increased to the desired strength; it is then held at this degree of strength as long as is thought necessary, after which the strength is gradually decreased till no current flows. Of course this requires the co-operation of an assistant. The hair is destroyed in from five to fifteen seconds; then the needle is withdrawn, and, a few minutes later, the hair is gently pulled out. If it resists the traction, the needle should be reintroduced and the operation repeated. This will not be required, however, if the needle has been properly introduced and has reached the bottom of the follicle. This traction should be so gentle as to pull out only a well-loosened hair. It is important not to attach the needle to the positive pole, as that will lead to the deposit of metal in the tissue and so produce an indelible spot.

During the passage of the current, froth appears at the surface of the skin close to the hair, and, from the amount of this, an experienced operator can judge of the amount of destruction which is taking place underneath. The operation usually leaves a small papule and some tumefaction, both of which disappear in a short time. Soothing lotions can be used to calm this inflammation, or the face may be bathed in hot water. In order to avoid unsightly inflammation and scars, too many hairs in close proximity should not be treated at the same sitting. The result of a single sitting should be considered satisfactory if from twenty to thirty hairs have been successfully removed. No attempt should be made to remove lanugo hairs by electrolysis, as their removal requires destruction of neighboring tissues, it being beyond human skill to strike their bulbs with the needle except by chance.

The employment of anæsthesia for the relief of the trifling pain caused by the electrolysis is altogether superfluous. Hypodermic injections of cocaine are more painful than the operation itself, and they are also somewhat dangerous. External applications of cocaine in the form of salves or solutions are obviously ineffective.

An interval of a few days should be allowed between the sittings. Even a highly skilful operator is sure, out of the total number of hair bulbs thus treated by him at a single sitting, to have some failures; indeed, it may safely be assumed that the number of hairs permanently destroyed at such a sitting will not exceed fifty or sixty per cent of the total number attacked. The hairs that return should be electrolysized again as soon as they reappear. This method of treatment, notwithstanding the results which have just been mentioned, is a highly effective one.

TUBEROUS POTASSIUM-IODIDE ERUPTION.

Potassium iodide taken internally gives rise, in some people, to a tumor that may be mistaken for a malignant growth, and the patient may thereby be exposed to a wholly unnecessary operation.

In well-marked instances the tumefactions caused by potassium iodide are soft, round tumors of very variable size. They may be pea-sized, or they may be as large as a crab-apple or even larger. They are smooth, round, and of a purplish color. They are seated on the skin and are surrounded by a constricted base, from which the tumor flares upward and outward. The top is covered with a thick, brown crust. When this crust is removed, the inside of the tumor is found to be rotten, uneven, and purulent, and bleeds freely. Usually the lesions are multiple, and some of them are papillary. When the administration of the drug is stopped, the tumors heal in about five weeks, either with or without scarring. Sometimes the scar is characteristic, being circular, slightly depressed and with sieve-like depressions in its floor. (Plate XVII.)

As indicated above, the eruption may be mistaken for a malignant growth, which it resembles because of its vegetative, fleshy, exuberant appearance. In its tomato-like appearance it resembles some of the sarcomata. It may also be mistaken for some of the epitheliomata, but epitheliomas are rarely multiple, while the iodide tumors almost invariably are. In rare cases, however, single iodide tumors have been found, and, in the doubt which has arisen in regard to their true nature, they have been submitted to a microscopical examination. But such an examination with the microscope may easily lead one still further astray, for the epithelial infiltration of the iodide tumor simulates very closely the epithelial infiltration in epithelioma.

The tumors observed in mycosis fungoides are strikingly like those produced by potassium iodide, but in mycosis fungoides there are present eczematous, itchy patches that are absent in the iodide eruption.

In California there is a disease called granuloma coccidioides, that has tumefactions exactly like those of the iodide eruption and of mycosis fungoides; but in the tumors of granuloma coccidioides there are spherical, double-contoured, capsular bodies resembling coccidia, which are absent in the other two.

TATTOO MARKS.

Attempts to dissolve the pigment or coloring matter are usually unsuccessful and the only reliable methods of obliterating the marks are those which involve the destruction of that part of the epidermis and derma in which the pigment is implanted.

Two chemical methods enjoy special favor among French dermatologists,

those of Variot and of Brunet. Variot covers the tattoo mark with a concentrated solution of tannin, then with a bunch of needles he repeats the tattooing by working the tannin into the skin by a number of needle punctures. Then he rubs the surface with a silver-nitrate stick. In a few minutes the silver salt is reduced by the tannin, silver tannate being formed, and the punctures stand out as black points. The excess of the salt is wiped off. The surface turns black, some inflammation takes place, and an eschar is formed, which drops off in from sixteen to eighteen days, leaving a scar which is first red, but grows gradually paler. The scar is soft and smooth.

Brunet covers the neighboring skin with adhesive plaster, leaving free only the part to be treated; to this he applies for fifteen minutes a wad of cotton saturated with liquid ammonia. The epidermis is thus raised, and is then torn or cut away. The derma is treated by rubbing it with the silver-nitrate stick, after which a wet dressing is applied. The protecting plaster should be left in place until the following day. The eschar falls off in the course of about eighteen days. Brunet uses cocaine (by injection) both before the application of ammonia and before cauterization with the nitrate of silver (application on a wad of cotton).

When small marks are to be treated, electrolysis with the electric needle may be used with success. "The needle is introduced, as a rule, from the edge, slanting toward the centre, as if to undermine the mark. The whole border is thus gone around, the punctures being about one-eighth inch apart. The strength of the current varies from one to four or five milliamperes, and with each introduction the current is allowed to act for from one-half to one minute or a trifle longer. It is in reality a destructive method; reaction takes place, a thin eschar or crust forms and is finally cast off, leaving a superficial scar" (Stelwagon). In some cases the x-ray is to be preferred (Barthelemy). These methods leave the nicest scars and should be preferred for destroying small marks where they are situated upon exposed parts of the body.

If the pigment is deeply implanted, as is often the case, nothing short of complete excision by the knife will destroy the unsightly mark. The damage done may be repaired by skin grafting.

Ohman-Dumesnil advocates the removal of tattoo marks by repeatedly retattooing them with glycerol of papoid, which acts as a solvent. The solvent should be applied also as a dressing for several days. An eschar forms, which takes away the pigment, or most of it.

POWDER STAINS.

If the stains are recent and superficial, vigorous scrubbing with a stiff brush may remove all or most of them. This should be done while the patient is under the influence of an anæsthetic, and mild antiseptics should be used after

EXPLANATION OF PLATE XVII.

This plate represents a form of toxicoderma special to potassium-iodide poisoning. The regions in which the lesions characteristic of this extreme form of iodism appear in the most pronounced manner are the nose, cheeks, lower forearm, and wrist.

In Fig. 1 the lesions on the nose and cheeks are shown; in Fig. 2, those on the forearm and wrist. Note the round or oblong oval red patches in which the skin is plainly infiltrated. The bullæ, which are full of sero-purulent or sero-sanguineous liquid, may attain the size of a silver dollar. After the rupture of the bullæ there will be left ulcerated areas with mammillary vegetations, and the healing of these will be very apt to result in the formation of irregular cicatrices and the ultimate establishment of contractures and more or less pronounced deformity.

PLATE XVII.

TUBEROUS POTASSIUM IODIDE ERUPTION

(FROM *La Pratique Dermatologique*, MASSON ET CIE, EDITEURS, PARIS.)

the operation. If the surface afterward is raw or suppurating, much may be done by patiently picking out the grains of powder and by washing the surface with hydrogen dioxide. Some of the resulting bubbles of gas manage to form under the grains of powder and thus dislodge them. When the grains which heal in the skin happen to be few in number, they may be removed by cutting out the piece of skin with the cutaneous punch. (Fig. 58.) In order to do this, the skin must be first frozen with ethyl chlorid; then the punch is placed over the piece of skin to be removed and is firmly pressed in with a screwing motion to the desired depth. The central core, having been made to project by pressure upon the sides of the wound, should then be cut off as low down as may seem necessary. The little wound should be dressed with boracic acid or some other simple dressing.

FIG. 58.—Stelwagon's Cutaneous Punch.

Another method recently tried by me may have some merit. A dental burr (see Fig. 42) dipped in pure carbolic acid is pushed, with a slight boring motion, a short distance into the skin, just as in lupus vulgaris. The flutings of the burr catch the powder grains and loosen them, and sometimes tatters of skin containing powder grains can be seen with a pocket lens and cut away with sharp-pointed scissors. The traumatism and the cauterization of the tissues with the carbolic acid is followed by slight suppuration that may further loosen the powder grains. The little suppurating holes should be wiped out with peroxide of hydrogen. The use of the carbolic acid mitigates the pain.

Powder stains may also be taken out with the electrolytic needle by using it in the manner recommended for the removal of tattoo marks.

PARASITES OF THE SKIN THAT ARE SOMETIMES SURGICALLY IMPORTANT.

Wood Ticks.

Ticks or ixodidæ, tape-worms or Cysticerci telæ cellulosæ, and echinococci are the most important of these.

Wood ticks usually attack those who sleep under trees in the country or who have been walking through underbrush. Their favorite points of attack are the back, belly, perineum, and particularly the scrotum, where they bore head first into the skin and fill themselves with blood. Nothing is felt for several

hours or until the day following, when the discomfort causes one's hand to wander unconsciously to the seat of the annoyance. Then a little, smooth body about the size of a pea is felt projecting from the skin, and a slightly painful sensation is experienced when this is touched. As the tick by this time is tightly filled with blood, its smooth, brownish-red body wobbling around on its thin neck and its head implanted firmly in the skin, the appearance presented will be that of a pigmented, pedunculated, soft wart. The body can be easily torn away, but the head remains buried in the skin like a shot. One can dig it out with a knife, leaving a steep-edged, circular, flat-floored depression with two little holes in the centre where the hooklets have remained sticking in the tissues. The surrounding skin is inflamed and reddened, or it is raised up into a welt. After the head has been removed the pain is much more severe than before, probably because the animal, in trying to retain its hold, pours out a great deal of its poisonous sputum into the tissues. This inflammation may give rise to suppuration or even to gangrene; and if the head is not dug out, it may remain embedded in the tissues for several days. When the presence of the tick is discovered it is best to apply to its body some spirits of turpentine, which causes it to shrink and dry up. If the body has been torn away before one is aware of the nature of the animal, the head has to be dug out, and, if necessary, the hole in which its head lay must be somewhat enlarged. Then a moist dressing of a saturated solution of boracic acid should be applied to allay the inflammatory reaction.

Cysticercus Telæ Cellulosæ.

The unripe or bladder form of the tape-worm occurs in the skin and the subcutaneous tissue in about five per cent (Zurn) or more (Lewin) of all cases. They may occur either from eating measly pork or from conveying the eggs from the patient's own anus by the fingers into his mouth.

The cysticercus bladders cause tumors in the skin which vary in size all the way from that of a bird shot up to that of a pigeon egg. They are very seldom solitary and are present usually in great numbers. Lancereaux has reported one case in which there were over a thousand. They almost always occur in people over twenty years of age. They form round or oval, smooth, occasionally slightly prominent, hard tumors. The skin over them is movable and normal, and the tumors are almost always movable on the subjacent tissues, excepting when inflammatory adhesions have bound them down. The individual tumors can undergo sudden and great changes in their size, either through increase in the cyst contents, or by thickening of the capsule, or by growth of the cysticercus itself. The tumors may also become smaller by reason of the death of the cysticerci and the calcification of the contents of the cysts. The favorite situations of the cysticercus cysts are the back, the sides of the trunk, and the

extremities, but when they are multiple they may appear in any region without any regularity of distribution.

In the first part of its residence in the skin the cysticerus bladder gives rise to no subjective symptoms whatever, but after a time, as it grows larger it may cause pains of a rheumatic character, or there may be tenderness, especially when the tumor is in a situation exposed to injury. Inflammatory disturbances around the parasites may also cause pain, and these disturbances may go on to the formation of an abscess and so lead to the spontaneous extrusion of the animal.

The diagnosis rests on the already mentioned characteristics of the tumors in regard to their situation and their form and consistence. However, since none of these is determinative, errors in diagnosis are liable to be made. Thus, for example, they may be mistaken for fibromas, neuromas, chondromas, and cysts of some other nature, or for enlarged lymph nodes, syphilitic or of other nature, and for gummata. Echinococci mostly occur singly, while the cysticerci are almost always multiple. A probable diagnosis of cysticercus of the skin can be arrived at if the patient has tape-worm. A positive diagnosis, however, can be obtained only by microscopical examination. An exploratory puncture may show a cysticercus bladder, or characteristic hooklets may be found in fluid withdrawn from the sac. A negative examination, however, is not determinative. The demonstration of the parasite in the skin may be of great help in clearing up the cause of obscure symptoms involving some internal organ, such as the brain.

So far as the presence of these little animals in the skin is concerned the prognosis is good. One must not forget, however, that their presence in this part of the body may be only a part of their widespread presence throughout the organism, and that in such cases the prognosis may be grave.

The treatment consists either in introducing a needle and tearing the bladder or in injecting a little alcohol into the bladder. In either case the animal dies and the lesion shrinks up. If inflammation occurs around the bladder, total extirpation is the best and easiest treatment.

Echinococcus of the Skin.

The ripe embryos of the Tænia echinococcus, like those of the Tænia solium, get into the stomach and there are set free to reach the different organs, either through the blood-vessels or by way of the connective-tissue spaces. As a rule, there is present only one echinococcus cyst, and very rarely does it exist in the skin. As soon as the embryo comes to rest in the tissues it loses its hooklets and begins to form around itself a chitinous capsule. Inside of this capsule there accumulates a fluid, the echinococcus fluid, and round about this capsule the connective-tissue condenses into another capsule. From the inner surface

of the echinococcus or inner capsule there now spring out buds to the number
of twenty or less, and these in turn form capsules, and so on until at length a
very complicated structure, the multilocular echinococcus cyst, is formed.
This course of events proceeds very slowly, but it may at length result in the
formation of a very voluminous tumor.   This tumor, however, does not give
rise to any particular trouble excepting by reason of its weight and of the
stretching which it causes.   After a time the animal dies, and the contents
become turbid and slowly change into a fatty, smeary mass.   The capsule
shrinks, and finally the contents may become calcified.

A probable diagnosis may be made from the symptoms alone.   The large,
superficially situated tumor, with the unaffected skin stretched over it, its
peculiar fluctuation, the hydatid thrill, and its translucency when examined
by transmitted light, may all be present.   If the sac is aspirated, and if some
of the delicately striated chitinous membrane or the hooklets are found, the
diagnosis is fixed.   On the other hand, if these are not found, we are not
warranted in concluding that the sac is not echinococcic.

The prognosis is good, and the treatment is extirpation.

SURGICAL DISEASES AND WOUNDS OF MUSCLES, TENDONS AND THEIR SHEATHS, BURSÆ, FASCIÆ, AND CONNECTIVE TISSUE.

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It is deemed best to omit, under this heading, all anomalies, malformations, and degenerative or inflammatory changes that have no special interest for the surgeon.

I. MUSCLES.

Wounds and Surgical Diseases.

Wounds of muscles may be divided into: Incised wounds; lacerated wounds; ruptured wounds; contused wounds; sprains and strains of muscles; and traumatic lesions of the muscle sheath.

In considering all injuries of muscle it is important to remember the character of the repair which takes place after such injuries. Practically all muscle defects are repaired by the substitution of connective tissue for the damaged or removed muscle tissue. The reproduction of striped muscle occurs so rarely that it may here be ignored. Hence it becomes most important that such connective-tissue substitution be reduced to a minimum by careful methods of surgical treatment.

The *complete division of a muscle transversely*, with perfect primary healing, means not merely the interposition of a thin film of connective tissue between the segments, but the separation of the muscle permanently into two physiologic segments, provided that the nerve supply of neither is interfered with. In case one segment is permanently disassociated from its nerve supply there will result physiologic disuse of this segment with atrophy, and it will then act simply as a connecting medium between the active, still innervated segment and its tendon. This makes it imperative that, when it becomes necessary temporarily to divide a muscle for any surgical purpose, the apposition of the segments should be made as perfect as possible, and, further, that the line of division should be located at a point where there will be no interference with the larger branches of the nerve supply of the muscle.

In all operations which involve an incision through muscular planes, as in the abdominal wall, it is most important so to plan the incision as to avoid both the division of muscle fibres transversely and the severance of motor nerves.

The various muscle-splitting incisions that are made for the purpose of afford-

ing access to the abdominal cavity illustrate the ease with which muscular integrity can be preserved without seriously limiting the field of operation. The great tendency of the connective tissue, which unites the divided segments of the muscle, to stretch and allow the formation of hernia after abdominal operations, makes it still more important to utilize muscle-splitting incisions as the best preventive of such unfortunate results.

Incised wounds of muscles are common accidents and deserve more careful treatment than is usually given them. In such cases the most careful attention must be given to asepsis, and the continuity of severed muscle fibres must be restored as perfectly as possible by the use of buried absorbable sutures or of some form of removable suture. Sutures should be passed deeply in order to prevent them from cutting out or from becoming relaxed by the splitting of the muscular tissue, and all connective-tissue septa, etc., should be utilized to obtain firm holding for sutures. In muscles with dense sheaths and in those covered by fascial planes, a careful suturing of such muscle sheath or fascia should be done to prevent muscle hernia.

Non-septic lacerated wounds should be sutured in the manner already described, and blood-clot healing in a closed wound can be utilized to obliterate large defects. In all doubtful or infected wounds great care must be used to obtain efficient drainage, as the muscle is very vulnerable to pus processes; and suppuration, which may do great damage, is apt to burrow along the connective-tissue planes and the sheaths of muscles.

Contusions, sprains, and strains of muscles may be classed together, as the known lesions resulting from such injuries are the same, being a mixture of the rupture of muscle fibres and the extravasation of blood. Such injuries give rise to more or less swelling and pain and to functional disability of the injured muscle, with marked pain when any attempt is made to use it. Hæmatomata of various sizes may form in the muscles as a result of injury. They quite regularly become absorbed after a varying length of time, but in a few cases they may undergo suppuration. The affected muscles are enlarged, either locally or throughout their length, and are painful and stiff when used.

Diagnosis.—The diagnosis is usually easy, the history of injury, the acuteness of the hard swelling and its location, making a symptom-complex difficult to mistake for any other lesion. In hæmatomata of the sterno-mastoid in newborn babies the diagnosis is more difficult. This lesion, which occurs in babies at birth or soon afterward, is usually confined to one side and is important only because it may be considered to be a tumor of some sort. A knowledge of the condition and a short period of waiting will usually clear up the diagnosis, as these hæmatomata are regularly absorbed within from two to six months, and they naturally do not increase in size as a tumor would.

Treatment.—The treatment should be rest and immobilization during the early stages, followed by massage and passive motion after a few days. In cases

in which the extravasation of blood is localized and forms a considerable hæmatoma, a longer period of rest is advisable; and it may even be necessary, in case of non-absorption and in the rare cases which suppurate, to incise the swelling and evacuate the blood clots or the pus. In the cases that remain aseptic the wound should be closed tightly for primary union, after all dead spaces have been obliterated by means of buried sutures.

Rupture of a muscle may result from too violent contraction or from direct violence, with or without lesions of overlying tissues. Rupture in open wounds does not differ in any way from lacerated wounds of the muscle; and ruptures from direct violence occur too rarely and are too irregular in their location and symptomatology to afford any basis for classification. A good illustration of the severer grade of this kind of injury is reported by Eisendrath, in the *Annals of Surgery*, June, 1904. In this instance all the muscles and fasciæ attached to the iliac crest were torn loose by a crushing accident, and, nevertheless, a perfect functional result was obtained by early incision and the suturing of the torn
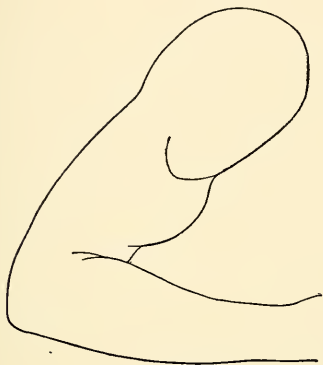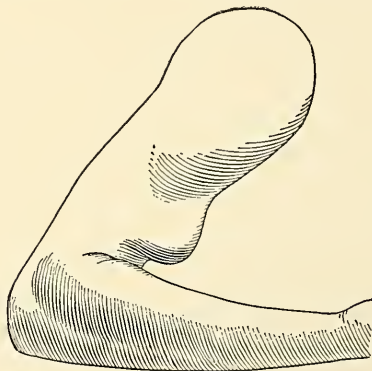
FIG. 59.   FIG. 60.

Diagrams showing Side View of a Normally Contracted (Fig. 59) and a Ruptured Biceps (Fig. 60; from von Bruns).

muscles. Spontaneous rupture of muscles may occur from any form of over-exertion or even from moderate exertion in some cases of muscle degeneration. Horseback-riding, jumping, lifting heavy bodies, the passive stretching of a tightly contracted muscle, tetanus, and parturition have all been reported as causing rupture of voluntary muscles. Spontaneous rupture of a muscle may affect the muscle fibres in their continuity, or the muscle fibres may be torn from their insertion in the bone or terminal tendon, or, finally, there may be a rupture of the tendon itself, or it may be torn loose from its bony insertion. For the sake of convenience all such lesions will be considered together.

Among the muscles which may be affected by such lesions are the quadriceps extensor femoris, the biceps, the triceps, and the deltoid, in the arm; the plantaris, ilio-psoas, and the adductors, in the thigh; the abdominal rectus; and the sterno-mastoid.

The *symptoms* of such a rupture vary with the muscle affected, being most striking in the larger and superficially placed muscles of the arm and thigh. In the arm the biceps is most frequently ruptured, the long head being the commonest site of the lesion. In some cases the symptoms are a distinct snap, sudden pain and disability, followed by the occurrence of a palpable gap at the seat of rupture, but in many cases loss of function and a downward displacement of the belly of the muscle may be the only symptoms (Fig. 60). In all locations the loss of function is the only constant symptom, but, next in order of frequency, is the occurrence of a palpable depression between the segments of the ruptured muscle. The quadriceps extensor of the thigh may rupture in several ways. First, there may be total or partial rupture of the rectus muscle, with partial rupture of either of the vasti; next, the broad aponeurosis below the union of these muscles may be extensively torn; and last, there may be rupture of the ligamentum patellæ above or below the patella. The symptoms will depend upon the location of the injury, which is made very clear by the deformity in the lower lesions. More or less complete disability will exist, and the power to extend the limb will be wholly or partially lost.

The plantaris muscle is frequently ruptured by severe strains and exertion, the muscle being torn from the tendon or the latter itself being ruptured. The symptoms are a sudden sharp pain in the calf of the leg, with some slight swelling and considerable inability to use the other calf muscles. In all

FIG. 61.—Method of Treating a Herniated Muscle. The figure shows diagrammatically the manner in which, when the torn edges of the fascia cannot be accurately sutured together, the gap can be closed by bridging it with catgut after the hernia of the muscle has been reduced. (Cheyne and Burghard.)

of these injuries, when left untreated, the *prognosis* is favorable, there being but little chance of permanent disability.

Treatment.—All the authorities advise rest and bandaging unless complete rupture is very evident. This plan of treatment is probably sufficient for the plantaris and for partial ruptures of the quadriceps; but, in the case of the head of the biceps, its belly, the ligamentum patellæ, the tendo Achillis, and all tendons and muscles of much functional importance, any considerable rupture should be an indication for exploration and suture. The result of aseptic suture in these latter cases is better than can be expected from non-interference.

Muscle Hernia.—A muscle hernia results when the rupture of its sheath allows the muscle to protrude. Such a rupture results from violent and unusual contractions of the underlying muscle, and also results from the stretching of fascial scars. In a few cases muscle hernia appears to have been due to a localized thinning and weakening of the muscle sheath. Occurring spontaneously it is most frequent in the adductors of cav-

alrymen, but may occur at any point of local weakness. The symptoms are a soft swelling which is shown, by the fact that voluntary contraction takes place in it, to consist of muscle.

Treatment.—This has not been very satisfactory, the best results having followed incision and suturing of the fascial or aponeurotic gap (Fig. 61) after reduction or excision of the protruding muscle. Subsequent fixation of the parts for a period of about twenty days will be found necessary.

INFLAMMATIONS, TUMORS, AND PARASITES.

The long list of degenerative changes which sometimes occur in muscle has little practical interest for the surgeon except where they are combined with other lesions. This statement, however, does not apply to the various forms of myositis, which are not rare, and the early diagnosis and differentiation of which from the various tumors that occur in muscle are most important.

Classification.—

Acute
- Simple acute traumatic myositis.
  - Ossifying.
  - Fibrous.
- Rheumatic myositis.
- Suppurative myositis.

Chronic
- Myositis fibrosa.
- Tuberculous myositis.
- Syphilitic myositis. . . .
  - Multiple gummata.
  - Single gumma, fibrous.
- Parasitic.

Polymyositis ossificans progressiva.

Perimyositis crepitans.

Tumors.

Animal parasites.

Simple acute traumatic myositis results from contusions and from straining, with laceration of the muscle fibres and often with hemorrhage. The part injured becomes stiff, hardened, and tender, and function is impaired. Resolution generally follows promptly, and the injured part returns to a normal condition except for the presence, in many cases, of a small amount of fibrous tissue. In some cases, instead of a prompt resolution, there is a long delayed recovery, followed by marked diminution of functional power.

Myositis fibrosa is a form of myositis in which, after a traumatism, rheumatoid pains set in and the affected part becomes enlarged and tender. Examination shows what appears to be a tumor in the affected muscle, but exploration and microscopic study demonstrate that this is merely a great local overproduction of fully formed fibrous tissue, with atrophy of many of the muscle fibres. In some reported cases exploratory incision has seemed to act most happily in initiating resolution of the inflammatory process with prompt disap-

pearance of the swelling. In other cases, largely as a result of some slight recurrent traumatism, there is established an interesting condition which is characterized by the production of masses of bone in the affected muscles. It is claimed by some that these areas of new bone are due to injury and displacement of periosteum and hence do not represent a myositis, but commonly they are movable and form, clinically, a part of the affected muscle. Not rare illustrations of the condition are the "riders' bone" in the adductor muscles of cavalrymen and the similar bone in the pectoral muscles of men belonging to the infantry. Rare but authenticated are the cases in which after a single severe traumatism a mass of bone has developed in the muscle and has been demonstrated, by x-ray examination and by operation, to be entirely distinct from any neighboring bone. (Fig. 63.)

Rheumatic myositis is a most common clinical entity of which the pathology and minute lesions are as yet obscure. Rheumatic wryneck and lumbago are good illustrations. Treatment can hardly be called surgical, unless faradization, acupuncture, and dry heat, added to the salicylates, can be so designated.

Acute Suppurative Myositis.—Suppurative lesions in the muscles may arise as part of any local or general infection, and great destruction of muscle tissue is likely to ensue. Multiple muscle lesions, resulting from the ordinary pus infections and less often from typhoid, glanders, and gonorrhœa, have been frequently observed. There has also been described a primary purulent myositis in which the suppurative process originates in a single muscle without apparent antecedent general infection. These cases can differ little in their clinical history from the other acute forms of myositis, unless there be considerable sepsis, when the local symptoms may be entirely overshadowed by the constitutional condition.

Glanders may cause a multiple purulent myositis of unusual character. In an observed case, after a chill and several days of fever, headache, and general disturbance of the health, small, slightly painful swellings appeared in the flexor carpi ulnaris, in the biceps of the opposite arm, and in the soleus muscle of the calf. These slowly increased in size, with little pain, but with considerable soreness, and the general symptoms gradually subsided. After a delay of several days they were opened, through carbolic-acid fields, in the hope of preventing skin infection and metastasis. Success proved the value of this technique, and it should be of use in other especially infective deep abscesses. An incision was made nearly to the abscess cavity, but without opening the same; the wound was then filled with ninety-five-per-cent carbolic acid through which the pus was evacuated. After the mixed pus and acid had been sponged away the surplus of the latter was neutralized by alcohol, the wound sutured, and gauze drainage inserted. The evacuated pus was peculiar in being viscous and ropy, and appeared as if mixed with some albuminous material like the white of an egg.

Treatment.—Essentially the same treatment is required for all forms of acute myositis which do not promptly undergo resolution: namely, early exploration, and a resort to incision without waiting for the development of signs which indicate clearly the true nature of the trouble. Such incision will exclude sarcoma, and will abort suppuration in many cases, and it seems the most effective curative measure in those cases in which the myositis has a fibrous character.

Chronic myositis includes the more slowly developing cases of the fibrous form (in some of which treatment will prove them to have a syphilitic origin), and the two distinct classes of tuberculous and syphilitic myositis.

Tuberculous infiltration of the muscles is common in the neighborhood of other tuberculous processes, especially in the more chronic cases of fascial tuberculosis; but, in addition, there are cases of genuine primary tuberculous myositis. In these a painless swelling appears in a muscle, and this swelling slowly grows, softens, and, if left untreated, will finally perforate and form a tuberculous sinus. Such a myositis can be diagnosed early only by the aid of tuberculin, and its treatment demands the earliest possible incision, curettage, and drainage.

Syphilitic myositis, of which two forms have been described, seems to be rare. In the first form there are multiple tumors—gummata—in various muscles. These are, at first, small and movable, but later they become adherent and ulcerate through the skin. Before ulceration takes place they closely resemble multiple subcutaneous sarcomata. In the second form of syphilitic myositis there is a single lesion that resembles closely the already described myositis fibrosa, except that microscopically there are more round cells present and considerable obliterating endarteritis. Both forms can be readily diagnosed by incision or by the results of antisyphilitic treatment; they both occur most frequently in the biceps cruris and the muscles of the neck; and, finally, both result—although in different ways—in contractures of the affected muscles.

Parasitic myositis, due to trichinæ or to hydatids, has no surgical interest except from a diagnostic standpoint. Actinomycosis may affect muscles by metastases or by direct infection from a near-by focus. Nodules of granulation tissue are formed which tend to undergo fatty degeneration or suppuration. When abscesses thus form they heal slowly and cause firm and disabling scars in the muscles.

Polymyositis ossificans progressiva is a rare and hopeless disease of no surgical importance except in so far as it may become necessary to differentiate it from the more common forms of muscle ossification. Rager (*Zeitschrift f. orthop. Chirurgie*, 1901, Bd. ix., page 380) reports 54 cases of this rare disease. Multiple bony tumors form in the voluntary muscles and cause contractures and great deformity. These conditions are well shown in the accompanying cuts (Figs. 62 and 64).

Perimyositis Crepitans.—This rare disease, described by Brauer (*Mitthei-lungen aus d. Grenzgebieten d. Med. und Chir.*, 1902, Bd. x., page 758), is a chronic inflammation of muscle aponeurosis. Clinically, it is characterized by pain on motion of the muscle and by crepitation, which can be felt and heard. There is no swelling nor deformity, and usually a group of muscles is involved. The

Fig. 62.—Case of Progressive Myositis Ossificans Multiplex. (Rager, in *Zeitsch. f. orthop. Chir.*, ix. Band, 1901.)

pain produced, when the affected muscle is used, often greatly impairs function, and this is especially true of locomotion when the disease involves muscles of the lower extremity. The cause seems to be over-exertion, but there is a suspicion that syphilis and alcoholic habits may enter into the etiology.

Tumors.—Primary tumors of the muscle proper are almost unknown, a few doubtful sarcomata being the only cases described. Tumors regularly arise from the intermuscular connective tissue or from the muscle sheath.

Sarcoma, which is the variety most commonly encountered, forms large, soft tumors that contain round and spindle cells with which a myxomatous element is apt to be combined. The new growth generally does not at first involve muscle fibres, but causes atrophy by pressure; later, it may involve all parts of the muscle (Fig. 65).

Rhabdo-myo-sarcomata and rhabdo-myo-mata have been rarely noted, and are thought to arise from embryonic inclusions and not from adult muscle tissue.

Of the benign tumors, fibroma, chondroma, and osteoma are rare, a few fibromata occurring in the sheath of the rectus abdominalis.

Cavernous angioma is not rare and frequently is non-encapsulated. When this is the case the tumor is apt to be mistaken for a sarcoma. Lipomata, angio-lipomata, and myxomata are common, the latter being always under suspicion as to its relation to sarcoma; for it is a common clinical observation that a pure myxoma recurs as a myxo-sarcoma, or even as a spindle-cell sarcoma.

Carcinoma in muscles is always secondary and rarely of large size.

Teratomata.—Small teratomata and dermoid cysts are found in the muscles of the cheek, tongue, neck, lumbar region, and abdominal wall.

Treatment.—All benign tumors of muscle should be enucleated; on the other hand, of malignant tumors, carcinoma and sarcoma should be operated
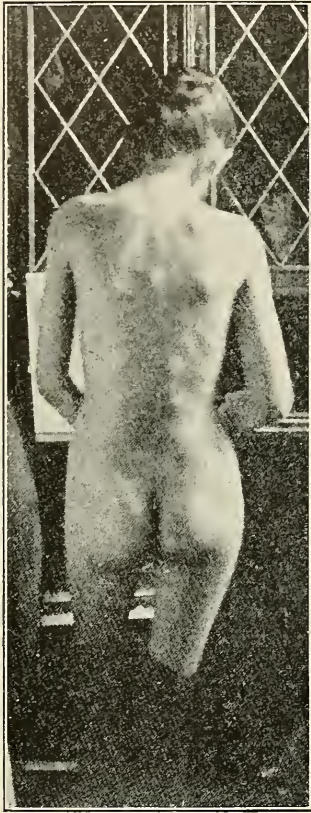
upon only when they are seen at an early stage. In such cases a complete excision of the whole affected muscle should be done.

Animal Parasites.—The Trichina spiralis is the most important of the muscle parasites. It occurs encysted in the muscles, most commonly in the diaphragm, tongue, intercostal muscles, those of the neck, larynx, and thighs, and more sparsely in the other muscles.

The parasites are located mainly near the tendinous parts of each muscle. The embryos develop in the intestine and pass thence by the lymphatics into the voluntary muscles, destroying the affected fibres. These swell, lose their striations, and contain granular masses which stain with eosin.

The parasite is at first surrounded by the sarcolemma alone, but subsequently a hyaline chitin-like capsule develops, which later becomes calcareous, and it then appears to the naked eye as a whitish dot in the muscle. The parasite may live in this condition for an indefinite time. The process of encapsulation and calcification takes some four or five months.

Fig. 63.—Ossified Musculus Brachialis Internus, the tendon of which still remains normal. (Blasius and Volkmann, in Tillmann's "Surgery.")

Fig. 64.—Another Case of Progressive Myositis Ossificans Multiplex involving the Muscles of the Back. (Helferich, in Tillmann's "Surgery.")

The symptoms are almost entirely general, the only local ones being pain on use of the affected muscles, with œdema. Excision is the only possible treatment in suitable cases.

Cysticercus cellulosæ is another parasite which becomes encysted in muscle, and by its presence forms small cysts with thick capsules. These usually contain a single parasite and become spindle-shaped from pressure of the surrounding muscle.

Echinococcus is by far the rarest of the muscle parasites, and forms cysts of various sizes which, like the above, become calcified. Lyot, in his article on "Diseases of Muscles, Tendons, etc.," in Le Dentu and Delbet's "Traité de Chirurgie Clinique et Opératoire," Paris, 1896, quotes the following statistics from Thomas, in Australia:

Hydatid cysts of muscles............................	1.90	per cent
" " of the epiploön and peritoneum...............	2.55	" "
" " of the lungs.................................	16.41	" "
" " of the liver.................................	59.66	" "

These cysts, he says, may make their appearance in muscles in any part of the body, and it cannot be shown that there is any particular muscle or group of muscles for which they show a predilection. Marguet,* however, calls attention to the fact that the most voluminous muscles are those which are most often attacked, viz., the adductors, the sacro-lumbar mass of muscles, the muscles of the buttocks, and the pectoral muscles. He adds that, while the small muscles escape almost entirely, the heart is fairly often the seat of hydatid cysts. Other authorities state that these cysts are most commonly observed in the muscles on the inner aspect of the extremities. As regards the size of these cysts Lyot says that on the average they attain the dimensions of a hen's egg, but that in exceptional instances they may grow to be as large as a man's head.

The rate of development and the symptoms vary according to circumstances. Ordinarily, the growth advances insidiously, but under the influence of a traumatism or a violent muscular exertion the tumor may increase rapidly in size. In some instances fluctuation may easily be made out, but in others the tension may be so great that the tumor will convey the sensation of a solid growth. It is in these hard cysts particularly that one may occasionally distinguish the hydatid fremitus or thrill. If the tumor is not of large size, or if it does not, by reason of the locality which it occupies, interfere with the motions of the body, or, finally, if an intercurrent inflammation does not set in, the

Fig. 65.—Dissemination of Secondary Sarcomatous Foci throughout the Substance of the Muscle of the Calf of the Leg. The primary growth originated in the periosteum of the posterior aspect of the tibia. (Le Dentu.)

hydatid cyst may remain stationary for years and give the patient little or no trouble.

Diagnosis of these rare lesions seems to be difficult, as Marguet states that so far as one may judge from the published reports, diagnosis has been made successfully in only twenty-five per cent of all cases. Such cysts are commonly

*Marguet: "Kystes hydatiques des muscles volontaires." Thèse de Paris, 1888.

mistaken for hæmatomata, and especially for old hæmatic cysts that fluctuate and that are confined strictly within the substance of a muscle; for muscular pseudo-hernias, which undergo spontaneous reduction when the muscle contracts; for cold abscesses; for gummata, portions of which still retain some measure of firmness; and, finally, for various neoplasms, some of which, like the lipomata, cysto-sarcomata, and sarcomata, are very likely to present physical characteristics like those of a hydatid cyst. In this connection it is well to remember the advice given by Denonvilliers, Desprès, Lannelongue, and Trélat, viz., always to keep in mind, when one is dealing with a round and hard muscular tumor of uncertain character, that it may be a hydatid cyst.

The best plan of treating these cysts is to remove them radically by means of the knife. The incision through the skin should be long enough to expose the tumor fully, and then an effort should be made to remove the cyst in its entirety, if possible, without setting free its contents. Then, by means of deep catgut sutures, the excavation left by the removal of the tumor should be completely obliterated. If the cyst is so deeply situated or has become so firmly adherent to the surrounding parts that it cannot be extirpated, then it should be laid freely open, the contents removed, its walls thoroughly scraped with the curette, so as to destroy every portion of the hydatid membranes, and finally the cavity packed with iodoform gauze.

II. TENDONS AND THEIR SHEATHS.

SURGICAL DISEASES AND WOUNDS.

Inflammations of tendons and their sheaths are apt to coexist, although there may be primary tendinitis from traumatism and probably also from various forms of bacteriæmia. Tendons are composed of parallel bundles of fibrous tissue, very scantily supplied with blood-vessels that run in the interfascicular connective tissue. This peculiarity of structure does not favor the occurrence of primary pathologic processes. Both acute and chronic tendinitis may, however, in rare cases, exist without changes in the tendon sheath.

The acute form of tendinitis arises from traumatism and may be of the simple fibrinous variety or purulent in character, as may also be the hæmatogenous form. Rheumatic and other so-called idiopathic forms occur, but in these the tendon sheath is regularly involved.

Chronic tendinitis is generally a part of a chronic tenosynovitis, but it occasionally occurs alone. It may follow acute tendinitis or may assume the chronic form from the first. Partial destruction of the tendon bundles occurs with proliferation and subsequently degeneration of the interfascicular connective tissue; there may also be a hyaline or a myxomatous change, or a calcification, of the tendon tissue; or, finally, a conversion of the latter into bone, cartilage,

or fat, may take place. In rheumatismus nodosus, nodules of connective tissue are formed in the tendons and may persist or be absorbed.

Spontaneous rupture of a tendon may be spoken of as a not very rare accident. In these cases the tendon, through some unknown cause, becomes weakened near its insertion, and finally, without being subjected to any special strain, it suddenly gives way. Women seem especially liable to this accident, and the clinical picture is quite striking. The extensor tendon of the terminal phalanx of a finger gives way suddenly with little or no pain, and the phalanx at once becomes partly flexed and unextensible. The patient will straighten it with the other hand, and will often seek advice holding the finger in this position.

Treatment is by one of two methods: either by fastening the finger in complete extension by a light splint (split quill), or by incision and suture. Theoretically, the latter should be the better method, but on account of extreme tenuity of the remnants of the tendon and the difficulty of successfully suturing these

FIG. 66.—Skiagram of a Case of Dislocation of the Patella following Rupture of the Quadriceps Tendon. (E. Schmidt, in *Centralblatt für Chirurgie*, No. 41, 1900.)

remnants to the phalangeal periosteum, this method often fails, and fixation must be relied upon to secure a new insertion of the tendon. The author has seen quite good functional results from absolute fixation by a quill splint for a period of three weeks. Exactly the same lesion results more commonly from considerable strains; the symptomatology and the treatment in these cases being the same as in the preceding ones. The results of operation, however, are better.

Rupture of the Larger Tendons, such as those of the quadriceps extensor femoris, the biceps cruris, and the tendo Achillis, occurs not infrequently, gives characteristic symptoms (Fig. 66), and requires careful suturing, which should quite perfectly restore function (see Rupture of Muscles). In the case of a rupture of the ligamentum patellæ, the traction plan of treatment is shown in the accompanying figure (Fig. 67).

Division of Tendons is a common result of accidental injuries, and such lesions vary greatly in their severity and in the seriousness of the results which

follow, according to the nature of the different causative injuries and their location and also according to the importance of the tendons involved.

Lacerated wounds involving tendons, especially if infected, are disastrous in their results, as the white fibrous tissue of which the tendons are composed is a very vulnerable tissue, and any considerable infection often leads to infection of its sheath and sloughing of the tendon, with resulting destruction and disabling adhesions. The tendon sheath, by reason of the fact that it
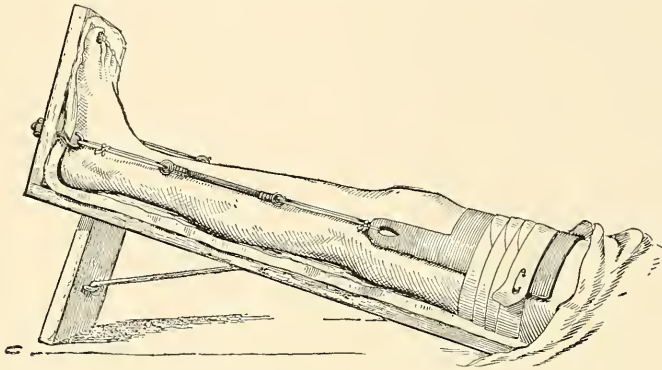
Fig. 67.—Rupture of Ligamentum Patellæ treated by Position and by Downward Traction exerted upon the Soft Parts above the Knee. For the sake of clearness the bandages fastening the limb to the splint have been omitted in the sketch. (Cheyne and Burghard.)

favors the spread of an infection, greatly increases the danger to the enclosed tendon when it (the sheath) becomes the part of an infected wound. In the presence of wounds injuring or dividing tendons, the surgeon should adopt immediately the wisest methods for combating infection, and immediate repair should be attempted under the most careful asepsis, attended with thorough drainage in cases in which infection is suspected, as delay in this regard increases the danger without offering a commensurate gain.

Divided tendons should be sutured by silk or chromicized-gut sutures, and, when possible, the edges of the wound in the tendon sheath should also be approximated. The injured member should then be put in a position that will afford rest for the affected tendon, and the desired immobility should be secured by a plaster-of-Paris or other suitable dressing.

OPERATIONS UPON TENDONS.

General Technique.—Needles should be round and small to avoid tearing the tendons (Fig. 68). Sutures should be introduced at some distance from the cut end of the tendon and should be passed so as to avoid tearing or splitting the tissue. Various methods have been devised, as illustrated by the accompanying cuts (Figs. 69 to 78; Fig. 111). Methods like that which is shown in Figs. 108, 109, and 110, and which (while favoring dead spaces) give

lateral union of tendons, with marked thickening at the point of union, seem to give a smooth and effective union after some months have elapsed, and they are to be preferred where there is likely to be tension during healing. Rigid asepsis, bloodless dissection, and final filling of the dead spaces with blood clot for organization without drainage, are necessary for perfect success.

After primary union has taken place, rest should be enforced for about four weeks, and then passive movements and massage should be instituted gradually until full mobility is secured.

Neglected Tendon Wounds.—The proper treatment for neglected tendon wounds which have been long since healed, with or without suppuration, is a difficult and debatable matter. The consensus of opinion seems to be that in a
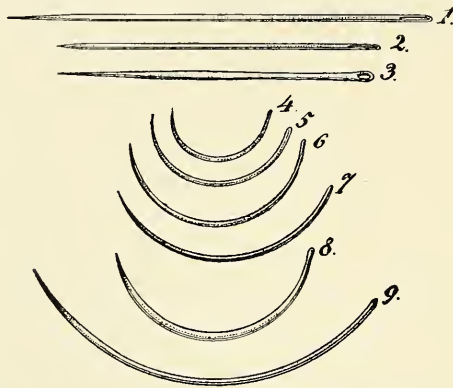
FIG. 68.—Various Patterns of Needles Suitable for Use in Suturing Tendons.

certain number of these neglected cases, where tendon function is lost by adhesion and non-union in continuity, great improvement can be attained by a properly planned and executed surgical procedure. The essential features of such a procedure comprise: An accurate dissection of the involved tendons; the careful removal of scar tissue; end-to-end suturing of the tendons where possible without tension, or suturing at a distance with the formation of new tendons (upon a support of silk or catgut); and healing by blood-clot organization with the formation of a new sheath and, as far as possible, the avoidance of adhesions by the use of Cargile membrane, decalcified bone tubes, or folds of adjacent connective tissue.

The technique in general is as follows: Strict asepsis, bloodless operating by means of the Esmarch constrictor, careful dissection of adherent tendons, removal of complicating scar tissue, and accurate approximation of the free corresponding ends of tendons; next, careful hæmostasis and suturing of the tendons with fine silk or twenty-day chromic-acid catgut. If the divided tendons can be brought together without tension they should be firmly sutured by any one of the accepted methods. If there is tension, they should be sutured at a distance by strands of silk or catgut which just hold them tense and which

will act as a framework for the formation of a new tendon. (See details under
Tendon Transplantation, page 416 *et seq.*)

To avoid the formation of new adhesions about the united tendons, various
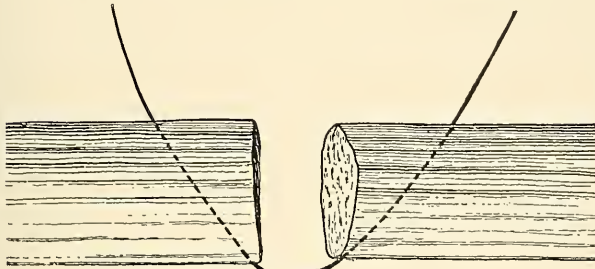
Fig. 69.
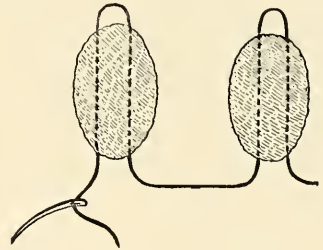
Fig. 71.
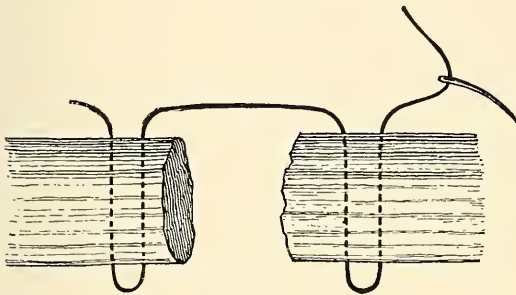
Fig. 70.
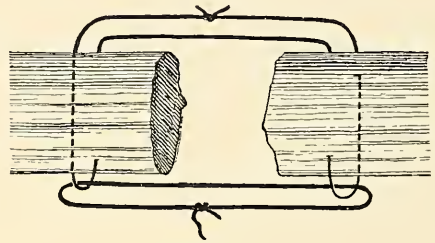
Fig. 72.
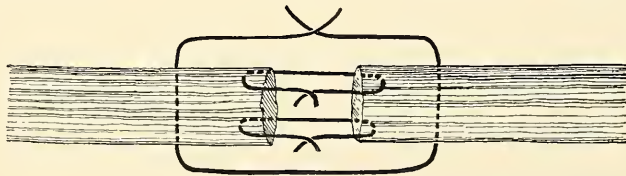
Fig. 73.
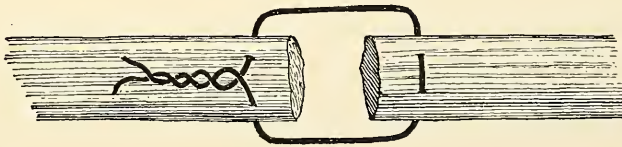
Fig. 74.
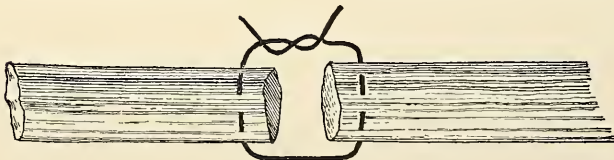
Fig. 75.

Figs. 69–75.—Various Methods of Applying Sutures. (From Monod and Vanverts.)

expedients have been devised and have been found to be more or less successful.
A film of adjacent connective tissue can sometimes be secured and utilized by
stitching it about the sutured tendon, this procedure aiding in the formation of a

new sheath. Decalcified bone tubes can be slid over the various tendons and, as they will not undergo absorption until after the lapse of about ten days, they will thus aid in preventing adhesions. Chromicized Cargile membrane (ox peritoneum) has also been utilized in the same way, and good results have been reported. In any case, after the sutures have been put in place and the dead spaces of the wound have been allowed to fill with blood, the fascia and the skin should be separately united by sutures without drainage. As a final step, a plaster-of-Paris dressing should be applied in a position which causes but little or no tension

Fig. 76.

Fig. 77.

A   B
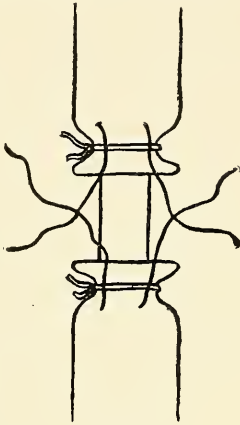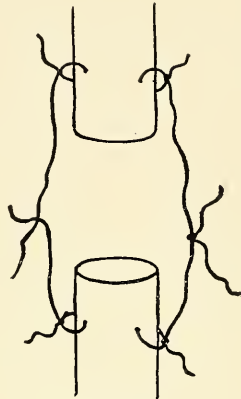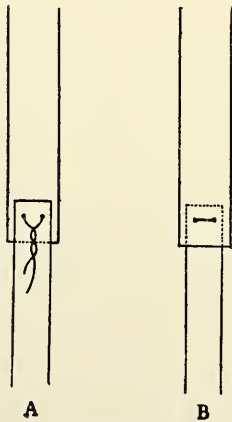
Fig. 78.
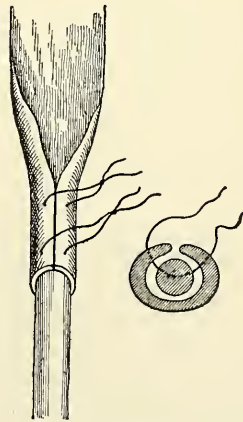
Fig. 79.

Figs. 76–79.—Various Methods of Applying Sutures. (Binnie: "Manual of Operative Surgery," Blakiston's Son & Co., Phila., 1905.)

on the sutured tendons, and this dressing should, if circumstances permit, be left undisturbed for four weeks. After it has been removed, massage and passive movements may be inaugurated at intervals and gradually increased until function is obtained.

Such methods, carefully carried out with rigid asepsis, will give a certain number of brilliant results and in any event can do no avoidable harm.

Where, in recent cases, a portion of a tendon is lost, continuity can be restored by various lengthening methods and by suturing at a distance with silk or chromicized gut, a new and serviceable tendon being often secured in this manner. It is in cases of this kind that brilliant results can sometimes be obtained by utilizing the principles of tendon transplantation as set forth under this heading, and either fastening the detached tendon to others of the same group or giving it a new insertion by some of the various methods in use.

Dislocation of tendons occurs from traumatism, most commonly about the malleoli. The diagnosis is easy unless the traumatism is very severe and there is much swelling. The peronei tendons (longus and brevis) are the tendons most often concerned in this lesion. Here the presence of the tendon above and on the outer side of the malleolus, with the ecchymosis resulting from the rupture of the annular ligament and tendon sheath, makes a picture which, in the absence of swelling, it is scarcely possible to misinterpret. The *treatment* is by incision, replacement of the tendon in its sheath, and suturing of the latter with fixation of the foot in a position of relaxation of the tendon. After three weeks, massage and passive movements should be instituted. When the annular ligament is so injured as to be useless as a means of retention, a flap of periosteum can be turned up from the fibula and sutured over the tendons so as to form a retention sheath for them.

In the treatment of various deformities associated with paralysis and contracture of muscles many operations upon tendons have been used. These are: 1. The lengthening of tendons by plastic operations or tenotomy; 2. The shortening of tendons; 3. The transplantation of tendons.

The *lengthening of tendons* may be accomplished in two distinct ways: First, by linear tenotomy, a very simple and successful operation that is frequently utilized in the treatment of deformity; second, by various plastic operations. Tenotomy can be done by the subcutaneous method and by the open method.

Subcutaneous Method. — For this method small tenotomes are used, sharp- and blunt-pointed, the latter for use near vessels and nerves. These knives should be short-bladed and strong, and are usually made in several shapes (Fig. 80). The sharp-pointed tenotome is inserted at a short distance to one side of the tendon to be cut, then passed above or below the same, and the tendon is cut by a gradual sawing movement; care being taken to avoid a sudden motion which might endanger the skin and adjacent parts. The deformity is then corrected, some small dressing or collodion is applied

FIG. 80.—Small, Narrow-bladed Knives, for use in subcutaneous operations upon tendons.

to the puncture, and the corrected member is fixed in some way to make the result permanent. The advantages of this method are diminished opportunity for sepsis, and absence of external scar. The chief objection to the method

is to be found in the possibility of the accidental division of a blood-vessel or a nerve and in the absence of control by the eye.

Open Method.—In this method the parts are exposed by an ample incision through the skin. Then, after the desired tendon has been isolated, it should be divided with the knife or scissors, and the tendon sheath and skin sutured independently. The only disadvantages of this method are the larger external scar and the greater liability to sepsis.

The structures commonly subjected to these procedures are the tendo Achillis, the tendons of the tibialis anticus and posticus, the hamstring tendons at the knee, the tendons of the adductors at the hip. and the plantar fascia in the foot. The result of a tenotomy is to lengthen the cut tendon to a varying degree, the gap being filled by newly formed tissue composed mainly of scar tissue with a small number of actual tendon fibres running through it. There is no certainty as to the final length or character of this new tissue, and in some cases it stretches badly. Hence, there seems to be a growing preference for other methods of lengthening tendons, methods that produce more accurate results. These newer methods call for splitting and partial division of the tendons, and for various plastic procedures. Bayer's operation (Fig. 81) gives, in the main, good results, but it narrows the resultant tendon. Poncet's method (Fig. 82), which is characterized by multiple cross incisions, is a bad one on account of the probable adhesions. Many other methods have been devised and are of varying degrees of utility. All these methods involve the production of more or less scar tissue, but less than is produced by a tenotomy; and, furthermore, the irregularities and thickening so formed are soon absorbed, leaving finally a smooth gray area in the tendon as the only sign of the operation.

Tendon lengthening is indicated in shortening of muscles from injury and disease, in paralysis, in spastic conditions, and in certain arthrogenous contractures; and it is frequently found necessary in transplantations of tendons.

(a)　　(b)

Fig. 81.—Anderson's Method. *a*, Line of incision; *b*, extent to which divided ends may be separated before they are finally sutured together. (Vulpius.)

Fig. 82.—Poncet's Method. (Monod and Vanverts.)

Tendon Shortening.—This may be done in a variety of ways:

1. By excising the surplus length and suturing the divided ends of the tendon;
2. By lapping and various plastic methods (Figs. 86–88); 3. By folding and

suturing (Figs. 84, 85); 4. By moving the point of periosteal insertion (Fig. 106).
The details of these various procedures are plainly shown in the cuts.   The
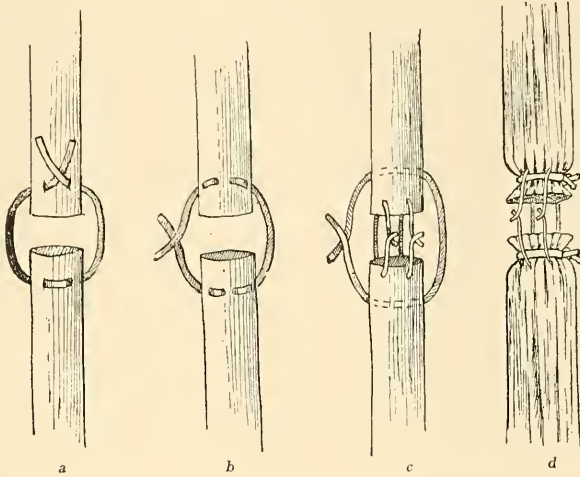
FIG. 83.—Various Methods of End-to-end Uniting of the Divided Parts of a Tendon.   a, Léon
Le Fort's procedure; b, method of Woelfler; c, Le Dentu's plan; d,   Schwartz's procedure. (Lyot,
in Le Dentu et Delbet: "Traité de Chirurgie," etc.)
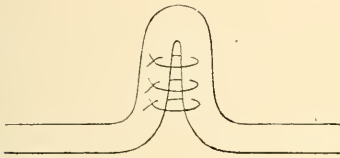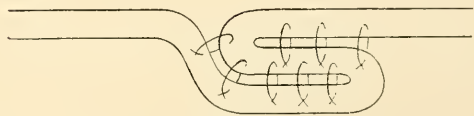
FIG. 84.   FIG. 85.

FIGS. 84 and 85.—Methods of Shortening a Tendon.   (From Vulpius.)
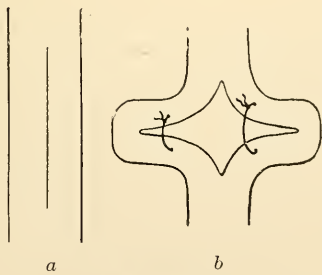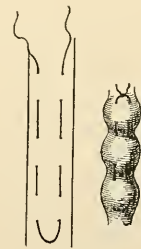
a   b
FIG. 86.   FIG. 87.   FIG. 88.

FIGS. 86–88.—Still other Methods of Shortening a Tendon. (Binnie: "Manual of Operative Surgery.")
In Fig. 86 the tendon is split longitudinally (a), and the longitudinal converted into a transverse wound
(b).   In Fig. 87 the whole thickness of the tendon has been cut away with the exception of a thin slip
at the side which aids in the subsequent healing.   Fig. 88 shows how a "draw stitch" may be utilized
as a means of throwing the tendon into folds and thus shortening it.

indications for tendon shortening are as follows: The overstretching of muscles
of tendons by injury; the paralytic relaxation of muscles; the atrophy due to

disuse; the stretching of tendons from chronic deformities and from spastic contractures of antagonistic muscles; and, lastly, the condition known as a flail-joint. In many of these conditions tendon shortening may result in a return of muscular function and may greatly aid in correcting the existing deformity. In flail-joint a carefully planned shortening of the relaxed tendons may result in the production of a joint with a springy fixation, and, therefore, much preferable to that resulting from an arthrodesis.

Tendon Transplantation.—Since Nicoladoni, in 1881, reported the first tendon transplantation for the relief of deformity, much skill and ingenuity have been exercised in devising methods and varieties of this procedure. The various
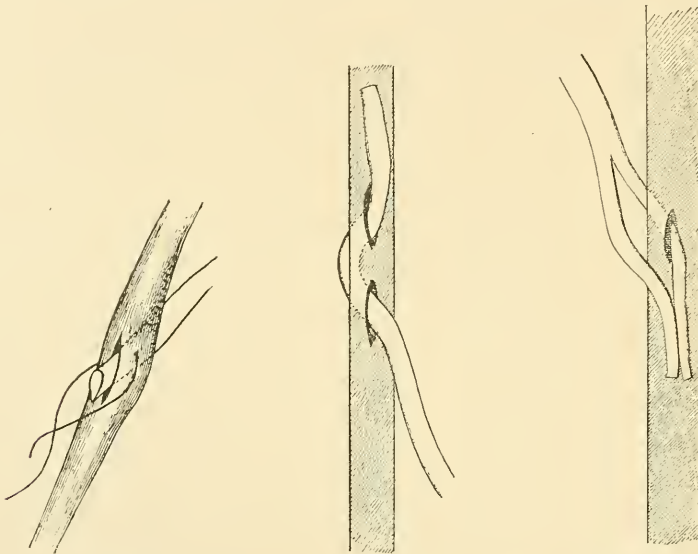
FIG. 89.   FIG. 90.   FIG. 91.

FIGS. 89–91.—Different Methods of Tendon Transplantation. (Vulpius.)

methods may be classed in two divisions: 1. Methods joining sound tendons to the tendons of paralyzed muscles; 2. Methods which fasten sound tendons to bone, either by direct insertion into or under the periosteum, or by means of artificial tendons of silk. The extent and degree of the paralysis of the various muscles must be exactly determined, mainly by observation of their voluntary use, as electrical tests are uncertain and in children often contradictory. All deformity must be relieved before tendon transplantation is done, and when, in order to accomplish this, it is found necessary to inflict considerable traumatism, the final operation must be delayed for several days in order to avoid undue vulnerability of the bruised tissues. Tenotomy of the tendons to be transplanted is best postponed until the time of transplantation, so that the degree of deformity due to these tendons can be left unrelieved until that time. Operations must be strictly aseptic and bloodless. Incisions should be longi-

tudinal and free enough to expose the insertion of the tendon into the muscle. They should not be made exactly over the tendon to be exposed, for fear that adhesions may form. Flap or V-shaped incisions are, for the same reasons, objectionable, as are also superimposed incisions in the fascia and tendon sheath. After the tendon selected has been isolated, it can be transplanted in various ways, viz.: 1. By uniting the healthy tendon as a whole to the paralyzed ten-
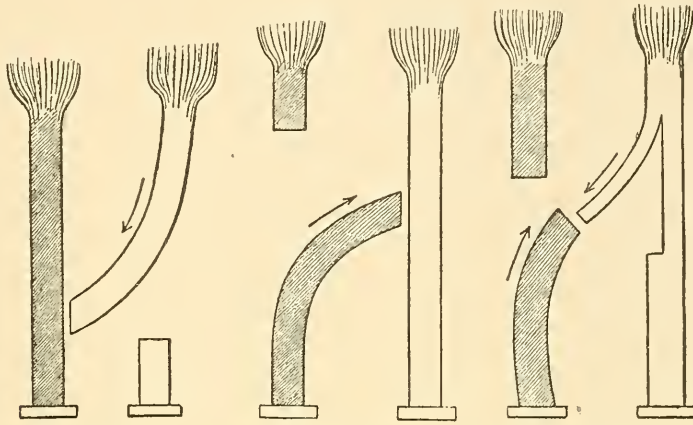
FIG. 92.   FIG. 93.   FIG. 94.
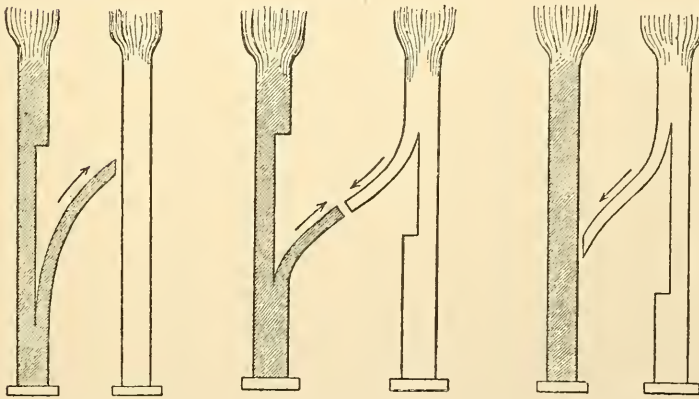
FIG. 95.   FIG. 96.   FIG. 97.

FIGS. 92–97.—Different Methods of Tendon Transplantation. (Vulpius.) The arrows in these cuts and in Figs. 98–104 indicate the direction in which the muscular power is transmitted. In this and the two following groups of diagrams the non-paralyzed muscle and tendon (the donor) are uniformly left unshaded, while the paralyzed muscle and tendon (the receiver) are shaded.

don, thus sacrificing the function of the power-giving muscle. This is advisable only when the latter's function is unimportant, but it is an efficient method when it is deemed expedient to employ it. The severed distal tendon of the power-giving muscle can be united centrally to some functionally similar muscle
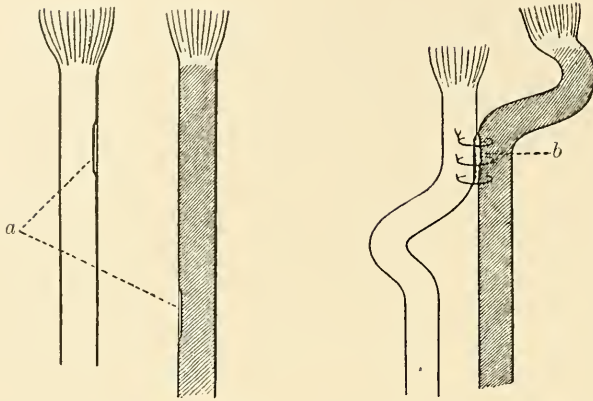
FIG. 98.—A Simple Method of Attaching one Tendon to Another. At *a* the surfaces of the two tendons are freshened and then they are made to unite at these points by means of sutures (*b*).   (Vulpius.)

FIG. 99.   FIG. 100.   FIG. 101.

FIG. 102.   FIG. 103.   FIG. 104.
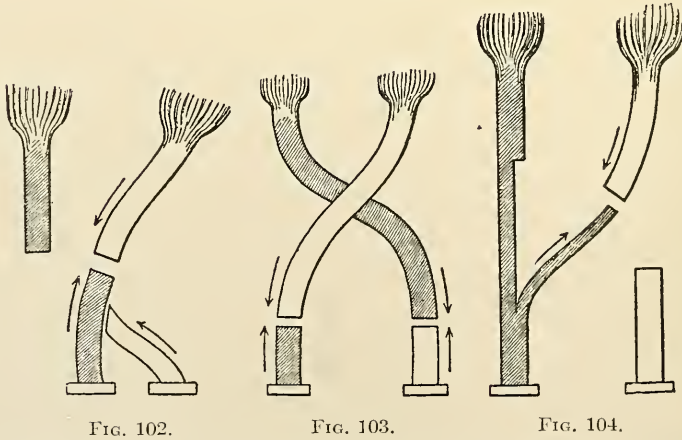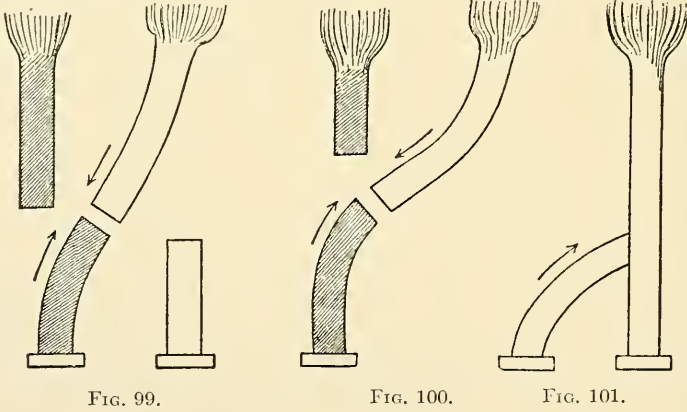
FIGS. 99–104.—Diagrams showing a Variety of Ways in which the Power of a Normal Tendon may be in Part transferred to one that has lost its Power. (Vulpius.)

or tendon, and thus a partial restoration of function may be secured. 2. By splitting the power-giving tendon and attaching only a part of it to the power-receiving tendon. The tendon of the paralyzed muscle may be cut entirely off and united with the tendon of the power-giving muscle, or it may be split and a part united, or it may, without section, be united to the power-giving tendon. In splitting the tendon of the power-giving muscle the split should be carried high into the muscle itself so as to form two complete muscles, pains being taken to avoid any injury to the supplying nerve.

There are thus three distinct methods of procedure (Vulpius): 1. The descending or active-passive or intraparalytic method; 2. The ascending or
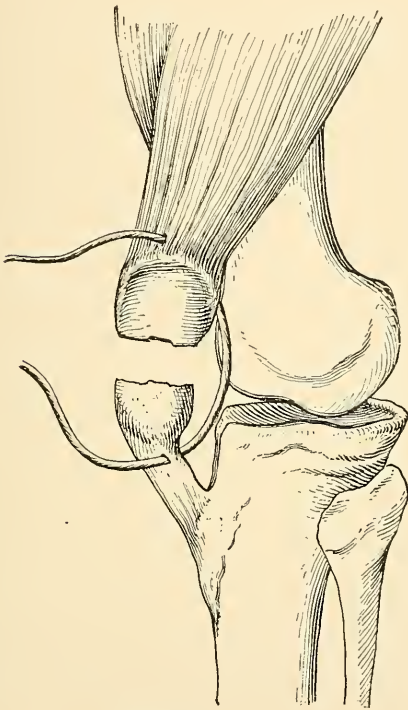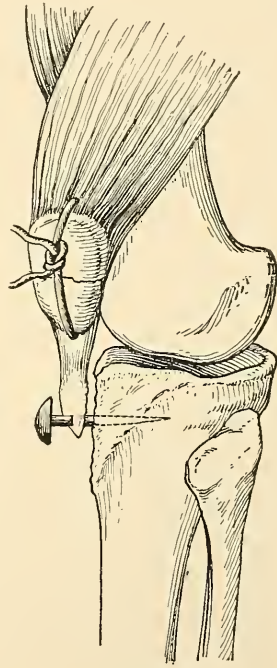
Fig. 105.   Fig. 106.

Figs. 105 and 106.—Diagrams showing Methods of Uniting Fractured Patella and of Establishing a New Attachment for the Tendon of the Quadriceps Extensor. (Monod and Vanverts.)

passive-active or intrafunctional method; 3. The reciprocal method. By a comparison of these methods it is easily seen that the first is the best, for by this method only can independent action, reproducing that of the paralyzed muscle, be obtained. The simple attachment of a paralyzed tendon to a healthy one may give motion to the paralyzed parts, but only synchronously with those moved by the power-giving muscle. The freed tendons are to be carried to their point of suture through tunnels made by blunt dissection under the fasciæ, through the interosseous membrane or even through the

bones, but angulation must be avoided if possible. The tendons must be united by suture under moderate tension. Various methods for accomplishing this have been proposed, the most secure seeming to be the carrying of the power-giving tendon through a slit in the power-receiving tendon and suturing it firmly there (Figs. 89, 90, 91). Suture material of any kind may be used, but the best seems to be fine silk. Catgut becomes absorbed too quickly, or when chromicized it often acts as a foreign body, as do metal sutures.
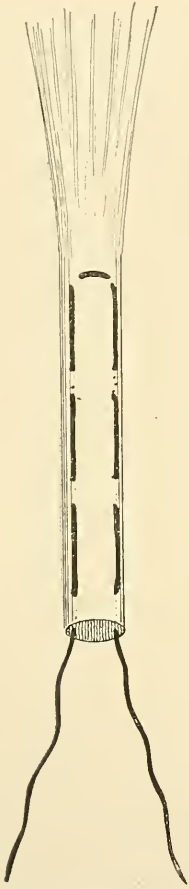
The second method—viz., that by periosteal insertion of a healthy tendon—differs little in its technique from the first, except in the following particulars: The paralyzed muscle and its tendon are disregarded and the healthy power-giving tendon is cut loose from its normal insertion and given a new one which will best serve to correct the deformity present; or, if it be found that it is too short to reach the desired point of insertion, it is to be lengthened by strong silk sutures fastening it to the periosteum or bone, such silk sutures acting from the first mechanically as actual tendons and also providing a framework for the later growth of true tendon tissue (Fig. 107). Lange, of Munich, is a prominent advocate of this method, and in his hands and in those of his pupils it has enjoyed much success; and yet there are many surgeons who will hesitate to bury these large strands of silk, remembering the unpleasant experiences of the past in operations upon the abdominal wall and in cases of hernia. However, much experience and the results of experiments on animals have proved beyond a doubt that these strong silk cords can and do generally serve to organize new tendons of connective tissue with true tendon tissue in small amounts formed along the framework of silk, and also that after six or seven years the silk entirely disappears. In a few cases the silk cords will act as foreign bodies and be extruded, or they will have to be removed on account of suppuration, which seems to occur when the skin covering the new tendons is subjected to traumatism. Vulpius, while admitting the tolerance of the silk and the formation of new tendons by its use, rejects the method because in his experience the tendons of paralyzed muscles do not stretch perceptibly, but can be depended upon permanently to remain durable, and also because he does not believe that the suturing of tendon to periosteum furnishes as secure a union as that of tendon to tendon.

FIG. 107.—Diagram showing Method of Introducing Strong Silk to act as a Tendon for Periosteal Implantation.

Indications for Tendon Transplantation.—These are: First, paralysis or spasm of some muscle with resulting lack of balance and deformity; second, available

non-paralyzed muscles existing in the neighborhood. Given these two condi-
tions and a properly planned and executed transplantation, one may reasonably
count upon securing a result which is often brilliant and almost invariably
satisfactory. The immediate functional result aimed at is a restoration of
muscle balance, with the joint remaining in a position midway between exten-
sion and flexion. This immediate result should become permanent after healing
has taken place. Anatomically, the result is never perfect, as healing always
takes place with the formation of scar tissue in the tendon and there are more
or less extensive adhesions, but these do not prevent a good functional result.
In general, the best results are obtained when the transplantation is done soon
after the development of the paralysis, as the condition of the muscles is then
good, and when the function of the power-giving muscles corresponds closely to
that of the paralyzed one. Hence, the transplantation of muscles of the same
group gives the most perfect result. Still, even when such muscles are wanting,
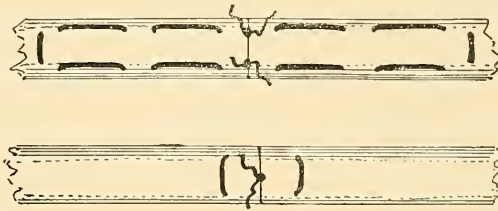
Fig. 108.—Illustrations of a Good Method of Suturing adapted for Use in Cases in which a Mod-
erate Degree of Tension is expected.

good results may be obtained by utilizing muscles of opposed function, the
brain adapting itself to the changed conditions to such a degree that it is
possible for the divided parts of a single muscle to act as functional antagonists.
In flaccid paralysis there results correction of the deformity with movements
normal in direction, but not in extent; and in spastic cases there occurs,
in addition, a disappearance of the spasm. Failure is sometimes due to sup-
puration and tearing out of sutures, but more often it is the result of lack of
judgment in selecting proper cases for operation and in estimating what is needed
to secure the desired correction, especially in spastic cases.

Detailed Indications.—Peripheral paralyses which are mainly circumscribed
give excellent opportunities for operation, although here plastic operations
to restore continuity of the injured nerves may, when they prove successful,
remove the indications for tendon transplantation. Infantile spinal paraly-
sis will afford the greatest number of cases in which tenoplasty can be utilized.
In this condition the most favorable cases are those in which a single muscle
of a group is paralyzed, the other members of the group remaining intact and
being available for transplantation. The worst cases are those in which the
paralysis is extensive, especially when it involves the stronger muscles, such as
the gastrocnemius and the soleus; for in such cases it is difficult, or even im-

possible in the majority of instances, to restore their function by the use of the weaker muscles available.

Transplantation methods are of considerable utility in cases of deformity at the knee joint, both those due to paralysis and those of arthrogenic origin. The quadriceps extensor is the muscle which most commonly suffers from paralysis, and the resulting disability can be greatly relieved by transplanting the hamstring tendons forward and inserting them into the extensor tendon, or even by carrying silk extensions into the tibia. The sartorius and the tensor vaginæ femoris can also be utilized with good results. The division of the flexors in this manner does not prevent flexion at the knee, as this can still be accom-
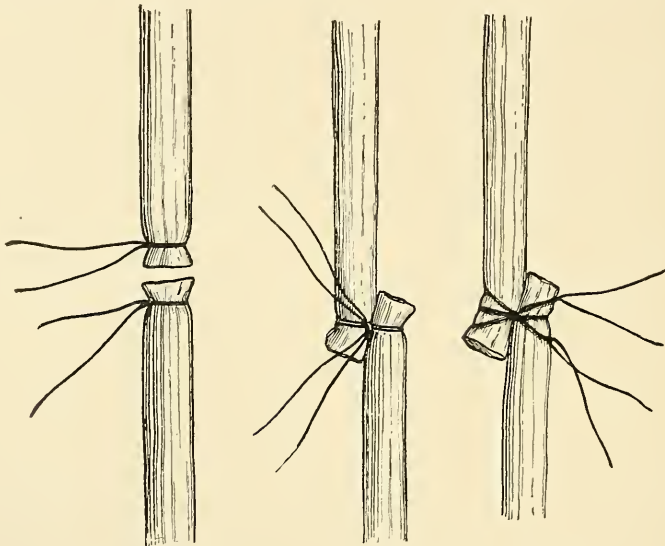
FIG. 109.   FIG. 110.   FIG. 111.

FIGS. 109–111.—Suter's Method of Uniting the Divided Ends of Tendons. (*Archiv für klin. Chirurgie*, 1903–1904.)

plished by the gastrocnemius. In arthrogenic contracture at the knee, transplantation in the manner described above gives much better and more permanent results than simple tenotomy. This statement is vouched for by Vulpius, who says: "We know that after the most different affections of the knee joint, after rheumatic and tuberculous inflammations, after arthritis, after arthrodeses and resection of the knee joint, there is very frequently produced a flexor contraction which is to be referred to the predominance of the flexor muscles over the extensors." After stating that such contractions often recur after tenotomy, he advises transplantation of the flexors forward into the quadriceps tendon or patella, and concludes by saying: "We have gained sufficient experience to be able to say that the transplanted flexor muscles are really able to repair the damage caused by them, and they not only save the knee joint, which is redressed into a straight position, from a newly recurring contraction, but also

effect a gradual straightening of a bent knee joint, the full correction of which is impossible at first."

Loss of part of a tendon can be remedied by grafting a portion of a less important adjacent tendon into the gap by a two-step operation, the damaged tendon being first sutured to the other so as to repair its defect, and later, when healing has taken place, being again cut loose. "Suturing at a distance" with silk would seem to be equally efficient. Up to the present time most of the successful tendon-transplantation operations have been done in the lower extremities, but there is every reason to expect that equally good results will in time be achieved in paralysis of the upper extremity.
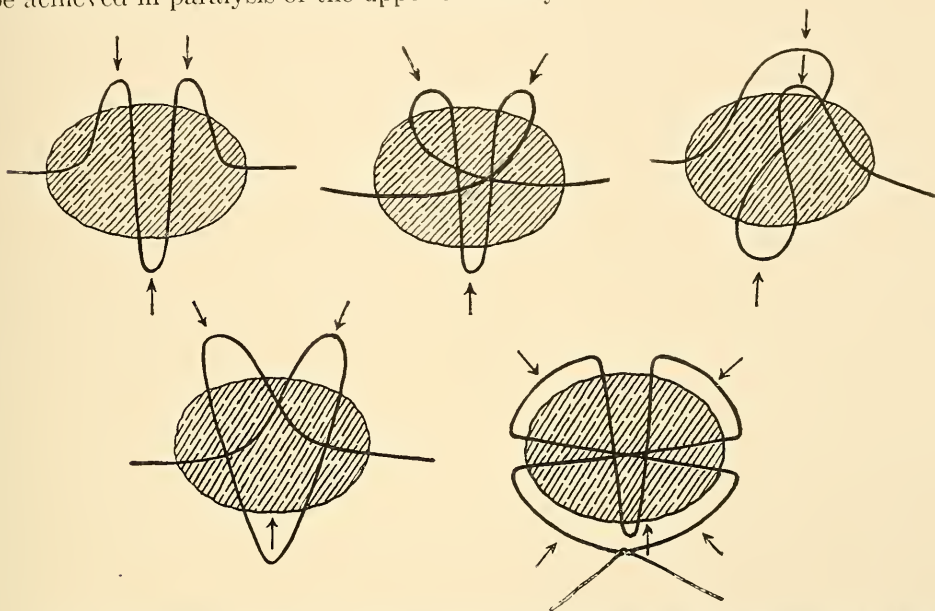
Fig. 112.—Diagrams showing Different Ways of Introducing Sutures into a Tendon. The arrows indicate the direction in which traction is to be exerted upon the thread at different points. (Suter, in *Archiv für klin. Chirurgie*, 1903–1904.)

Of late years tendon transplantation has been broadened out so as to include under its principles muscle grafting, muscle transferrence, and muscle shortening, and by these means, especially in the region of the shoulder, much success has been attained. The trapezius has been in part grafted on to the deltoid, the pectoralis minor into the biceps, the pectoralis major into the serratus magnus, etc., with good results. The insertion of the pronator radii teres has been so altered that it will act as a supinator in hemiplegic cases, and the result has been a great improvement in function.

SPECIAL CONDITIONS AND THEIR TREATMENT.

1. *Talipes Equinus due to Paralysis of All or only a Part of the Anterior Tibial Group.*—In this condition a portion of the tendo Achillis can be carried around the inner side of the ankle and attached to the tendon of the tibialis anticus

or to that of the extensor communis digitorum just above the ankle joint. When the tendo Achillis is contractured, preventing dorsal flexion of the foot, it should be lengthened by one of the plastic methods already described. When the tendo Achillis is too short to allow direct transplantation of its slip into the extensors it can be lengthened by a two-step operation, another tendon being grafted into the gap. The accompanying figures (Figs. 113 and 114) illustrate this procedure, in which a slip is transplanted on the outer side of the foot, the tendon of the peroneus brevis being used as a graft.

2. *Talipes Equino-Valgus Due to Paralysis of the Tibialis Anticus or of Both the Tibialis Anticus and the Tibialis Posticus.*—In this condition the tendon of the peroneus brevis is detached, carried behind the ankle under the tendo Achillis, and then united by sutures to the periosteum of the scaphoid, while the tendon of the peroneus tertius is carried under the anterior tendons to the same point of insertion.
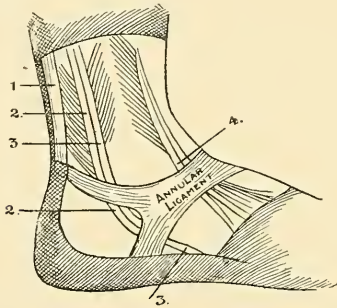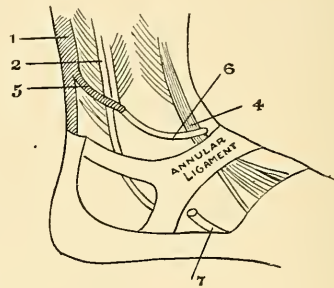
FIG. 113.   FIG. 114.

FIGS. 113 and 114.—Diagrams illustrating Method of Grafting Tendons. (Binnie: "Manual of Operative Surgery.") 1, Tendo Achillis; 2, peroneus longus; 3, peroneus brevis; 4, extensor tendons; 5, slip from tendo Achillis; 6, tendon of peroneus brevis used as a graft; 7, distal end of divided tendon of peroneus brevis.

3. *Talipes Equino-Varus, a Common Paralytic Deformity Due to Paresis of the Anterior Tibial Group of Muscles, with Weakening of the Peroneal Group.*—In this condition the outer half of the tendo Achillis may be sutured to the peronei tendons or to the tendon of the extensor longus pollicis, or the outer half of the tendon of the tibialis anticus may be passed under the outer tendon and inserted in the periosteum of the cuboid bone. The tendons of the extensor communis digitorum can also be shortened.

4. *Talipes Varus without Equinus.*—This condition requires the same tendon transplantation as that described in the preceding paragraph.

5. *Talipes Valgus.*—This is a rare paralytic deformity which is due to paralysis of the tibialis posticus. It requires the same transplantation of the peronei as that noted for talipes equino-valgus.

6. *Talipes Calcaneus.*—This condition is produced by paralysis of the calf muscles, with over-action of the anterior tibial group, causing dorsal flexion

of the foot and marked pes cavus, or hollow foot. One way of treating this condition consists in shortening the tendo Achillis and transplanting the tendons of the peronei into the os calcis, after forcible correction of the deformity. Goldthwait reports the following procedure in this condition: "An oblique incision four inches long was made so that it crossed the tendo Achillis about one inch above its insertion. The peroneal tendons were then divided at the lower border of the malleolus, and the tendon of the peroneus brevis was passed under the tendo Achillis and sutured to the tendon of the flexor longus pollicis, while that of the peroneus longus was inserted into the tendo Achillis." This operation gave a good result in spite of accidental infection and suppuration.

7. *Talipes calcaneo-valgus*, with the foot drawn upward and to the outer side, requires transplantation of the peroneals, one behind the ankle to the flexor longus pollicis and the other in front to the tibialis anticus.

Such procedures as are described above are only of use in cases of club-foot depending upon paralysis for their causation, and not in similar deformities of other origin.

8. *Paralysis of the quadriceps extensor of the thigh* is very common. In this condition the tendon of the biceps, on the outer side, and those of the semi-membranosus and semitendinosus on the inner side, are loosened and swung forward and then attached to the quadriceps tendon above the patella, or, according to Lange, to the periosteum of the tibia, by silk cords carried across the patella. The sartorius and the tendo vaginæ femoris may be grafted into the quadriceps muscle. Many variations of the above procedures will be necessitated by the irregular distribution of the paralysis and the irregular character of the resulting deformity.

TENO-SYNOVITIS.

Teno-synovitis (Tendo-synovitis; Tendo-vaginitis; Thecitis).—Teno-synovitis occurs in the following different forms:

Acute dry and acute serous teno-synovitis.
Acute purulent teno-synovitis.
Chronic dry and chronic serous teno-synovitis.
Gouty teno-synovitis.
Gonorrhœal teno-synovitis.

Tuberculous teno-synovitis.
{ Hygroma with rice-bodies.
Granulation form.
Connective-tissue form.

Syphilitic teno-synovitis. .
{ Simple serous or dry form.
Chronic fibrous teno-synovitis.
Gummatous teno-synovitis.

Acute Teno-synovitis.—In this variety there is a deposit of fibrin upon the inner surface of the sheath, with little or no serous exudate, and crepitus, from friction of the roughened surfaces, can always easily be felt, and sometimes heard at a distance.

The disease is produced by friction over the sheath of the tendon affected and also by over-use, especially when exposure to cold is added, as in wading with chafing boots. The disease may also have a rheumatic origin.

The parts most frequently affected are the sheath of the tendo Achillis and the extensor and supinator tendons of the forearm.

The symptoms accompanying the disease are the following: There is an ill-defined fluctuating swelling over the affected tendon sheath; it is sensitive on pressure and gives a fine crepitating feeling when the tendon is moved. There is also considerable pain, sometimes continuous, but more often felt only when the tendon is being used. There is regularly more or less stiffness and disability when the part is first used, and, although these symptoms wear off after use, they may be expected to return after resting.

As regards the treatment, rest and wet packs, either hot or cold, usually afford prompt relief; early counter-irritation by liniments, etc., seems also to aid absorption. When the distention is extreme the aseptic use of the aspirating needle will relieve pain, etc., but this interference is rarely necessary.

Acute Purulent Teno-synovitis.—This most frequently owes its origin to direct infection from a wound of the tendon sheath, but it is also very often due to extension of a neighboring infection into the tendon sheath, as in abscess, cellulitis, paronychia, etc. It may also be of hæmatogenous origin, as in general sepsis, gonorrhœa, pneumonia, etc.

The pathological changes consist in a purulent infiltration of the walls of the tendon sheath, with an accumulation of pus in its cavity. After a certain length of time the pus perforates the sheath and escapes into the surrounding tissues. At an early stage the tendon is found to be œdematous and there is a round-cell infiltration of the interfascicular tissue. Later, the tendon bundles become cloudy and swollen, and suppuration of the interfascicular tissue takes place, as a result of which the tendon fibres become separated. Finally, in some cases the tendon melts away in whole or in part, while in others it may slough *en masse*, owing to the severity of the infection and the pressure under which the exudate is held by the unyielding sheath. When the process is of a very mild character or is cut short by surgical intervention, the integrity of the tendons may be preserved; but in such cases adhesions will regularly form between the tendon and its sheath. Scar tissue also develops in the tendons, and this may later undergo calcification.

Suppuration may take place in any tendon sheath, but it is especially common, and also particularly serious, in the complicated flexor sheaths of the fingers and palm.

The following symptoms characterize the disease: There are the usual signs of a more or less severe sepsis, and in the region of the part affected there is a painful swelling, sometimes fluctuating, but more often merely boggy to the touch.   The function of the inflamed tendons is abolished and the part is held
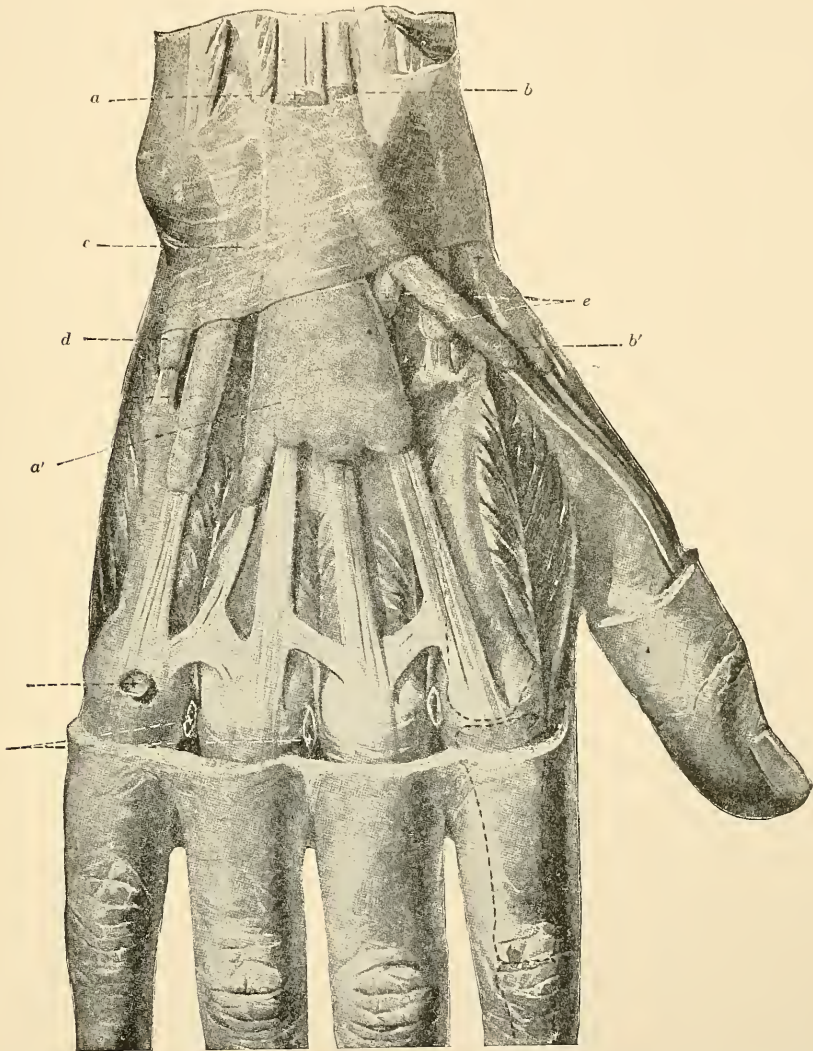
FIG. 115.—Sheaths of the Tendons on the Back of the Hand. (Spalteholz: "Hand Atlas of Human Anatomy." Leipzig, 1901).   a, a', Common sheath of the extensor tendons of the fingers ; b, b', sheath of the extensor longus pollicis ; c, sheath of the extensor minimi digiti ; d, sheath of the extensor carpi ulnaris ; e, sheath of the extensor carpi radialis.

in a position which permits relaxation of the affected tendon.   When the hand is the part involved suppuration in the sheaths of the flexor tendons gives a characteristic position—"claw-hand"—in which the partly flexed fingers cannot be straightened by pressure on account of both pain and swelling.

Owing to the arrangement of the flexor sheaths and the so-called bursæ of the wrist (Fig. 116) infections of the thumb and little fingers run an especially rapid and disastrous course. In the case of the other fingers, the tendon
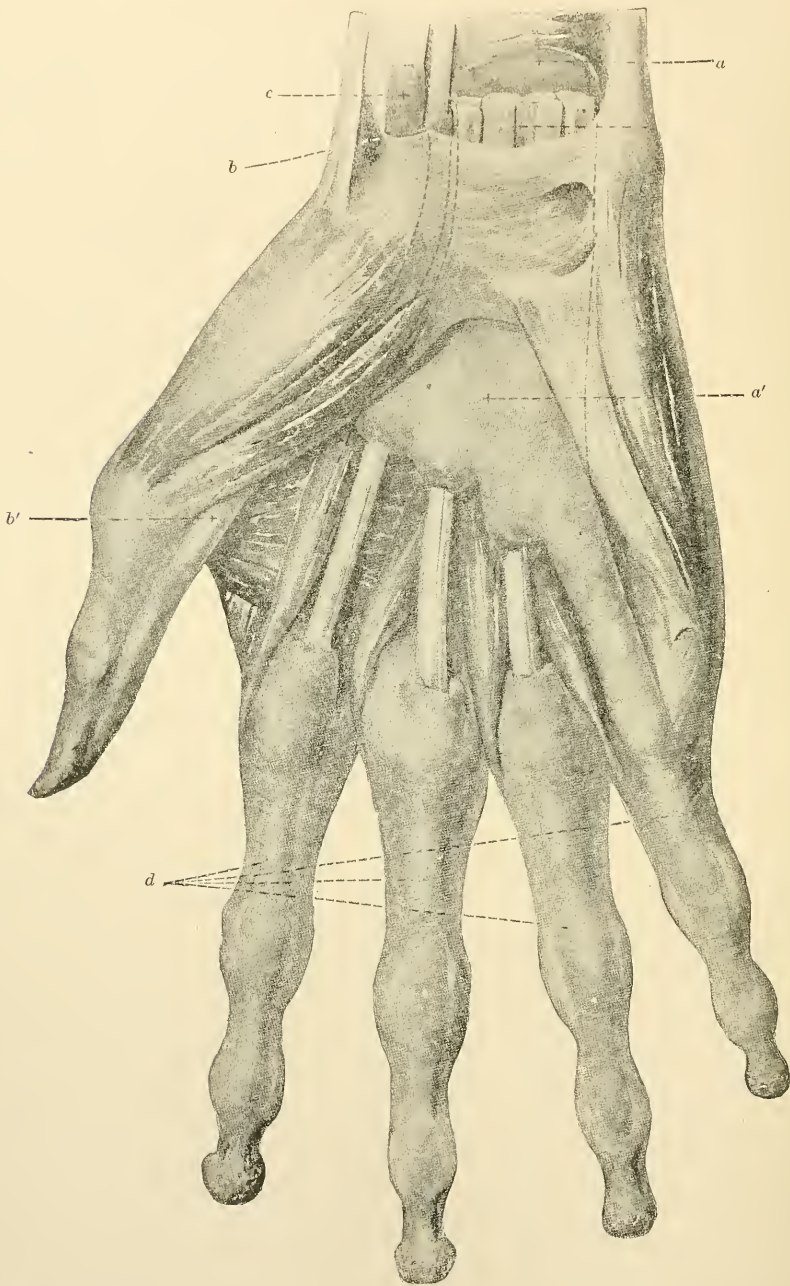
FIG. 116.—Sheaths of the Tendons in the Right Palm. (Spalteholz: "Hand Atlas of Human Anatomy," Leipzig, 1901). a, a′, Common sheath of the flexor tendons of the palm, showing extension into the wrist; b, b′, sheath of the tendon of the flexor longus pollicis extending into the wrist; c, sheath of the flexor carpi radialis; d, sheaths of the flexor tendons in the fingers, showing termination of the first three at palm.

sheaths of which terminate as blind pockets; the suppurative process is likely to be limited to the distal portion of the palm; but, when the disease is allowed to run on unchecked, the collection of pus may readily break through the wall of the pocket and escape into the large fascial spaces in the palm of the hand.   In all such neglected cases of infection of the tendon sheath of a finger the regular sequence of events is as follows: First, there is a local inflammatory distention of the sheath; then the inflammation extends upward and causes palmar abscess; and, finally, the pus travels upward under the annular ligament and burrows between the muscles, as far as to the elbow, or even higher.   In many of these cases such an extension of the infection is followed by widespread sloughing of the tendons and of all fibrous tissues involved in the process, and the most serious damage results.

As soon as it is possible to make the diagn is, the finger should be incised at the points indicated in the diagrams (Figs. 117 and 118), and an incision should also be made in the distal part of the palm.   These incisions will allow the pus to escape from the inflamed sheath cavity throughout its entire extent.   As the next step in the treatment, a large-sized, hot, wet antiseptic dressing should be applied and should be changed frequently.   In cases which are seen late, and in which the index, middle, and ring fingers are involved; and in all cases in which the thumb or the little finger is involved, even when seen early, the immediate surgical procedure must be still more radical.   In these cases either the deep palmar spaces or the radial or ulnar bursæ are likely to be infected, and no operation can be successful unless this fact is recognized and the infected areas thoroughly explored and, if necessary, drained, both in the palm and in the wrist.

FIG. 117.—Incisions for Suppurative Teno-synovitis and Extension into Forearm.   (Palmar aspect of hand and wrist.) Note incision between the arterial arches for draining palmar spaces; also spot marked × for through-and-through tubal drainage.   A tube can also be carried from the radial incision at wrist under the annular ligament and out at incision in the web of the thumb, shown at x in dorsal view (Fig. 118).

In cases in which the disease has advanced still further, nothing but the most thorough following up of all extensions of the suppuration, which should all be freely incised and thoroughly drained, can be expected to check the suppurative process.   (Figs. 117 and 118.)   And even when these radical measures have been adopted and the disease has been mastered, it will be found, nevertheless, that much permanent damage, in the way of deformity and loss of function, can scarcely fail to be the ultimate result of the attack.

In the *treatment* of palmar abscess and its upward extension no dependence can be placed upon gauze drainage; rubber tubes of sufficient size must be introduced, and care must be taken to remove them early enough to prevent

the occurrence of any pressure necrosis from their use. With these local meas-
ures should be joined the ordinary constitutional treatment of any septic con-
dition, as, for example, early purgation, measures to support the patient's
strength, the use of antistreptococcic serum,
and any other specific measures which promise
to be useful in the particular case in hand.

Too much stress cannot be laid upon the
necessity, in these always serious cases, of
making the diagnosis at the earliest moment
possible, and, when once the true nature of the
disease has been ascertained, of immediately
making incisions sufficiently free to secure
thorough drainage (Figs. 117 and 118). Pro-
longed waiting, the employment of poultices,
and the making of insufficient incisions have
destroyed the usefulness of many hands which
could have been saved by proper treatment
instituted when the cases were first seen by
the attendant. After complete healing has
taken place there will often be great disability
and claw-like deformity of the hand. This
must be combated by long-continued massage and passive movements, and
the result will often, after the lapse of some months, be surprisingly good.
Long-continued rowing of a boat has been observed to change a very stiff,
claw-like hand due to healed teno-synovitis into a flexible useful member.

Fig. 118.—Dorsal View of Hand
showing Incision in Web of Thumb, also
Superficial Incisions between Knuckles,
needed when Neglected Palmar Ab-
scess is carried backward by the at-
tachments of the Deep Fascia.

Chronic Teno-synovitis.—Both dry and serous forms occur, the latter being
more common and causing more or less extensive swellings of the tendon sheaths.
These may be so extensive as to simulate cyst formation, especially in connec-
tion with the flexor tendons of the hand. The cystic dilatation is usually con-
stricted by the annular ligament at the wrist, and cannot be distinguished from
the similar form of tuberculous teno-synovitis, except by the presence of the
rice-bodies (Fig. 119). Such cases in time regularly become tuberculous and
develop rice-bodies, with thickening of the sac wall; and, while some pathologists
contend that these cases have not been proven to be of a tuberculous nature, it
is much safer clinically so to consider them. The so-called "ganglion" is sup-
posed to be due to a chronic hydrops of the tendon sheath, the accumulating
mucoid or colloid material causing the sheath to bulge out in the form of a
diverticulum. It is usually seen on the dorsum of the hand where the tendons
belonging to the thumb leave the other extensors. The clinical evidence obtained
by operation upon these ganglia favors the view that there is no lesion of the
tendon sheath except at the site of the ganglion. This appears to be a hernia-
like sacculation of the tendon sheath, the sac itself having thickened walls and

containing colloid material of about the consistence of the vitreous humor of the eye; and there is generally no evidence of contiguous active or past inflammation of the tendon sheath, nor apparent communication with the lumen.

The dry form of chronic teno-synovitis gives few symptoms aside from the fact that there is more or less disability of the affected tendon, with at times creaking, and coarse crepitating sensations on palpation. There is usually little pain. In the serous form the symptoms are about the same as in the tuberculous form: there is simply an indolent flat or oval swelling in the course of a tendon, sometimes fluctuating, at other times too tense to permit the recognition of this sign. With these changes may be associated some tenderness and pain on movement or on direct pressure. Such cases cannot be distinguished from the similar ones of a tuberculous nature except by the aid of an operation and by microscopic and bacteriologic examination.

The only cases that require surgical intervention are those which appear to be of a tuberculous nature and the larger ganglia. Such require aseptic excision and the formation of new tendon sheaths by organization of a blood-clot. After operation the part should be fixed for about three weeks and then given massage and passive movement until perfect function is restored.

Gouty Teno-synovitis.—This disease is characterized by the presence of a deposit of urates in the tendon and also in the sheath. The parts affected are markedly thickened, the newly formed tissue often containing giant cells, and in some cases both the tendon and the inner surface of the sheath being covered with a layer of crystals of uric-acid salts.

Gonorrhœal Teno-synovitis.—Acute suppurative teno-synovitis has in a few cases been demonstrated to be due to the gonococcus. The symptoms are like those of a mild case of any other origin, except that there is less tendency to sloughing of tissue. The treatment required is also essentially the same as for the other forms of the disease.

Tuberculous Teno-synovitis.—This is not an uncommon form of local tuberculosis, and, while it may be only a part of a general tuberculosis, there is every reason to believe that in some cases it may be the primary tuberculous lesion. Any local tuberculosis may in the same way appear before there is any generalization of the disease. In order to explain the local tuberculosis in such cases, we are compelled to assume that, on the one hand, there are tubercle bacilli in the blood stream, and, on the other, that there exists some point of least resistance due to slight injury or disease. The most plausible explanation of the occurrence of local tuberculoses in general is that the tubercle bacilli find entrance into the body through the air, the food, or the drink, that they pass through the mucous membranes, and that they finally localize in an adjacent lymph node. Here they form tubercle tissue which caseates and may then become quiescent. Early or late this caseous tubercle tissue breaks down, perforates the afferent vein of the lymph node, and is carried into the general circulation, there to be

destroyed or else to lodge at weak points and set up a local or general tuberculosis. This view must be modified to reconcile it with the results of the work of Ravenel.* He fed dogs upon butter mixed with a pure culture of tubercle bacilli, and was able to recover the bacilli from the thoracic duct and to establish, by careful post-mortem examination, that there were no tuberculous lesions in the intestinal tract, nor in the associated lymphatics; in other words, he demonstrated the fact that tubercle bacilli, ingested with the food, may pass directly into the blood through the lymphatics without causing an infection of such lymphatics, and then, locating at some weak spot, may establish a truly
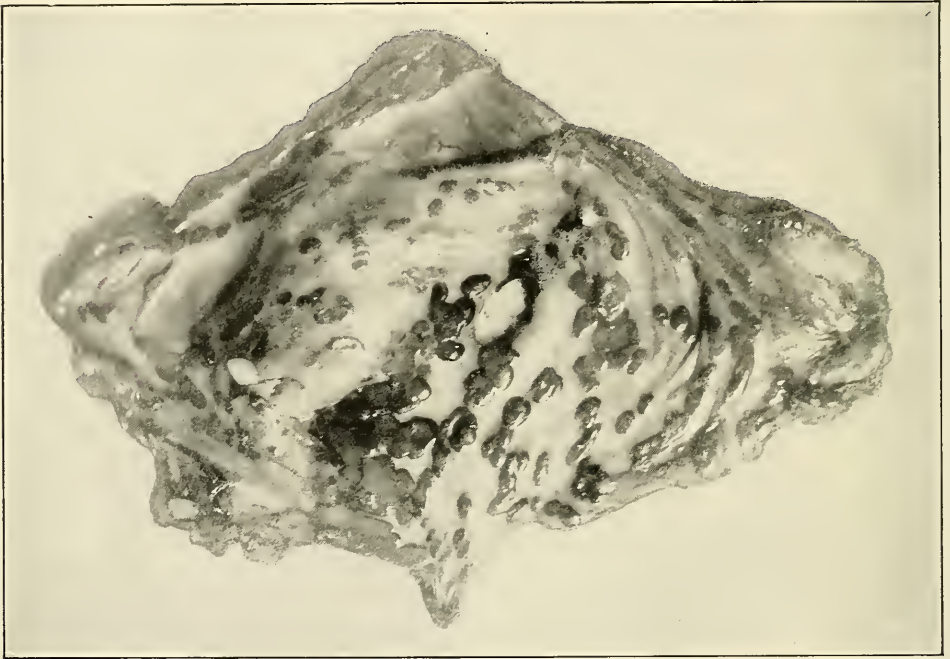
FIG. 119.—Primary Tuberculosis of an Adventitious Bursa, showing Rice Bodies in process of formation. (Original.)

primary local tuberculosis. Although, therefore, it must be admitted that a tuberculous infection may come directly by way of the food, the rare presence of live tubercle bacilli in the latter, compared with the omnipresence of these same germs in the respired air (thanks to the laxness of sanitary precautions against tuberculosis), renders it extremely probable that the lymph nodes connected with the respiratory tract are the first points of localization in tuberculosis.

Tuberculous teno-synovitis occurs in three distinct pathologic forms. In the first and most common form there is a hydrops of the tendon sheath with

* " Relation between Human and Bovine Tuberculosis," by M. P. Ravenel. Pp. 34 and 35, Vol. 29, Transactions of American Public Health Association, 1903.

thickening of its walls and the formation of numerous polypoid masses that protrude into its cavity (Fig. 119). In addition to the latter there are many so-called rice- or melon-seed bodies floating free in the serum which distends the sheath. In rare cases there may also be caseous areas in the thickened wall, but, as a rule, there are no very distinct evidences of tuberculosis, and it is even difficult with the aid of the microscope to discover tubercle bacilli in sections of either the wall, the polypoid masses, or the free rice-bodies. Animal inoculation, however, demonstrates that even the almost structureless rice bodies are of a tuberculous nature. It is possible that cases presenting exactly this clinical picture may be of other than tuberculous origin, but only the test of inoculation will demonstrate the difference; hence it is probably better, from a surgical standpoint, to consider all cases in which there are rice-bodies as tuberculous in character.

In the second form the cavity is lined with a thick layer of

Fig. 120.—Widespread Tuberculous Teno-synovitis of the Fingers, Palm, and Wrist. (Treves.)

tuberculous tissue which resembles ordinary granulation tissue in its gross appearance, but which microscopically shows tubercles and areas of caseous change. The amount of caseation varies in different cases and also in proportion to the acuteness of the process in any given case; the more acute and rapidly progressing cases giving the larger amounts of caseous material. The fluid present in these cases is moderate in amount, and may be serous, bloody, or pseudo-purulent in character. Such a tuberculous process is apt to spread from its original location to the contiguous structures and thus infect the fasciæ and joints.

In the third and rarest form there is great over-production of fibrous tissue, causing massive thickening of the wall of the affected cavity. This new fibroid tissue seems macroscopically normal, but the microscope usually, and animal inoculation regularly, shows it to be tuberculous in character. The amount of such fibrous tissue varies with the chronicity of the case, being largest and most perfectly developed in the most chronic cases—a result which represents

Nature's response to the long-continued irritation caused by few or non-virulent bacilli.

The tendons are affected differently in the three forms of this disease. In the first form they remain for a long time unimpaired, but finally an interfascicular growth of tubercle tissue develops and the tendon is rapidly destroyed.

In the second form this same interfascicular process begins early, often destroying the tendon before the process in the sheath has fully developed, so that pathologic rupture of the tendon may be an early symptom, calling attention to the gravity of the case.

In the third form the tendons may or may not be involved early, but, sooner or later, they always become firmly ankylosed to their sheath without destruction. This is the rarest form of tuberculosis of the tendon sheath, and it is almost impossible to differentiate it from syphilitic disease except by animal inoculation.

The most common site of a tuberculous teno-synovitis is at the wrist, the flexor tendon sheaths being much more often affected than the extensor. In other sites the disease is rare, the tendo Achillis and the hamstring tendons affording occasional cases.

The symptoms of the different forms of tuberculous teno-synovitis vary little and are in general obscure. A slowly forming, doughy, sausage-shaped, fluctuating tumor at the wrist generally proves to be, in the absence of an acute traumatic history, tuberculous in its nature. The presence of rice-bodies, and the occurrence of an afternoon rise of temperature, confirm the diagnosis. There are usually slight pain on exertion and a feeling of stiffness and weakness of the affected part. Such a process may extend over two or three years, with periods of apparent improvement, but the tumor gradually increases in size along the course of the affected tendon sheaths

Aside from the general danger to life from dissemination common to all local tuberculoses the prognosis is fairly good when proper treatment is instituted at an early date. The prognosis as to restoration of tendon function differs with the variety of the disease. Early operation gives good functional results in the first and third varieties, but can do little in the second, in which the tendons are impaired very early.

The *ideal treatment* of this disease is a complete excision of all tuberculous tissue with aseptic blood-clot organization to form a new tendon sheath. This is not an extremely difficult procedure when the extensor tendons are involved at the wrist, but it is a much more formidable affair when the flexors are attacked. Under general anæsthesia, and with the strictest aseptic precautions, an Esmarch constrictor being employed to insure bloodlessness, a careful dissection of the whole affected region is made. All tuberculous portions of the sheath are completely removed by the knife and scissors, care being taken not to damage the tendons or the larger vessels any more than is absolutely unavoidable.

The Esmarch constrictor is then removed and the larger vessels are ligated; some of the smaller ones, however, are neglected, as they are needed to supply blood for the desired blood-clot. On the other hand, if one is confident that no considerable vessels have been cut, the fascia and skin may be sutured separately, without any provision being made for drainage, before the elastic bandage is removed. Care should be taken that all dead spaces left are completely filled by blood, and also that there is not undue distention by over-supply, before the part is finally dressed. If the supply of blood should prove to be excessive a damp gauze pad applied over the wound will usually dispose of any moderate surplus. Finally, the limb is put up in a plaster-of-Paris dressing and left for about three weeks, when passive motions and massage should be gradually instituted. It is by the employment of some such method that the formation of a new tendon sheath may be secured, with restoration of a satisfactory degree of function in the affected tendons.

In view of the tediousness and difficulty of this procedure and the disastrous results which are sure to arise from any error in aseptic technique, it must be confessed that some less formidable operation is greatly to be desired. Several methods have been extensively exploited and have attained varying degrees of success. The injection of iodoform emulsion into the aspirated cavity has probably enjoyed more popularity than it deserves, and is now seldom used. The same statement is true of carbolic-acid and iodine injections. A most efficient substitute for excision, and one which, on account of the ease with which it may be employed and the satisfactory results which are obtained, is oftentimes to be preferred to the more formidable operation, may be described as follows: A free incision is made into the swelling, in order to expose the full extent of the disease, and all the rice-bodies and polypoid growths are carefully removed; then the whole interior of the tendon sheath is soaked for at least one minute in ninety-five-per-cent carbolic acid, after which strong alcohol is applied; and, finally, the sheath and overlying structures are sutured separately, without drainage. Such a plan of treatment is applicable only to the first variety of tuberculous teno-synovitis, but as this comprises the great majority of observed cases, and as the results seem to be equal to, or even more favorable than, those obtained by complete excision, the procedure has certainly much to recommend its adoption in all suitable cases.

Syphilitic Teno-synovitis.—This is said to be more common than the number of cases actually diagnosed would lead one to suppose; it is generally confounded with tuberculosis. There are three forms: An acute syphilitic teno-synovitis, a chronic hydropic form, and a gummatous form. The acute syphilitic teno-synovitis occurs in the secondary stage of syphilis, and differs clinically in no respect from the simple non-specific form. The chronic hydropic form occurs later in the disease: it is more common in women than in men, and affects the extensors

of the fingers and toes, the biceps, and the peronei tendons. The gummatous form is not rare as a late lesion. It is located most often in the sheath of the tendo Achillis and in that of the tendon of the flexor carpi radialis; and the pathological changes observed are the same as those of gummata in other parts of the body.

It is extremely difficult to differentiate these lesions clinically or even pathologically from those of tuberculosis. The history, the therapeutic test, and finally animal inoculation must decide.

Tumors.—Sarcoma, myxoma, osteoma, chondroma, and lipoma are described as originating in the tendon or its sheath. The last-named is very rare and occurs as the lipoma arborescens, or branching fatty tumor, which fills and distends the tendon sheath.

III. BURSÆ.

Injuries and Diseases of Bursæ.

The bursæ are connective-tissue sacs lined with synovial membrane, and in their structure they correspond in every way to tendon sheaths. They vary greatly in different individuals as to their number and location, but they are regularly found where tendons or muscles play over bony points or where the skin is subjected to excessive pressure or friction. Bursæ may and do develop frequently at points where normally they are not found, and such bursæ seem especially liable to inflammatory changes. In the diagnosis of bursitis, therefore, one must remember that it may occur at any point where the conditions favor the formation of a bursa.

The pathology of bursal diseases is the same as that of the diseases of the tendon sheaths, inflammatory and tuberculous conditions being the most important. The lesions which may occur in these structures may be classified as follows: Wounds; hæmatomata; acute simple bursitis; acute suppurative bursitis; chronic bursitis with effusion; chronic bursitis with fibrous change; chronic bursitis with tuberculosis; syphilitic changes in bursæ; gouty changes in bursæ; and tumors of bursæ.

Wounds.—Wounds of bursæ are either penetrating or non-penetrating. Under the first head are included incised wounds without infection, lacerated wounds, and primarily infected wounds. In simple incised wounds rigid asepsis and early suture are advised, and they will usually secure union without complications. In all lacerated and infected wounds of bursæ ordinary surgical principles apply; free incision and packing with gauze being the means best adapted to secure the final obliteration of the bursa. Non-penetrating wounds are caused by falls and blows upon bursal sites and are unimportant.

Hæmatomata.—Hæmatomata may arise in bursæ either from traumatism, or as an expression of a general state (hæmophilia) or of some marked circula-

tory change. In many cases the coagulum becomes organized and fills the bursa as a hard fibrous mass which may calcify. In a few cases, mostly traumatic, suppuration may take place, and when this occurs it will be found necessary to make a free incision, to evacuate all septic clots, and to treat the exposed parts as an open wound.

Acute Simple Bursitis and *Acute Suppurative Bursitis.*—These forms of inflammation are usually traumatic in origin, but they may arise from the presence in the blood of pus cocci, gonococci, pneumococci, and, in some instances, probably of other bacteria. The exudation is usually serous in character, but it may be sero-fibrinous or even sero-purulent, the latter being especially common in the prepatellar bursa when acute inflammation is added to a pre-existing chronic serous bursitis.

The symptoms are: Local pain, heat, and tenderness, with usually great swelling. In the more severe cases there is regularly considerable constitutional disturbance.

The diagnosis must depend upon the discovery of a painful fluctuating swelling at the known location of some bursa, or at the site of an adventitious bursa.

So far as the treatment is concerned it may be said that an acute serous bursitis usually undergoes resolution, after the lapse of a few days, under simple rest and hot applications, but it is apt to recur and to pass into the chronic form. Aspiration has been advised, but is usually not needed in the acute forms and is certainly not the method of choice in the more chronic cases. In the acute suppurative cases early drainage is imperative and this is best secured by free incisions and packing, with the view of promptly obliterating the bursal cavity. The proximity to joints and the possible early extension of the suppuration to adjoining parts by the rupture of the bursal sac, make these cases a field where early and thorough operative methods are likely to prevent much damage and loss of time.

Chronic Bursitis.—Chronic bursitis presents three distinct types, viz., the serous, the fibrous, and the tuberculous. The serous form consists of a distention of the bursa with serum and is associated with more or less thickening of its walls. The course of the disease is very chronic, but may be varied by repeated exacerbations and periods of improvement. Many of these cases seem to pass on into a tuberculous condition. The symptoms are merely those due to the presence of the bursal tumor which is usually painless and is not accompanied by constitutional disturbance, except during exacerbations.

As regards the treatment it may be said that, while rest, counter-irritation, and pressure may relieve the condition, a cure can be obtained only by methods which cause an obliterative inflammation of the sac, or by excision, the latter being by far the best mode of treatment in most cases. Excision may become an operation of importance on account of the proximity of a bursa to a

joint and because some bursæ actually communicate with the neighboring joint cavities; but careful asepsis and closure of joint openings, if such exist, give perfect results. In those cases in which an excision is refused, the aspiration of the sac, with the injection of tincture of iodine or carbolic acid, as in hydrocele, has given some favorable results.

Chronic bursitis with fibrous change is described as a distinct type of bursitis, but it is probably, in most cases, either syphilitic or tuberculous in its origin. The bursal walls are greatly thickened and there is little effusion; consequently there results a hard, tumor-like mass which replaces the bursa. The treatment is excision.

Tuberculous Bursitis.—Tuberculous bursitis may be of three forms. In the first, which is the most common, the bursa is distended with serum, and there are present, both attached to its walls and lying free in the fluid contents of the cavity, the so-called rice- or melon-seed bodies. There are also more or less thickening of the bursal walls by fibroid tissue and at times areas of caseous degeneration (Fig. 119). In the second form the bursa is lined with a thick layer of tubercle tissue, which resembles ordinary granulation tissue in gross appearance, but under the microscope shows tubercles and areas of cheesy degeneration. The fluid in such bursæ is moderate in amount and may be serous or pseudo-purulent in character. The tuberculous process in such bursæ is apt to invade surrounding parts, and in this way adjacent joints may become infected. In the third form, which corresponds to the chronic fibroid variety, the microscope and inoculation tests reveal the fact that the disease is in reality of a tuberculous nature.

In all forms of bursal tuberculosis the presence of a doughy, indolent swelling at a bursal site justifies the suspicion of tuberculosis, and this view of the true nature of the disease is confirmed when rice-bodies can be felt, or if there are constitutional signs of tuberculosis, or if a reaction follows the diagnostic use of tuberculin.

When such a course is practicable all tuberculous bursæ should be dissected out and the wound closed in such a manner as to favor healing by first intention. When this cannot be done, a free incision should be made into the cavity of the bursa, which should then be thoroughly curetted and packed with iodoform or sterile gauze. But in cases which belong to the second type the whole bursal lining must be dissected away if a recurrence of the disease is to be prevented.

As it bears upon the question whether these local tuberculoses can be the only expression of the disease, I insert here the history in condensed form of a rare case of tuberculous bursitis. The case is doubly rare because the disease occurred in a robust woman of thirty, in whom there were no other demonstrable tuberculoses, and because it was situated in an adventitious bursa. The accompanying photograph (Fig. 119), which has been inserted on a previous page, illustrates the process of formation of the rice-bodies in the first variety of the disease.

The history of the case is as follows:

The patient was 5 feet 7 inches in height, weighed about 185 pounds, and was a picture of robust health. She had been a teacher of physical culture, and had performed various athletic feats upon the stage. During these performances she had worn high-laced shoes, and it was to this circumstance that she attributed her trouble, viz., a slightly painful swelling over the middle of her left tibia, which was followed soon afterward by a second swelling over her right patella. An examination, made a few weeks after she first noticed these swellings, revealed the existence of a boggy, indistinctly fluctuating swelling over the middle of her left tibia. This swelling, on palpation, gave the sensation common to rice-bodies, while that over the right knee appeared to be simply a moderately enlarged, tightly distended prepatellar bursa. There were slight local heat and tenderness over both swellings, but her general temperature was normal, and a careful examination by the dispensary internist failed to discover any other tuberculoses. Her general health appeared perfect.

Operation upon the swelling over the left tibia showed that an adventitious bursa had formed here at the expense of the deep fascia. It was found to be filled loosely with clear serum, and contained a moderate number of loose rice-bodies, while its walls were thickened, red, and studded with polypoid outgrowths resembling the rice bodies in section, and apparently identical with them in every respect except as regards the fact that they were attached to the wall of the cavity. The prepatellar bursa was found in exactly the same condition, except that it was more tensely filled with serum. Both were excised, and the wound in each case was closed, without drainage. Primary union followed promptly.

The patient is still alive and well, and, although three years have elapsed since the operation, she has developed no other tuberculoses of any kind.

Syphilitic Bursitis.—Syphilitic disease of bursæ is of three kinds. First, there is a simple serous bursitis which occurs during the secondary stage of the disease. This is exactly like other forms of simple bursitis except in one respect, viz., that it is relieved promptly by antisyphilitic treatment. It occurs most frequently in the prepatellar bursa, and next, in the order of frequency, under the biceps brachii, biceps femoris, tendo Achillis, and patellar ligament (Mauriac). The second form of syphilitic disease is a gummatous bursitis, the gummata originating either in the peribursal connective tissue or in the bursal lining, and forming an irregular, nodulated, painless enlargement, which goes on to soften and break down, and finally perforates the overlying skin. The third variety—the fibrous form—is a rare disease and not very well established. It is said to occur late in the disease, and closely resembles the fibrous form of tuberculous origin, except for the facts that the character of the connective tissue is different and that there is an entire absence of tubercle bacilli.

Gouty Bursitis.—Gout may affect bursæ in very much the same way as it does other synovial membranes; the urates being deposited in the form of tophi, which may suppurate, and which regularly cause painful nodular swellings at bursal sites. The bursa over the olecranon is said to be the one usually affected.

Affections of Special Bursæ.—The *prepatellar bursa* is, from its situation,

especially predisposed to inflammation and injury. It is the common site of all forms of bursal disease, simple chronic bursitis being especially common in those who work in a kneeling position. The housemaid's knee (Fig. 121) is an example of this. Persons having this trouble are especially liable to acute suppurative processes, which develop, in the course of the chronic disease, under the provocation of slight injuries. Such suppurations are oftentimes severe and may, if neglected, threaten the integrity of the patella and even of the knee joint. They regularly, unless promptly relieved, cause the bursa to rupture, the inflammation then extending to the lateral aspects of the knee joint, so that, if the case is seen at this time, one is likely to gain the impression that the joint itself is infected. The test which eliminates the latter condition is the finding of pus in front of the patella in cases where floating patella, the ordinary sign of intra-articular fluid, cannot be excluded, owing to tension and tenderness. Such cases demand early and thorough drainage, best secured by lateral incisions, which do not leave disabling scars in front of the patella.

The *subpatellar bursa*, which lies between the ligamentum patellæ and the head of the tibia, is more rarely the seat of bursitis. Such bursitis is usually of the simple serous variety and gives rise to very characteristic symptoms. The distention causes a fluctuating, dumb-bell-shaped tumor which protrudes at each side of the ligamentum patellæ, is especially tense when the leg is extended, and is less so, or disappears entirely, when the leg is flexed. Chronic distention of this bursa may cause the symptoms of loose cartilage in the joint by pressing the ligamenta alaria between the bones when the leg is extended. Commonly the only symptoms are: pain on standing upon a straightened leg, and the presence of the bursal tumor.

As regards the treatment: Simple cases may be relieved by aspiration and by the subsequent injection of a few drops of carbolic acid. Suppurative cases, however, must be incised and drained. The proximity of the synovial membrane of the knee must be borne in mind, and the bursa must be approached with care from as low a point as possible.

The *hamstring bursæ* are quite common seats of bursitis, generally of the simple variety, and in such cases there will be found, in more or less close relation with the hamstring tendons, rounded tumors that have a certain degree of mobility. They are important surgically because they quite frequently communicate with the knee joint by a small opening. On this account the treatment of any form of bursitis at this location should consist in careful excision, with ligation of any channel that may possibly lead to the knee joint.

The *bursa beneath the tendon of the popliteus* is of special importance, being usually an extension of the synovial membrane of the joint.

The *bursa under the tendo Achillis* may be the seat of any form of bursitis, but the disease usually observed is either the acute or the chronic variety of a simple bursitis, which is quite commonly associated with a similar disease of

the sheath of the overlying tendon, as both processes arise from the same causes, viz., traumatism from bad shoes and exposure to cold. Other small bursæ in this region may also become inflamed, but this occurs only rarely. The symptoms are: pain on dorsal flexion of the foot or when the patient is standing flat on the foot, and the presence of a fluctuating tumor under the tendon. The treatment is the same as that noted above for other bursæ.

Distention of the *bursa under the psoas tendon* causes a fluctuating tumor in Scarpa's triangle, with flexion of the thigh and pain when the limb is extended.
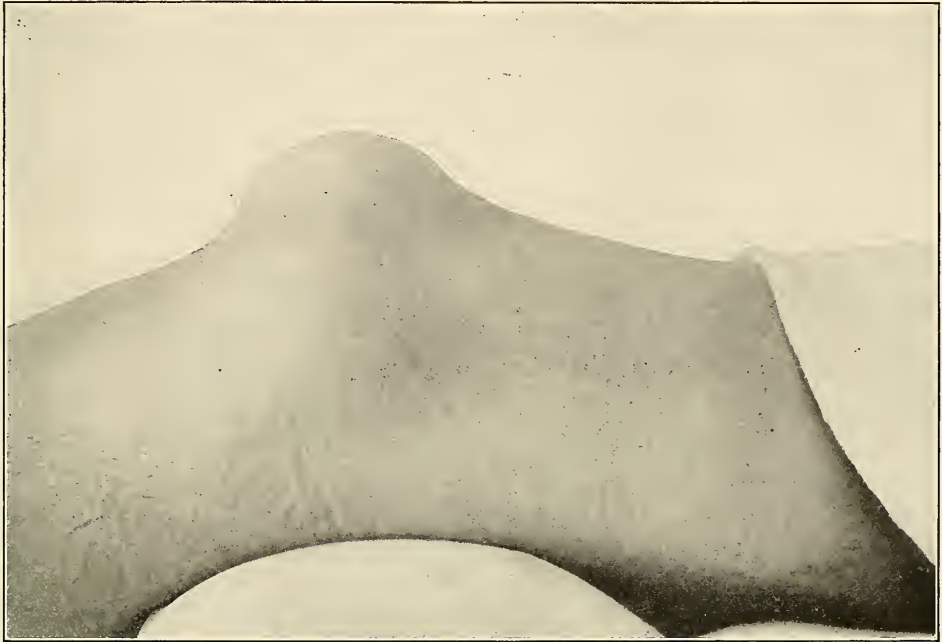
FIG. 121.—Simple Chronic Prepatellar Bursitis.   (Original.)

This bursa lies in immediate contact with the capsule of the hip joint, a fact that must be remembered in operating in this situation. The distended bursa may press on the anterior crural nerve and so cause pain in the area of its distribution.

The *gluteal bursa*, which is located between the gluteus maximus and the great trochanter, is not a rare seat of bursitis, and this is often tuberculous in its nature. This gives rise to a doughy tumor behind the trochanter, with eversion and abduction of the thigh, but without flexion and without any limitation of the movements of the hip—characteristics which distinguish it from hip-joint disease. If relief is not afforded, the bursa ruptures and the tuberculous process burrows widely among the muscles of the hip. The proper treatment comprises early incision, curettage and packing, or excision of the bursa when this is possible.

The *bursa lying over the tuber ischii* is occasionally the seat of a painful bursitis which prevents comfortable sitting. It should be excised.

Various authors describe a total of thirty-one bursæ about the hip, but the three mentioned above are the most important and the ones most often affected by bursitis. Others are: The *bursa trochanterica subcutanea*, the *bursa glutei medii*, the *bursa glutei minimi*, the *bursa tendinis obturatoris interni*, the *bursa vaginalis obturatoris interni*, a *bursa subcutanea* over the anterior superior spine, and a *bursa iliaca posterior* between the posterior iliac spine and the fascia.

Bursitis of the *bursa over the head of the first metatarsal bone*—the seat of *bunion*—is a very common trouble and often a source of great annoyance. It is regularly associated with deformities of the great-toe joint, such as hallux valgus and exostoses arising from the head of the metatarsal bone of the great toe. The process is at first a simple bursitis with moderate swelling, but with great pain and tenderness on pressure; afterward the disease regularly becomes subacute or chronic in character, with occasional exacerbations. In some cases the bursa becomes greatly thickened and may undergo calcification, the lime salts being deposited in nodules which are apt, under pressure, to cause ulceration, with a suppuration of the bursa.

The *treatment* is removal of the pressure in the mild cases, and excision in the more severe and chronic ones. In addition, it is necessary to correct the hallux valgus and to remove all exostoses. Very satisfactory results can be obtained, even when there is extreme hallux valgus, if the procedure is carefully adapted to suit the case. A good general method is to expose the bursa by a curved incision through the skin, which will throw the scar entirely upon the dorsum at the joint, and then to remove the bursa *in toto*. Next, in cases where the great toe does not deviate much from the correct line, remove all exostoses and hypertrophied tissues on the inner side of the joint, opening the latter freely if necessary, and finally suture the joint capsule and skin, without drainage. Put on a plaster-of-Paris dressing and leave the parts undisturbed for about three weeks; after which, use massage and passive movements.

When there is marked hallux valgus the procedure just described will have to be modified to correct this deformity, and this can be done in several different ways. When the joint surfaces are fairly normal and there is no marked bony enlargement, a simple or cuneiform osteotomy of the metatarsal bone will bring the toe back to a normal position; but in many cases the joint surfaces are so changed and the end of the metatarsal bone is so enlarged that better results may be obtained by excision of the distal end of the metatarsal bone or of the proximal end of the first phalanx, but not of both. At the same time it is important to correct the position of the toe—if necessary, by dividing all restraining ligaments. Such operations give very satisfactory results and can be advised in all cases where there is much pain and disability. After the parts have been released from the plaster dressing, a gauze pad or toe-post should be worn to preserve the adduction of the great toe, and suitable shoes must be insisted upon.

Another method, recommended by Weir (*Annals of Surgery*), is the following: After chiselling away all bony deformity, divide the joint capsule on the side toward the second toe and the dorsal tendon at its insertion, and transplant the latter to the median side of the toe by suturing into the periosteum at the base of the first phalanx (Fig. 122). This modification may be added to any of the preceding methods, as a means of lessening the chance of relapse. Whatever method is chosen it is imperative, if a relapse is to be avoided, that the toe shall rest in its corrected position without tension.

The *olecranon bursa* is a very common seat of simple chronic bursitis, and the inflammation may here terminate in suppuration and cause superficial necrosis of the olecranon, but it is said rarely to implicate the neighboring joint. The treatment calls for no special remarks.

The *subdeltoid bursa* is large and multilocular, and when inflamed it may simulate disease of the shoulder joint. Such an inflammation may be distinguished
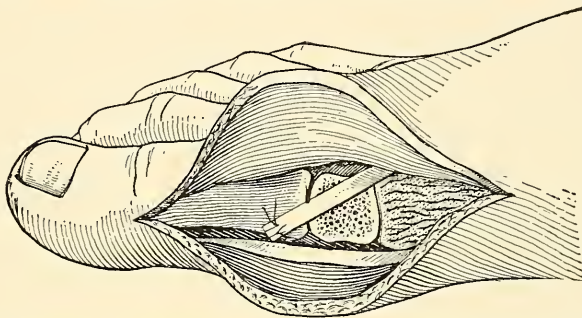
Fig. 122.—Attachment of Transplanted Tendon to Bone. (Weir, in *Annals of Surgery*.)

from the latter disease by the absence of any axillary swelling and by the fact that the joint may be moved freely in any direction except such as put the deltoid muscle on the stretch and so press upon the sensitive inflamed bursa beneath.

True *bursæ in the hand* are rarely inflamed, and the so-called radial and ulnar bursæ have already been considered in the section devoted to tendon sheaths.

Inflammation of the *sublingual bursa* occasionally produces a cystic tumor at the base of the tongue.

Bursal cysts follow simple chronic bursitis, and are found in regions which are not regularly the sites of bursæ.

Tumors.—All tumors of bursæ are rare, chondroma being, according to published reports, the most common. Instances of fibroma and sarcoma are on record. I have personally observed a small lipoma lying free in the cavity of the subcutaneous bursa over the great trochanter of the femur; it was removed by a general practitioner under the supposition that it was "a loose body in the hip joint!"

Ganglion, looked upon by some as a bursal disease, has been considered under Diseases of Tendon Sheaths.

IV. FASCIÆ.

DISEASES AND WOUNDS.

The fasciæ are connective-tissue membranes which are composed of dense white fibrous tissue, quite poorly vascularized. They are subject to all the ordinary inflammations and infections and to the results of injuries. Most morbid processes affecting fasciæ also involve more important structures, and are better discussed under other headings; therefore only such lesions will be considered here as derive their importance from the fascial involvement. These conditions may be divided into wounds and contusions; contractures; tuberculosis.

Wounds.—Traumatic defects of fasciæ are repaired by the formation of new connective tissue; consequently quite perfect healing results, and nothing is needed, in order to secure ideal results, but a very careful apposition of the edges of such defects. As fascial planes are regularly in relation with voluntary muscles it is easy to see that failure to obtain perfect repair will produce more or less weakening of the muscular covering—a condition which sometimes permits the muscle to protrude. As the common result of an unsutured or imperfectly sutured wound of a fascial plane is hernia of the underlying muscle, it is very important to secure most careful apposition of the edges of such wounds. Owing to the avascularity of fascia it is especially liable to pressure necrosis; hence, too numerous or too tightly tied sutures often cause lack of union from sloughing of the narrow edge included in the suture. Most authorities therefore advise as few interrupted sutures as will suffice for accurate apposition, and they disapprove of the continuous suture because it is more likely to cause pressure necrosis. Rest of the subjacent muscles must be enforced until healing is well advanced.

Contusions of severe character may, without rupture of the skin, cause necrosis of various-sized areas of fascia. Such fascia will disintegrate and, with the broken-down blood present, will in most cases form a circumscribed or diffuse abscess. The treatment is incision and drainage. Muscle hernia may result from the stretching of the scar tissue formed in such cases, but this result may be largely prevented by prolonged rest of the subjacent muscles. On the other hand, contractures may follow prolonged healing, during which process there is apt to be formed a large amount of scar tissue which later contracts and may cause great deformity.

Contractures.—Contractures of fascia may be due, as stated above, to scar tissue which has developed during healing after necrosis, as also after extensive destruction caused by lacerated wounds or by deep burns. Such contractures involve the skin, subcutaneous connective tissue, and deeper parts, as well as the fascia, and there seems no propriety in considering them as lesions of the fascia *per se*.

Dupuytren's contracture is a disease which locally manifests itself in the palmar fascia and results in a fixation of the fingers in a characteristic position (Figs. 123 and 124). This condition is brought about by a gradually increasing thickening and contracture of the fascia, especially of the longitudinal fibres that run to the sheaths of the flexor tendons of the fingers. The cause of the disease is unknown, it being variously ascribed to trauma (König), to primary fasciculitis (Soderhose), and to neural lesions (Neutra). It occurs almost en-
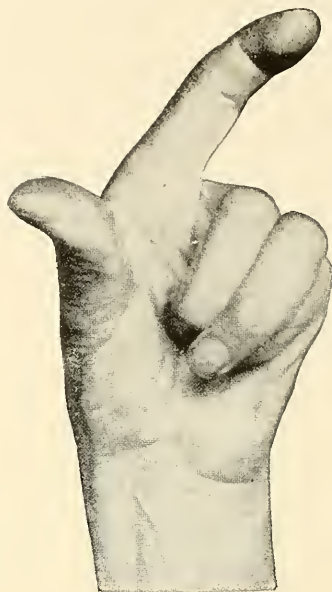
FIG. 123. FIG. 124.

FIGS. 123 and 124.—Different Stages of Dupuytren's Contracture of the Palmar Aponeurosis. (Friederich, in von Bergmann's "Chirurgie.")

tirely in adult males, usually after middle life. The disease is first manifested by some diminution of the power to extend the little finger; later, the ring finger and then the middle finger and thumb participate in the process; and, last of all, the index finger becomes involved. Early in the disease nodules appear in the palm, and, without pain, the disease slowly progresses to deformity, until, after the lapse of from five to ten years, the contracture is so complete that the nails may be forced into the palm. The disease is usually unilateral, but may afflict both hands. In a few observed cases father and son have both suffered. The diagnosis is very easily made from the history of the development of the disorder, the thickening in the palm, and the characteristic deformity.

The treatment is purely surgical. It consists in subcutaneous division of the contracted bands at several points (Adams), or in open incision of the bands (Dupuytren). In both of these operations the contracted tissue is incised in various places, care being taken to avoid the subjacent tendons and

their sheaths; and the wounds are allowed to heal while the hand is held in a
position of extension by a splint. After healing is complete, thorough massage
and passive movements should be initiated and persisted in for some weeks.
Hardie's operation involves a complete loosening of the skin and tendon
sheaths from the fascia, and the division of the latter at numerous points.
Then, after all bleeding has been arrested, the wound is sutured and the
hand fixed on a dorsal splint. As in the case of the other two methods
of treatment, massage and passive movements are measures of great impor-
tance. Operations aiming at the complete excision of the contracted fascia
are numerous, and in the main they are best suited for the severe cases;
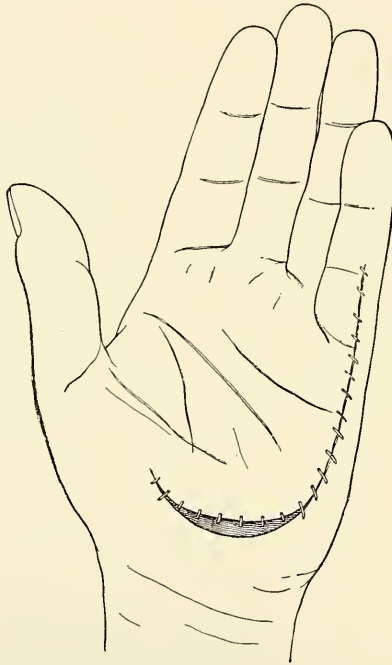
FIG. 125.—Diagram showing Shape, Position, and Mode of Suturing the Edges of the Flap in
Lotheissen's Operation for the Relief of Dupuytren's Contracture of the Hand. (*Centralblatt für
Chirurgie*, No. 30, 1900.)

while Adams' operation should be tried in early and mild cases. Various in-
cisions have been devised for these radical operations, the one most generally
used raising a V-shaped flap with the base at the web of the fingers. The
included skin is carefully dissected loose; the fascia is divided at the base
of the fingers and carefully removed; bleeding is checked; and the flap is
sutured back in position. When the operation is completed there will remain,
on account of the shrinkage in the loosened flap, a Y-shaped suture line.

Another method—that of Lotheissen (Fig. 125)—is to make a curved incision
along the ulnar border of the palm and across the wrist to the base of the thumb,
then to dissect up this skin flap fully, and finally to excise the palmar fascia

as completely as possible up to the base of the fingers. When the bleeding has been arrested the skin should be sutured in position, but at the same time a gap should be left at the wrist to allow for the shrinkage of the detached skin.

Keen (*Annals of Surgery*, February, 1906) recommends still another procedure, which differs from the preceding operations in one important respect, viz., he dissects up a large flap, which has its base at the wrist and includes all tissues down to the tendon sheaths, and he then removes the contracted fascia from the under side of the flap. He claims that by this method he diminishes the danger of sloughing of the flap.

In all these operations it will be found impossible to remove the whole of the palmar fascia, but the greater part can be quite easily excised. Hæmostasis must be perfect, as a pressure dressing cannot be used owing to the danger of causing necrosis of the flaps. In all cases the hand must be dressed in complete extension upon a dorsal splint, and, after union is complete, massage and passive movements must be persisted in for a long time.

Tuberculosis.—Under this heading are included all primary tuberculous inflammations of the fascia and all secondary cases in which the lesion in the fascia is the more extensive and important one clinically.

Primary tuberculosis of the fascia is a rare disease, but seems to be much more common in the Northwest, among the Scandinavians, than along the Atlantic seaboard or in the Southern States. There are two forms or classes of the primary kind, which differ considerably from each other in their pathology and treatment, while their clinical features may be quite identical.

The clinical symptoms of both classes of cases are about the same, except that those of the first class have a more acute onset and run a more rapid course. Both begin insidiously, developing more or less swelling of the affected part, with a local elevation of temperature, and, after a time, with a red or bluish discoloration of the skin. Some patients suffer marked pain, and nearly all have a slight afternoon elevation of the temperature. After more or less delay the process reaches the surface and characteristic sinuses are formed, giving vent to tuberculous pseudo-pus. Usually there soon arises pyogenic infection, with more marked fever and wasting, and occasionally this may occur before the sinuses are formed, giving a clinical picture closely resembling that of acute phlegmon.

Class I.—This class includes most of the more acute cases of primary tuberculosis of the fascia, cases which occur most frequently in young subjects and in which the disease usually attacks the fascia of the calf, thigh, or back. The clinical history is obscure, the first symptom noted—and generally the only one—being the occurrence of a cold abscess at the site of one of the large fascial planes. Such cases presumably have slight afternoon fever and the other signs of beginning tuberculosis, but they rarely come under observation until

the cold abscess forms and is discovered. On incision, the walls of the cavity, which are composed of the diseased fascia, are found to be lined with a layer of partly cheesy tuberculous granulation tissue, resting upon a layer of healthy fibrous tissue; the cavity itself is filled with fluid or cheesy pseudo-pus. The proper treatment of such cases is easy to carry out. It is only necessary freely to incise the cold abscess, to scrape away all soft tissue with a sharp spoon, to swab out the cavity with ninety-five-per-cent carbolic acid followed by alcohol, and finally to suture the edges of the wound or to introduce a suitable packing into the cavity. One precaution must be observed, and that is to follow up all softened points in the sac wall, as such points often lead to small adjoining foci, which, if overlooked, would surely cause relapses. As this type of the disease is rather rare I will add here the history of an original case (*Journal of American Medical Association*, August 12, 1899):

A Swedish street-car conductor, aged 25, came into my service at Asbury Hospital, in 1894, with a sinus in the middle of his right calf, discharging bloody puriform fluid. His history was misleading, as he said that he had been well until within a few days, when his leg began to cause him pain and became swollen. A physician saw him at this time and made an incision, evacuating a large amount of bloody fluid and diagnosing a hæmatoma. I saw him one week later, at which time there was a sinus with flabby granulations admitting a probe, which passed freely upward to the vicinity of the knee and downward almost to the heel. He had also greatly enlarged lymph nodes in the neck and right axilla.

Under anæsthesia the large cavity was opened by a median incision that reached from the middle of the popliteal space nearly to the heel. The extensive flaps and the walls of the cavity were then scraped thoroughly with a sharp spoon until a smooth surface was reached. This operative procedure, which resulted in the removal of a double handful of tuberculous granulations, revealed the existence of an eroded vein as the cause of the previous hemorrhage. The long incision was sutured over iodoform-gauze packing, which was removed after forty-eight hours, and then pressure was applied. The large wound healed solidly in ten days, after which I removed the tuberculous lymph nodes in the neck and axilla. The patient made a good recovery and is now (1905) alive and well.

The tissue removed was examined microscopically and showed typical, rapidly formed tubercle tissue, with many giant cells and a few tubercle bacilli. There was considerable caseous degeneration, and there seemed to be nowhere any attempt to form fibrous tissue.

Class II.—This class of cases differs greatly from the preceding one as regards both the gross and the microscopic lesions, and the history is apt to cover a much longer period of time. The majority of the cases of this type arise from small local tuberculous lesions in the bone or in the lymph nodes, but a few of them are primary. I will add here the histories of two such cases, both of them primary. The first case occurred in the practice of my colleague, Dr. J. E. Moore:

F. F., aged 48 years, a Mexican coffee planter, suffered in January, 1896, from a hydrops articuli of the right knee. The disease, although chronic, was quite mild

in character and yielded promptly to the treatment, which consisted of tapping followed by irrigation with a bichloride solution and rest in a plaster cast. Twenty months later, in September, 1897, the patient returned with a beginning tuberculosis of the fascia of the lower third of the left thigh. There were two sinuses and the disease seemed to be superficial. The part was laid open, freely scraped, and packed with gauze. On January 10, 1898, a second operation was done, and all the apparently diseased tissue was removed. On January 29th it became evident that the last operation was a failure, and a more radical operation was planned. There were at this time several sinuses and a mixed infection, and the patient was rapidly failing. An incision was made from just above the knee joint to the tip of the greater trochanter. At the lower third of the thigh a strip of integument, two inches wide and eight inches long, which was perforated by the sinus, was removed. A large portion of the fascia lata was removed because it was diseased beyond all hope of recovery. The disease was found dipping down into the vastus externus muscle to such an extent that it was deemed necessary to remove the whole of that muscle. It should be noted that this disease was in the left thigh, while the hydrops articuli had been on his right side. The left knee was healthy, but its synovial membrane was being attacked from the outside, and in our effort to remove all the diseased tissue the upper pouch of the knee was opened. A piece of synovial membrane two inches long and one inch wide was removed, and the opening into the joint was immediately closed with a running catgut suture. Although the patient was suffering from a mixed infection at the time of the operation, no joint symptoms followed. The enormous wound resulting from the operation was closed, and, with the exception of a small spot at the lower end, where there was a small slough, it healed by first intention. The slough soon separated and the wound healed by a process of granulation without return of the tuberculosis. The patient left the hospital in less than three weeks, and very soon afterward returned to his home in Mexico. Before he left he walked with a cane, and the function of his limb was remarkably good if the amount of tissue removed be considered.

In May, 1899, a report was received that his leg was giving him no trouble, but that his general health was failing and that he had a cough.

A very early attack of primary tuberculosis of the second type occurred in the person of a colleague, from inoculation at a post-mortem examination. The patient —Dr. W.—infected his left middle finger while making an autopsy upon a tuberculous subject. Two weeks later, a small staphylococcus abscess formed at the site of the inoculation; it was opened and soon healed. After about a month a diffuse swelling appeared upon the back of the same finger and slowly grew in size for another month, when I dissected out the mass, which was grayish and succulent, and adherent to the extensor sheath. It surrounded the posterior half of the finger throughout a distance of about one inch, covering closely the first phalangeal joint. To the naked eye the tissue showed no evidence of being affected with tuberculosis. The wound healed kindly and there has been—five years having now elapsed—no recurrence of the disease nor any manifestation of a tuberculous nature in any other part of the body.

Sections of the mass which I had removed showed cellular tubercles, but without cheesy degeneration. A piece of the tissue was emulsified with sterile broth and injected into the peritoneal cavity of a guinea-pig, which died with manifestations of tuberculosis; and, besides, tubercle bacilli were demonstrated in the lesions found at the autopsy.

The important distinguishing feature of these cases was the production of a large amount of apparently normal fibrous tissue, and the occurrence of the cheesy tuberculous detritus, not in one large cavity limited by a firm fibrous layer, but in multiple small foci which were scattered widely throughout the newly formed fibrous tissue. The different pathology manifested in these cases necessitated a radical change in the operative treatment, as the conditions discovered could be relieved only by complete excision, by knife and scissors, of all affected tissue. It is especially to be noted that, under such conditions as were found in these cases, all the newly-formed connective tissue, however normal it may appear, must be excised to prevent recurrence; for the microscope clearly proves the presence of tubercles scattered widely throughout this new tissue. The fact that a goodly number of these cases, when neglected, must be placed in the inoperable class, emphasizes the need of the complete dissection here recommended. As illustrations of this are to be cited cases in which, after a tuberculous pleurisy, the fascia of the chest becomes involved. Some of these cases develop a great amount of new fibrous tissue completely encircling the ribs, the removal of which tissue is out of the question; and yet, without such removal, these cases are sure to relapse.
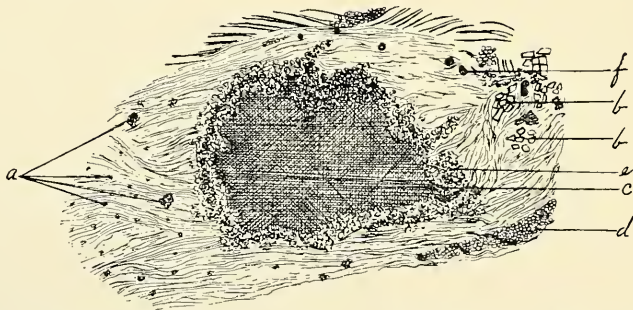
Fig. 126.—A Cheesy Focus Surrounded by Tuberculous Tissue in the Middle of a Dense Mass of Apparently Normal Fibrous Tissue, which, however, contains numerous miliary tubercles, *a, a*; *b*, muscle fibres; *c*, large cheesy centre; *d*, fat; *e*, tubercle tissue surrounding caseous mass; *f*, small blood-vessel. (Courtesy of *Journal of American Medical Association*.)

I have observed one case in which all the intermuscular septa and fasciæ of the forearm became tuberculous, secondarily to the development of a very small focus in the lower end of the radius. The swelling and the angry appearance of the parts suggested sarcoma, clinically, but exploration revealed the condition noted above and necessitated amputation, for it was clearly impossible to remove all the tuberculous material.

After a careful study of a number of these cases I am disposed to believe that those belonging to the first class are caused by a rapid and simultaneous infection of wide fascial planes by tubercle bacilli, as the lesions appear to be all of one age and are without the connective-tissue proliferation characteristic of the more chronic tuberculous processes. The lesions correspond quite closely

to those seen when a joint is infected by the rupture, into its cavity, of a cheesy bone focus, with a rapid spread of a large amount of tuberculous material over the synovial surface.

The cases belonging to the second class, on the contrary, resemble the more chronic forms of joint infection, in which the tuberculous lesion, starting in a small focus, gradually spreads and involves the various tissues of the joint. Here are to be found lesions of various ages, but always the characteristic fibrous tissue containing more or less widely scattered cheesy foci and many smaller tuberculous areas which have not yet begun to undergo degeneration. The proportion of the connective tissue to the cheesy foci varies according to the chronicity of the process, there being cases (like the last one reported above) in which the naked eye finds no indication of tuberculosis, but merely great production of fibrous tissue,—cases, however, in which the microscope and animal inoculation prove the presence of tuberculosis. In other cases the cheesy foci predominate and may attain a fairly large size, but they never, either by growth or by fusion, attain a size which would class them as cold abscesses.
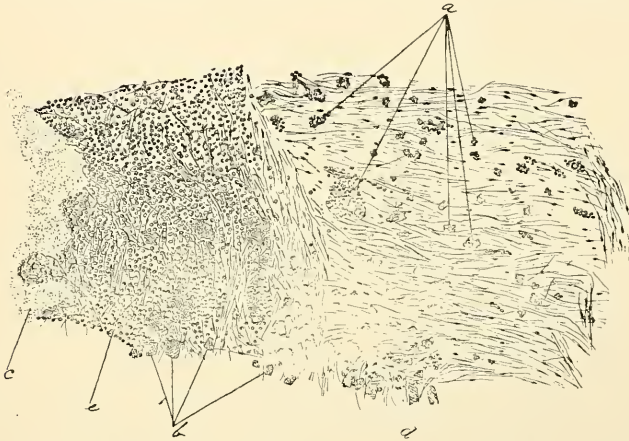
Fig. 127.—More Highly Magnified View of Edge of Cheesy Mass. *a*, Miliary tubercles, mostly perivascular; *b*, muscle fibres; *c*, cheesy centre; *d*, layer of tubercle tissue. (Courtesy of *Journal of American Medical Association*.)

The microscopic drawings in the text (Figs. 126, 127, 128) illustrate quite clearly certain points and demonstrate the tuberculous character of the apparently normal fibrous tissue. These three figures are from the second case reported above. Fig. 126 is a somewhat schematic drawing, which shows a large cheesy focus surrounded by tubercle tissue, the whole being in the centre of a dense mass of new connective tissue containing many scattered tubercles. Fig. 127 is from the edge of the same cheesy focus and shows, under a higher power, the details of the tuberculous zone about the cheesy focus and the scattered tubercles in the fibrous tissue. Fig. 128 shows a young perivascular tubercle with obliterating endarteritis—one of those marked "*a*" in Fig. 126. Figs. 129 and 130 are from Dr. W.'s finger (the third case reported above). Fig. 129 shows

the appearance, under a low-power lens, of what seemed to the naked eye to be normal fibrous tissue. A large tubercle, in which cheesy degeneration has begun, is shown at the upper part of the drawing; numerous smaller tubercles
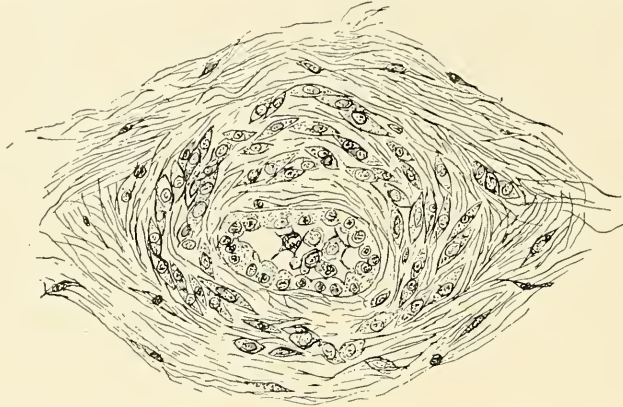
FIG. 128.—One of the Perivascular Miliary Tubercles marked *a* in Figs. 126 and 127. (Courtesy of *Journal of American Medical Association.*)

FIG. 129.—A Large Cheesy Focus (*b*) Surrounded by New Connective Tissue in which Lie many Foci of Tubercles of Varying Size; *a*, small focus of tubercles. (Semi-diagrammatic.)

are also visible in the same picture. Fig. 130 shows the detail of the small tubercle marked "*a*" in Fig. 129. There is here merely a massing of epitheloid cells and leucocytes, without the regular arrangement seen in the more slowly formed tubercles of Fig. 127. The vessels are taking part in the process, as shown

by the swollen and proliferating endothelial cells, but there are no well-marked perivascular tubercles.

The radical point of difference between these two classes of cases is that the fibrous limiting membrane of the first class is not tuberculous and may be left undisturbed in the scraping operations usually employed for such cases, while all the fibrous tissue in the second class is tuberculous and must be carefully
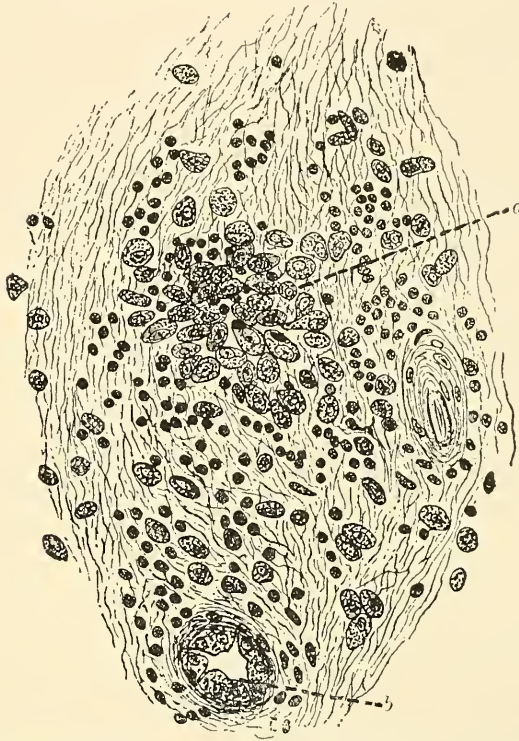
Fig. 130.—Highly Magnified View of the Area marked "*a*" in Fig. 129.   *a*, Cellular tubercle; *b*, blood-vessel showing endarteritis.

removed if a recurrence is to be prevented.   A recognition of these facts will do much to secure better operative results in the treatment of tuberculosis of the fasciæ.

V. CONNECTIVE TISSUE.

DISEASES AND WOUNDS.

Most wounds involve the connective tissue at the same time as the skin and underlying parts, but the lesions of the skin and more important structures beneath it overshadow in importance the injury done to the connective tissue. Injuries to connective tissue are repaired by the formation of scar tissue in greater or less amount according to the nature of the damage done, and, when a large amount of such scar tissue is formed, there is likely, at a later date, to be contraction and more or less deformity.   Contusions may cause extravasations

of blood into the connective tissue, but these are of importance only by reason of the fact that they form areas of least resistance to infections, and because the amount of extravasated blood may be sufficiently large to form a hæmatoma.

Such a hæmatoma may, by reason of its large size, become an object of surgical solicitude. The blood may coagulate or remain liquid in part; it may be rapidly absorbed or remain encapsulated for quite long periods, the former being the ordinary course of events. The symptoms of subcutaneous hæmatoma are usually clear; the early development of a fluctuating tumor after a contusion, and the changes in color which take place susbequently in the extravasated blood, being pathognomonic. When the hæmatoma is situated more deeply, or where the blood is completely coagulated, doubt may arise, but a delay of a few days will usually make matters clear. When immediate diagnosis is necessary the exploring needle can be utilized for diagnosis, but its use is to be deprecated except when it is employed with all the aseptic precautions that usually attend a major operation.

As regards the treatment, rest and the application of an ice-bag are the means usually advised. In deep hæmatomata much time is often lost in this way. If within ten days the tumor has not undergone a decided diminution in size, showing that the process of absorption of the extravasated blood is advancing satisfactorily, it is probably best to adopt more certain measures. An aseptic incision, the removal of all clots, and the suturing of the edges of the wound in such a manner as to obliterate all dead spaces, will usually secure primary union and much expedite the termination of disability.

Infections of the connective tissue are manifold, as it may become involved in nearly all the infective processes. Only such processes as originate in, and limit themselves mainly to, the connective tissue, will be here considered. Of these there are three which may be considered clinical entities: Acute circumscribed cellulitis; acute diffuse cellulitis; and acute gaseous cellulitis.

Acute circumscribed cellulitis is an acute suppurative infection of the subcutaneous connective tissue, which may be due to infection by any of the pus-producing germs, but which is usually due to the effects of the growth of the Staphylococcus pyogenes aureus. The result is an acute abscess, a localized collection of pus in a cavity circumscribed by an exudation of fibrin and white blood cells, and lined by newly formed granulation tissue.

It is hardly necessary to discuss here the bacteriologic etiology of suppuration or the possibilities of hæmatogenous infection, as these matters have been fully elaborated elsewhere. Only the clinical aspects of abscess will be briefly considered.

A subcutaneous abscess may be of any size, from the miliary abscess seen in some general infections, to large cavities holding a quart of pus, as seen in submammary, gluteal, and other abscesses in loose connective tissue. According to the virulence and character of their bacterial cause, their course may be

rapid or more prolonged. All abscesses start as a minute point of infection circumscribed by an inflammatory exudate into the surrounding tissue, and are then demonstrable merely as a hard, non-fluctuating area. As the bacteria grow, the exudate and tissues undergo liquefaction—*i.e.*, they form pus; and as the latter increases in amount the exudate melts away on its inner aspect but is constantly poured out at the periphery, so that the suppurative process remains constantly circumscribed. As the abscess in its growth approaches the skin or other external structure, this becomes infiltrated by the advancing exudate, and, as this is absorbed from within, an opening is formed through which the abscess discharges itself. After such discharge, if drainage conditions are favorable, the abscess cavity becomes obliterated by granulation tissue, which in turn becomes converted into scar tissue. The final result is a thickening of the connective tissue at the site of the former abscess, with adhesions to the skin or mucous membrane at the point where the rupture occurred.

In the course of its development the abscess shows itself clinically as a hot painful swelling, which soon gives a sense of fluctuation to the examining finger; and when perforation is threatened, the skin at this particular spot will appear markedly reddened. In addition to these phenomena there may be present constitutional symptoms, which vary in severity according to the size of the abscess and the virulence of the infection. The symptoms of such septic infection are headache, nausea, anorexia, chill, fever, and general prostration, with usually a marked leucocytosis; and in severe cases there may also be symptoms of renal involvement, as shown by the presence of albumin and casts in the urine.

An acute circumscribed abscess is easily diagnosed by the local signs observed on examination—local heat, tenderness, and fluctuation over a subcutaneous swelling pointing clearly to abscess.

The making of an incision as soon as pus has formed and the establishment of efficient drainage constitute the accepted treatment. The use of heat and ichthyol in the early stages is advised because in some cases it favors the dissipation of the developing abscess, while in others, on the contrary, it seems to hasten suppuration.

A deeply lying abscess, which is in close relation with some important structure, should be opened by the Hilton method, which may be briefly described as follows: Incise the skin and deep fascia with a knife, and then with a blunt instrument, such as a grooved director, work down upon and make an opening into the abscess cavity; then, before withdrawing the director, pass a closed artery forceps into the cavity, and, after partly opening its blades, withdraw it and the director, thus stretching the tissue sufficiently to permit the passage of a rubber drainage tube of fair size into the abscess cavity.

Gauze should never be used for drainage of an abscess cavity, as with such drainage the pus escapes in spite of the gauze and not by its help. Rubber tubes introduced at the most dependent points are usually the most available

and efficient means of drainage, and gauze should be used only where, on account of hemorrhage or for other reasons, pressure is desired. The various gauze packings are, in this class of cases, a delusion, and, as generally used, they lead to retention of discharges and delay in healing.

Acute Diffuse Cellulitis.—This form of cellulitis represents an infection of the areolar tissue in which the limiting exudate, which is a characteristic. of the circumscribed variety, is absent and the process spreads more or less widely, according to its location and the nature of the infection.

As to the etiology of the disease, it may be stated that it occurs usually in association with other infection processes in the blood-vessels, lymphatics, and skin, but may arise and exist without such complication. The ordinary pus germs are the common causes, the Streptococcus pyogenes being believed to be responsible for the more severe cases; but any pyogenic bacteria may set up the process, although the character of the resulting inflammation will vary according to the particular variety of the bacterial cause. Small and deep infected wounds seem to furnish the most common direct cause, but often it is impossible to discover such a primary wound owing to the fact that it has already healed in a satisfactory manner.

The characteristic pathological change in this disease consists in a conversion of the affected tissue into a grayish jelly-like mass which rapidly dies, forming extensive sloughs; and with this process is associated the production of ordinary pus. Suppurative lesions of the skin, blood-vessels, and lymphatics are likely to develop in the course of the disease. In its worst forms the process tends to extend indefinitely until checked by treatment or by death; in any event, it is always locally of an extremely destructive character.

One of the first local symptoms observed is a colorless, doughy, non-fluctuating and usually painless swelling, which rapidly increases in size, often in all directions, but when it is situated upon an extremity the extension generally takes place toward the body. If no treatment is employed, the skin overlying this swelling becomes dusky or tallow-like in appearance, and, as sloughing occurs in the infiltrated connective tissue, gangrene rapidly develops in the overlying skin, and extensive openings form, through which are discharged sloughs and pus. There is a great deal of œdema and venous congestion in the neighborhood.

The disease is ushered in by a severe rigor, followed by high fever and the other signs of sepsis. Later, when extensive sloughs have formed, there will be prostration, a lower body temperature, rapid and feeble pulse, and often a low form of delirium. With the further advance of the disease the condition becomes one of general sepsis and the patient dies with multiple abscesses, and pus in the large joints and serous cavities. In more favorable cases the process ceases to advance, the sloughs separate, and the extensive open wounds heal slowly by granulation.

The prognosis depends upon the amount and character of the bacterial infection, upon the resisting powers and general condition of the patient, and most of all upon the promptness and thoroughness of the surgical treatment.

As soon as the doughy swellings form they should, without delay, be incised freely, the incisions being made in such a manner as to lay open the whole infiltrated area down to, but not through, the deep fascia. Such incisions should be multiple and they should run parallel to the long axis of the affected limb, due regard being paid to preserving the superficial nerves and larger vessels. If the process spreads, the incisions must be prolonged and multiplied so as completely to relieve all tension and to allow the escape, at an early stage, of all liquid products of inflammation and later of the separated sloughs. The limb should be elevated and dressed with large, hot, wet dressings, aseptic but not carbolized or wet with any strong antiseptic. Such dressings should be changed frequently, and at each dressing all circumscribed areas of extension should be incised. The continuous warm bath applied to the limb is a very efficient substitute for wet dressings, and, where the facilities for its use are present, the bath will accomplish all desired ends even more successfully than large wet dressings. Sloughs

Fig. 131.—Bacillus Aërogenes Capsulatus (Welch). Smear preparation from the muscle juice of a leg affected with gas phlegmon. Staining with carbolic-fuchsin; Zeiss immersion lens, 3.0 mm.; compound ocular 4; original microphotograph enlarged one-third. (Eugen Fraenkel: "Ueber Gasphlegmonen.")

should be carefully removed as soon as they loosen, and all thrombosed veins should be ligated where they pass through the deep fascia, as infective emboli may be thus prevented.

The local treatment recommended above should be supplemented by the most careful diet and nursing, and all the means which tend to increase the patient's strength and general powers of resistance should be utilized. The use of Credé's ointment, the administration of antistreptococcic serum, and the use of the other means recommended as efficient in combating general septicæmia, should also receive careful consideration.

Acute Gaseous Cellulitis.—While the various septic processes associated with the formation of gas in the tissues have always been of great interest to surgeons, it is only within the last decade that their etiology has been thoroughly understood. Very little appears on this subject in surgical text-books, and the profession in general do not recognize the disease and therefore very naturally fail to institute efficient treatment.

A number of these cases have been reported in current literature, and while the authors of these reports claim various bacteria as the cause of the observed gas infection, it is probable that there is only one chief cause, viz., the Bacillus

aërogenes capsulatus of Welch. This bacillus is a short thick rod that retains the stain by Gram, and that stains with the ordinary basic dyes (Fig. 131).

In a paper which I read before the Section on Surgery of the American Medical Association, in July, 1905, I was able to collect 61 cases of gas infection, and since that time I have observed personally 3 fatal cases. An analysis of these 64 cases reveals the following facts: So far as the sex of the patients is concerned there is the usual preponderance of males in all diseases largely dependent on traumatism—viz., 48 males to 11 females, with the sex not stated in 2 cases. In over 80 per cent, one of the extremities was the seat of the disease: and in all but seven, traumatism or surgical interference preceded the onset of the disease. The sixty-four injuries are itemized thus:

Compound fractures	25
Bullet and shot wounds	7
Infusion of salt solution	3
Hypodermic injections	2
Ligation of artery for aneurism	4
External urethrotomy	3
Submaxillary abscess	2
Traumatic rupture of rectum	1
Appendectomy	1
Prostatic abscess	1
Herniotomy	1
Nephrectomy	1
Severe lacerated wounds	3
Spontaneous gas gangrene	4
Spontaneous general emphysema	2
After erysipelas	1
Unexplained	3

The mortality in the 64 cases was a little over 55 per cent. Of 18 compound fractures, 8 patients died, and 10 recovered after amputation. Of 7 bullet and shot wounds, 4 patients died and 3 recovered (1 with, and 2 without, amputation). Of 3 patients after external urethrotomy, 2 died and 1 recovered. The mortality in each of these three classes corresponds closely to the general mortality of the whole 64 cases; and, if several of Welch's cases (patients who died of pus infection and of tetanus after apparent recovery from gas infection) be excluded, it will be found that the average death-rate in surgical cases is about 50 per cent.

In regard to the etiology of gas infection, Welch has shown that the Bacillus aërogenes capsulatus is widely distributed in nature, being especially common in soil, hospital dust, and intestinal contents. Hence its more frequent occurrence in compound fractures, dirty wounds, and operations about the gut and perineum. The fact that it occurs after operations on the urinary tract, such as urethrotomy and nephrectomy, must be explained as due to accidental

contamination by gut contents, as the bacillus has not as yet been found in the urine before death. Welch and Bloodgood, however, both seem to favor the belief that the bacteria are probably carried to the seat of infection, in some cases, by the blood, as Gwyn has demonstrated their presence in the blood of the living patient.

According to Welch, it is extremely improbable that clinical gas infection is due to other germs than the Bacillus aërogenes capsulatus. The bacillus of malignant œdema has been reported as causing fatal infection in man, but without gas production. A few cases have been ascribed to the colon bacillus (for example, a case reported by Rizzo) and to the Bacillus proteus; but the reports do not show that either anaërobic methods of culture or inoculations of animals were attempted. Hence the proof of diagnosis in these cases is insufficient, especially in view of Lanier's work. The latter has demonstrated an aërobic form of the gas bacillus which closely resembles the colon bacillus and might easily be mistaken for it.

Certain German workers have made extensive studies which tend to show that the gas bacillus is at least closely related to the bacillus of butyric-acid fermentation; it is therefore probable that the last word has not been spoken in regard to the bacteriology of this class of diseases.

So far as the symptomatology is concerned, not much has been added to the descriptions of the older authors, of whom Maissonneuve and Pirogoff give especially full details. The latter, in 1864, described two varieties of gaseous gangrene: First, cases in which gas forms within forty-eight hours and the tissues become gangrenous and melt away without local inflammatory reaction, while the patient, who at an early stage shows an anxious countenance, sweats, and otherwise manifests unmistakable evidences of collapse, dies within a few days; and, second, cases in which the local reaction is marked, the disease, however, pursuing a slower course and being characterized by high fever and the other ordinary symptoms of severe infection. The symptoms noted in the cases listed above have been quite varied, and, on the whole, have not been striking; the one constant and diagnostic sign having been the presence of gas in the tissues or in the wound secretions—a phenomenon which first appeared at various times, from the eighth hour to the sixth day. Other symptoms noted have been the following: Rarely, a chill; regularly, a fever ranging from 100° to 104° F. in the different cases, with a rapid, running pulse and in many cases delirium; locally, gas in the tissues surrounding the point of entrance and in the wound secretions; a fetid or foul-smelling odor emanating from the discharge and from the incised tissues; a frothy, brownish discharge of horrible odor; a dusky redness of the skin, followed, in some cases, by the ordinary color changes of gangrene; general emphysema of extensive areas, sometimes of the whole body; explosive escape of gas from the tissue when incised; and immense production of gas in all parts of the cadaver after death.

There seems to be much difference of opinion as to whether a pure infection by the gas bacillus is more malignant than a mixed infection. Muscatello and Gangitano believe that the mixed infections are the most virulent, and they even claim that the gas bacillus is unable to exert any pathologic action on healthy tissues; while Hitschmann and Lindenthal take exactly the opposite view, stating that the pure infections are most virulent. Welch, while admitting extreme virulence in certain cases of mixed infection as well as in pure infections, positively contradicts, from experimental experience, the statement that the gas bacillus cannot attack healthy tissues. A study of some of the recent cases would suggest that, like tetanus, the relative virulence of this disease in any given case may be indicated by the period of time, or the stage, at which the gas makes its appearance—that is, that cases developing gas symptoms slowly should give the better prognosis.

The one diagnostic sign is the presence of gas in the tissues or the presence of the bacillus in smear preparations from the wound; in fact, the latter should be given precedence, as one or two observations establish the fact that this germ may live for some time in a wound without producing gas. All suspected wounds, therefore, should be subjected to this amount, at least, of bacteriologic study.

There is no record that any case of gas infection ever made a spontaneous recovery, so that the prognosis will depend in part upon the location of the infection, but more especially upon the early date and thoroughness of the treatment.

As to the treatment, the following measures may be recommended:

All contaminated wounds should be thoroughly cleansed and disinfected, best by ninety-five-per-cent carbolic acid and alcohol. As soon as the diagnosis shall have been made, either clinically or by the microscope, the seat of the infection should be laid widely open by multiple incisions, and the affected part should then be treated by the continuous bath; by irrigation with applications of hydrogen peroxide; and by wet dressings. When the lesion is confined to an extremity the consensus of opinion seems to favor early amputation, though there are on record some successes after a more conservative plan of treatment. Theoretically, the use of hydrogen peroxide is indicated on account of its power to inhibit the growth of an anaërobic germ, but the effect of this agent can only be a matter of speculation. In general, the early use of the means found efficient against streptococcus cellulitis seems effective against similar lesions due to Welch's bacillus.

SURGICAL DISEASES AND WOUNDS OF NERVES.*

By De FOREST WILLARD, M.D., Philadelphia, Pa.

I. WOUNDS OF NERVES.

ETIOLOGY.

WOUNDS of nerves are caused by incisions, contusions, lacerations or punctures.

Incised wounds not infrequently divide nerves, tendons, and blood-vessels at the same stroke. A nerve may also be deliberately or accidentally divided during the removal of a tumor.

The sciatic nerve has been caught up in the reduction of a dislocation of the hip and has been carried forward in front of the neck of the femur, causing not only flexion of the thigh, but constantly increasing pain.

In wounds from crushing or tearing forces, a considerable destruction of the nerve may result, with loss of substance.

SYMPTOMATOLOGY.

Complete division of a nerve trunk will cause immediate loss of all objective sensation, and paralysis of the muscles in the distribution of such nerve. Numbness and tingling speedily follow. In testing for loss of sensation, it should be remembered that adjacent nerves often vicariously take up the action in a short time, or, as frequently occurs, nerve filaments from different trunks intertwine.

Slight contusions are frequently followed by numbness or tingling at the peripheral ends, while more severe blows will result in partial or total loss of power, with atrophy. The accidental inclusion of a nerve in a ligature during an operation may be followed, according to the size of the nerve, by more or less pain, twitchings, even by tetanus or partial or complete paralysis. The complete isolation of artery and vein before the application of a ligature renders such an accident much less liable to occur than when the mass of tissue is included in the ligature.

Punctured wounds are followed especially by an aching pain with tingling or boring sensations.

Gunshot wounds, according to the nerve involved and the extent of the

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injury, will be followed, as in other injuries, by loss of motion or of sensation, then by atrophy and alteration of nutrition in the muscles, skin, joints, and other tissues. In no publication have these late results been so well described as in the careful research of Mitchell, Morehouse, and Keen, 1864.

Trophic changes in the hands give the glossy fingers with the skin apparently
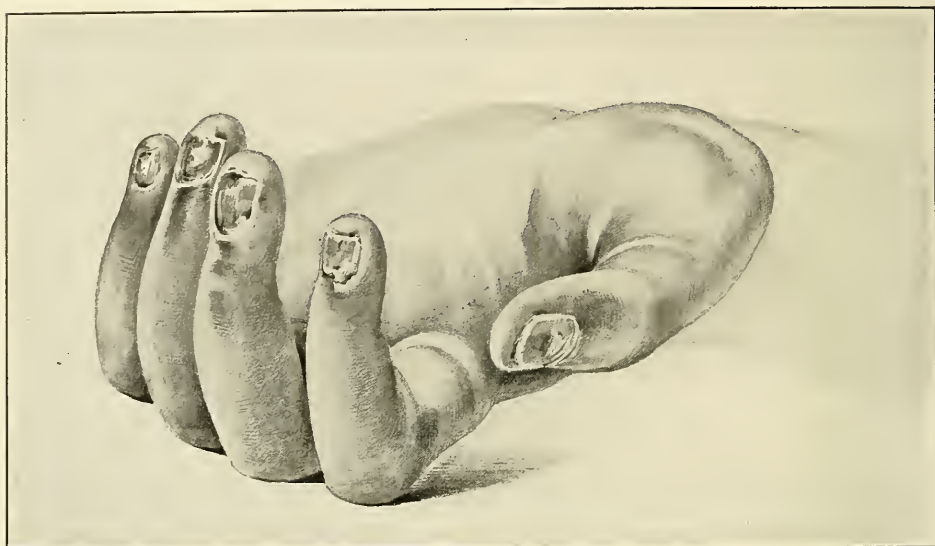
Fig. 132.—Trophic Changes (Glossy Skin and Turtle-shell Nails) following Injury to Nerves of Forearm. (S. Weir Mitchell's case, in "International Encyclopædia of Surgery.")

stretched too tightly over the members (Fig. 132). This is not infrequently seen when contractions following crushing wounds are present. The pain may be intense and ulceration and gangrene may follow.

PATHOLOGY AND PATHOLOGICAL PHYSIOLOGY.

Late Results of Nerve Wounds.—Late nutritive disturbances are indicated by altered nutrition, paralysis, loss of temperature, joint affections, etc. The altered nutrition of the skin is evidenced in trophic changes, redness, eczema, club nails, altered sensation, pain, stiffness, smooth polished skin, loss of hair, œdema, with burning sensations and marked hyperæsthesia, etc.; that of the muscles, by atrophy, degeneration, contraction, or rigidity. The extent of the lesion may be judged by the loss of muscular power or of sensory recognition, and by the presence or absence of muscular contractility under electrical excitement. Effusions into the joints are occasionally seen, and so also are the degenerations that simulate the spinal arthropathies observed in tabes. The treatment of these trophic changes is exceedingly tedious, since all forms of local applications will be unavailing. Nerve-stretching and

neurectomy have also failed, and even amputation, unless done at the point of nerve involvement, does not assure relief.

Nerve Degeneration.—A divided nerve speedily degenerates, the process taking place most rapidly in the peripheral portion. The secondary so-called
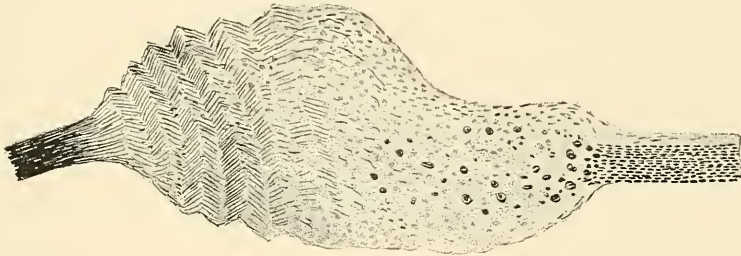
FIG. 133.—Resection of Three-Quarters of an Inch of the Sciatic Nerve of a Dog; the Gap between the Divided Ends was Bridged by a Compact Bundle of Four Strands of Chromicized Catgut. Specimen examined on the forty-sixth day after the operation. (From author's article in *The International Medical Magazine*, April, 1894.)

The upper fragment (on the left-hand side) terminates in a bulb of fibrous tissue, which contains numerous nerve fibrils radiating like a fan from the termination of the nerve fibres. The sheath is continued into the fibrous tissue of the bulb, being considerably thickened before the new fibres split up. Scattered through the fibrous tissue are numerous nerve fibrils, making their way toward the lower fragment (on the right-hand side). Below—*i.e.*, toward the right—are seen drops of degenerated myelin. (Examination made by Dr. W. S. Carter.)

Wallerian degeneration is of chief importance to the surgeon and most frequently requires his aid, as this form occurs after traumatism of the nerves or after partial destruction through the pressure of a tumor. Leucocytes invade the dying distal segment and the myelin breaks up; then follows proliferation of
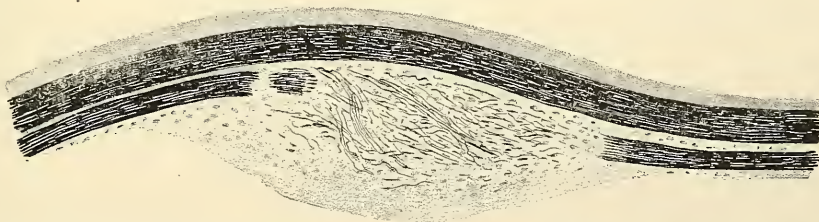
FIG. 134.—Resection of One-quarter of an Inch of the Sciatic Nerve of a Dog; the Divided Ends were Stitched together by means of Fine Chromicized Catgut. Specimen examined on the forty-sixth day after the operation. (From the author's article in *The International Medical Magazine*, April, 1894.)

To the naked eye there appeared to be a continuity of nerve fibres. The microscope, however, showed that only one division or bundle of the nerve had been severed. The opposite ends of this cut portion of the nerve had separated to the extent of half an inch and were united by fibrous tissue, scattered through which were found many new nerve fibrils. (Examination made by Dr. W. S. Carter.)

connective-tissue cells. Fatty degeneration, absorption, and formation of sclerotic tissue are the steps of the process.

A completely degenerated nerve cannot transmit either nerve impulses or electricity.

Nerve Regeneration.—Regeneration of nerve tissue is practically certain if the divided ends are carefully apposed, and it is probable even with a considerable separation. The process is slow* and consists, according to the former view, of the gradual outgrowth of axis cylinders from the proximal end into the connective-tissue cells lying between the divided ends. The more recent teaching is that axis cylinders are formed in the peripheral segment from neurilemma cells that stretch out first as fine threads, to become complete axis cylinders. These spider-like neuroblasts are seen as early as the third week. Almost any form of graft interposed between the ends may act as a scaffolding or guide to facilitate the efforts of the axis cylinders to reach the distal fragment. The peripheral portion is believed by some to be capable of regeneration even when union with the central portion is prevented.† This regeneration, without connection with the proximal end, is perhaps possible in very young animals, but is still uncertain.‡

In experiments§ that I performed several years ago upon dogs, this regeneration was found in nearly every case. The accompanying microscopical cuts

Fig. 135.—Removal of Three-Quarters of an Inch of the Sciatic Nerve of a Dog; the Divided Ends were then Split Longitudinally in the Manner Shown in Fig. 142, and the Flaps were Turned upon their Bases. The attempt was then made to stitch these flaps together, but it proved unsuccessful, as the lower half of the flap on one side tore out. The remaining upper half was then turned downward and stitched to the upper slit half of the other end of the nerve. Specimen examined eleven days after the operation. (From the author's article in *The International Medical Magazine*, April, 1894.)

In the upper fragment (left-hand side) the nerve fibres terminate abruptly in the mass of fibrous tissue without breaking up. In this mass of fibrous tissue are found many patches of degenerated nerve structure. Below the fibrous tissue—*i.e.*, in the upper end of the lower fragment (right-hand side)—the fibrils are beaded and each one is surrounded by a sheath. Degeneration, in this specimen, is not so far advanced as in some of the other specimens. (Examination made by Dr. W. S. Carter.)

(Figs. 133–138) show this under various circumstances. The degeneration of the muscle supplied by the nerve tends to diminish the advantages to be gained by the reunion of the divided ends, but months or years after section a certain amount of gain may be expected, provided nerve influences are renewed by reunion or by nerve transplantation. Conductivity may be present even when nerve fibres cannot be discerned, but conductivity may not be present even when nerve fibres exist, owing to the condensation and stricture caused by cicatricial connective tissue.

* Howell and Huber: Jour. of Physiology, Cambridge, 1893, vol. 14, No. 1, vol. xiii., 335, and Jour. Morphology, 1895.

† "Contributions from the William Pepper Laboratory of Clinical Medicine, University of Pennsylvania," 1903, by Spiller and Frazier.

‡ "Healing of Nerves," by Ballance and Stewart; Centralblatt f. allgemeine Path., vol. xv., 917.

§ Willard: The Medical News, October 6th, 1894, 375.

Joint conditions following nerve injuries, arthropathies, are extremely persistent, and are accompanied by rigidity, sometimes by redness, and almost always by pain and swelling. The tissues about the joint become indurated, and partial or complete ankylosis follows, with or without primary effusion. These symptoms usually make their appearance a considerable time after the injury and are found only in the region supplied by the injured nerve.

PROGNOSIS.

All wounds of nerves should be considered serious, since neuritis, neuralgia, or trophic changes may follow. If primary suture is performed, there may be a return, not only of sensation, but also of motion, especially in clean end-to-end sutures. After primary suturing, even though long delayed, sensation appears more speedily than motion. If the operation has been performed with due aseptic precautions, all that remains for the surgeon is to wait and endeavor by massage and other measures to increase the nutrition of the part, and also
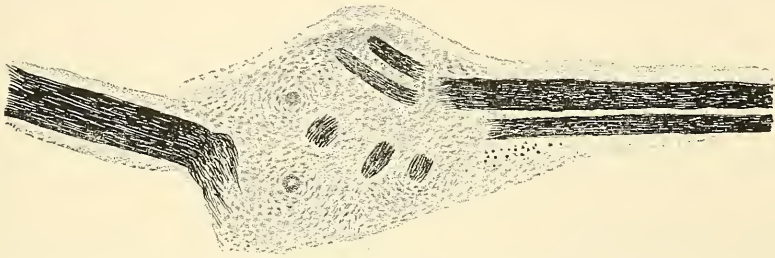
FIG. 136.—Removal of Three-quarters of an Inch of the Sciatic Nerve of a Dog; the Nerve was then thoroughly Cleared and Stretched, and the Divided Portions were Sutured together End to End. Specimen examined twenty-four hours after the operation. (From the author's article in *The International Medical Magazine*, April, 1894.)

In this specimen no continuity of nerve fibres is demonstrable. A few of the bundles have evidently been cut in different planes. There is no splitting up of fibres and no evidence of degeneration is discoverable. (Examination made by Dr. W. S. Carter.)

to allow time for the re-education of the brain. Secondary suturing may be done, even several years after the occurrence of the injury, with fair hope of success, unless alteration of the peripheral segment is complete. Full recovery is possible, provided primary aseptic union of the wound is secured; and we may wait hopefully for results. In either primary or secondary suturing, the individual conditions will determine the method of union—by direct suture, by bridging, by transplantation from a young animal, by suture *à distance*, by grafts, by insertion of a catgut or other form of bridge, by flaps from distal or from proximal segments or from both, by tubulization, or by anastomosis.

Both primary and secondary suturings yield a successful percentage of improvement in 75 per cent of the cases. In 123 cases* of primary sutur-

* Medical News, October 6th, 1894.

ing collected by me some time since, a large percentage of the cases were improved; in 130 cases of secondary suturing 80 per cent were improved. The operation involved practically no risk to life. The statistics will be found in
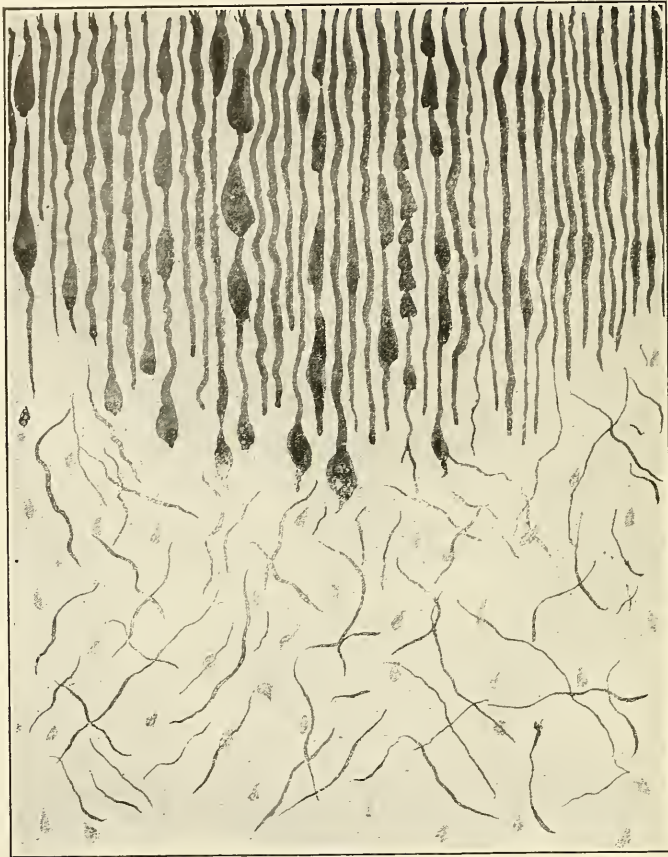
FIG. 137.—Nerve-Grafting; Bridge of Ivory. (From the author's article in *The International Medical Magazine*, April, 1894.)

In this case three-quarters of an inch of the right sciatic nerve of a dog was removed, and a small piece of ivory of the same length, bored at each end, was inserted and stitched with catgut sutures. On the fifth day the wound had nearly closed, and by the ninth day its edges had entirely united. The dog was killed by chloroform on the thirty-second day after the operation. There were no signs of suppuration. The piece of ivory was found encysted and lying in the connective tissue on a plane one-fourth inch superficial to the plane of the nerve. The nerve ends had separated three-quarters of an inch and were united apparently by fibrous tissue.

Microscopical Examination (by Dr. W. S. Carter).—The nerve terminates abruptly in a bulb of fibrous tissue, several bundles being cut off obliquely. At the lower end of the connective tissue there is a group of black-stained drops of degenerated myelin, surrounded by a capsule of fibrous tissue. In the diagram (Fig. 137) are shown the nerve fibres, some of them bulbous at the end, others lobulated or beaded. Some are shrunken, some enlarged. Throughout the fibrous bridge are seen numerous radiating and developing nerve fibres. While they are apparently straggling and without continuation, yet this may be due to improper section in the preparation of the specimen. Their presence shows that this attempt at reunion and transmission might have been perfected later.

full in the article mentioned. The longest period between the time of the accident and the suturing was nine years.

In a large lacerated wound I have seen eight inches of the musculo-spiral

torn from its bed and destroyed, with immediate total loss of motion and sensation. Restoration of function, even after the loss of so great a portion of tissue, is sometimes remarkable; it must take place either by vicarious action or by some form of nerve anastomosis. In the case just mentioned, an examination ten years later demonstrated that motion had been so far restored that the man was able to perform almost all the movements of the fingers, and that sensation had returned to every portion except a small spot in the palm.

TREATMENT.*

Rest upon a splint or in bed should be the first procedure. In punctured wounds, especially when the pain radiates toward the periphery, and even though there be no loss of sensation or motion, the wound should be converted into an open one, thoroughly cleansed, and rendered aseptic. The part can be put absolutely at rest in a plaster-of-Paris splint, which should be slit open as
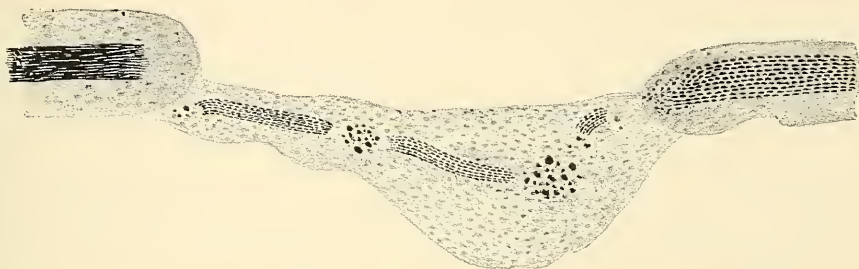
Fig. 138.—Nerve-Flap Splicing. (From the author's article in *The International Medical Magazine* April, 1894.)
In this experiment a section. one inch and a half long, of the sciatic nerve of a black Newfoundland dog was resected. Flaps were cut from the remaining ends of the nerve and were then turned over and united (end to end) by means of catgut sutures. The dog was killed on the twenty-eighth day after the operation. The microscopic examination of the specimen, made by Dr. W. S. Carter, shows the following conditions: An irregular connective-tissue bridge connects the nerve ends, in which are found beaded and degenerating remains of the nerve flaps. At several points aggregations of degenerating myelin are also seen. The upper fragment does not show any attempt to send out the fan-like projections of nerve fibrils before noted. The lower fragment is degenerated.

soon as it is sufficiently hard, in order that it may be removed as often as is necessary for purposes of examination. In neurectomy, when deliberately performed for the purpose of breaking off communications, a portion of the nerve, from one to two inches in length, should be destroyed, or a flap of fascia can be folded over the cut extremity of the nerve.

A divided nerve trunk should always be sutured, if possible, at the time of the primary dressing. Primary suturing, under strict asepsis, is best performed with fine chromicized catgut or silk sutures, inserted with a small, round sewing-needle through the sheath of the nerve; and preference should be

* For a full discussion of the subject, see Powers, Annals of Surgery, vol. xl., November, 1904; Chipault: " Etat Actuel de la Chirurgie nerveuse," 1903.

given to the mattress stitch or the Lembert suture. If this plan cannot be carried out, two sutures penetrating the substance of the nerve and crossed at right angles may be employed. Even the cauda equina should be sutured with-
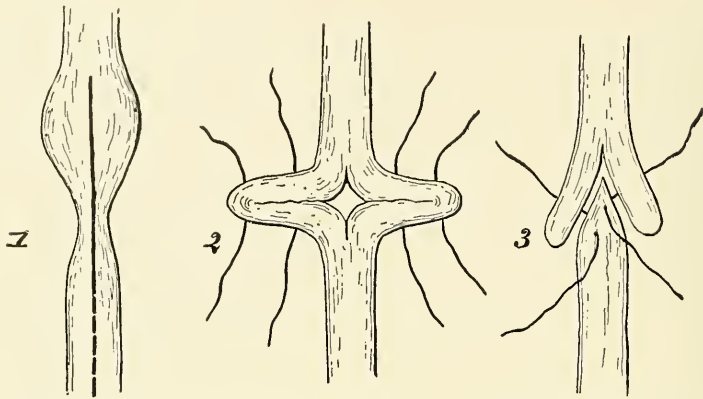
FIG. 139.—Different Methods of Suturing Nerves. 1, Longitudinal incision through cicatrix, extending into normal nerve substance on either side; 2, incision in 1 united transversely; 3, nerve stumps united by the wedge method. (Gleiss, in the *American Medico-Surgical Bulletin*.)

in the spinal canal, and a divided spinal cord is reported to have been united with advantage in several instances. The closer the ends can be approximated, the better will be the restoration of function. Even the ragged filaments of a lacerated nerve should be saved and sutured as far as possible, provided they have not been so contused as to render sloughing probable. A nerve will bear
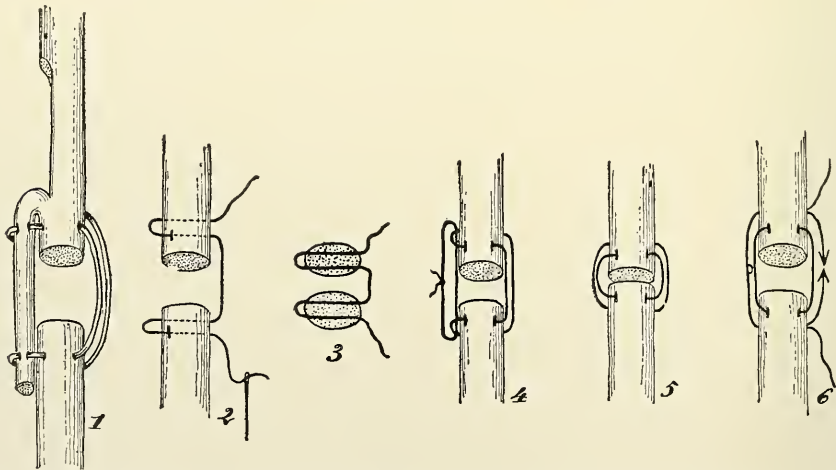
FIG. 140.—Still Other Methods of Suturing Nerves. (Truka, in *Centralblatt für Chirurgie*.) 1, Nerve suture by means of a flap; 2–6, other methods for the union of severed nerve ends.

considerable stretching, if this be found necessary in order to secure approximation of divided ends. When the loss has been considerable, the bridging of the gap may be effected by splitting the ends of the nerve in the manner shown in Fig.

139, turning these flaps toward each other, and suturing them in position, thus securing the best form of skeleton for the deposition of new nerve fibres. When the loss of tissue is very great, the distal end may be stretched to a neighboring nerve, the hope being entertained that a certain amount of nerve force may be transmitted over the new route. The limb should be fixed with gypsum for several weeks after the suturing has been done, thus giving the nerve a chance to be fully relaxed. If primary healing occurs after nerve suturing, a long period of treatment by massage, electricity, gymnastics, etc., should ensue, since restoration of function may be expected even after the lapse of years. It is impossible, as a matter of course, to determine, in either rapid or slow recoveries, whether there has been transmission of impulse through new fibres in the intervening gap or whether the restoration is due to collateral or vicarious action.

Secondary Suturing; Neuroplasty.—Secondary suturing of a divided nerve may be attempted even years after the injury, when, in the mean time, restoration of conduction has not been accomplished. When the ends have separated and have become bulbous, they may be split in the manner indicated in Fig. 141, and thus made to span the gap. Other forms of splicing are indicated in Figs. 139 and 140. Shortening of the bone, for the purpose of bringing divided nerve ends in apposition, has been performed, but it is an uncertain procedure. When the gap is great, a section of a nerve taken from an animal may be inserted in the gap. The animal should be as young as possible, since growth and activity of all tissues during the first few months of life are at their height. While such a graft seldom lives, it undoubtedly does act as a nidus, or as a skeleton or net-

Fig. 141.—Suturing of Nerves. The upper figures indicate the position before suturing, the lower after suturing. The dotted lines indicate the incision. (Duncan.)

work which favors the deposit of new nerve fibres and assists in regeneration. The deposit of new nerve fibres may also be limited and guided by tubes of decalcified bone, of rubber tissue, etc., which are to be placed between the ends. Catgut bridges probably act in the same way. There are various ways in which the purpose contemplated may be accomplished. From a number of experiments which I performed some years ago,* and which are illustrated in the accompanying cuts (Figs. 139, 140, etc.), and also from other experiments made since that time and from observations made upon the human body, the deduction is warranted that although a sutured nerve degenerates, especially in the peripheral portion, it nevertheless does eventually, although slowly, become restored. Not only is the gap bridged by connective tissue, but upon this tissue there are slowly deposited nerve filaments which finally become capable of transmitting both motor and sensory impressions.

* Inter. Med. Mag., April, 1894; Med. News, October 6th, 1894.

It is often very difficult, while the operation is in progress, to distinguish the
nerve ends from the surrounding cicatricial tissues, but if the nerve is exposed
above and below, identification will be found easier. This clearing away of the
surrounding tissues is known as *neurolysis*. The bulbous end should be trimmed,
but should not be entirely removed, lest the gap left between the ends be too
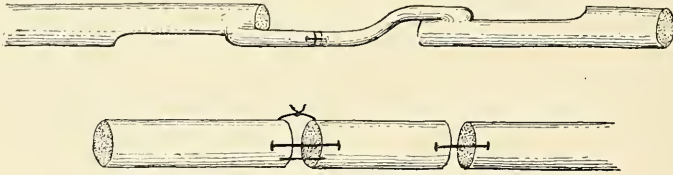
Fig. 142.—Nerve-Suturing; Neurorrhaphy; Nerve-Grafting. (Willard.)

great. The interposed mass of connective tissue should be carefully examined
and should not be unnecessarily sacrificed, since it sometimes contains trans-
mitting fibres. A flap may then be cut out of one end of the nerve and turned
downward to meet the corresponding flap from the other fragment, the sutur-
ing being done in the ordinary way. A knife should always be used for this
purpose.

The technique of nerve suturing, whether the object be to secure primary
union of a divided nerve, or to effect the repair of a nerve trunk by a secondary
operation, or to carry out some of the varied manœuvres required in neuro-
plastic operations, resolves itself into the three essentials of asepsis, perfect
apposition, and the minimum of injury to the axis-cylinder processes.

For obtaining perfect apposition, catgut treated with chromic acid or formalin,
so that it may not be absorbed under three weeks, of the smallest size compat-
ible with strength, and used with a small round sewing-needle or with a specially
curved and flattened needle as described by Kennedy (Chipault, Vol. ii., pp.
863–4), is the preference of most authors (Spitzy, Powers, Peterson, Esmarch,
and Kavalzig). Preference is always given to longitudinal suture through the
nerve sheath, although, for the sake of more perfect apposition of the nerve ends,
transfixing of the nerve substance itself is to be sometimes advised even at the
expense of injury and consequent degeneration of some of the nerve fibres.
In cases where apposition of the nerve ends is impracticable without too great
stretching of the nerve or the unjustifiable shortening of bone to obtain it, the
procedure of choice is the transplantation of a section of nerve from one of the
lower animals or from man, as has been done in some instances where an ampu-
tated limb furnished the material for bridging a nerve defect.

The use of tubes of rubber, decalcified bone, and magnesium (Payr, 1900,
Deutsche Zeitschrift f. Chirurgie, Bd. liv., S. 167), has been practised by various
authors as a means of guiding and protecting the path of the regenerating

fibres. Payr has used the magnesium drain method with success in four cases, the magnesium being absorbed and the fine chromicized gut used to draw the ends together within the drain, holding until union had been well established.

Tillmanns, Huber, and Peterson agree that a transplanted nerve is better as a path for the down-growth of axis-cylinder processes than catgut strands and ladders or tubular guides or protections.

In neuroplastic operations we are limited, according to Spitzy, to two essential methods:

(a) A part of a nerve with a central basis may be split off from an intact nerve, and this part implanted into a longitudinal slit of a paralyzed nerve and fixed by a longitudinal suture.

(b) As large a piece as possible, which has a peripheral basis, may be split off from a paralyzed nerve and be implanted into a longitudinal slit in an intact nerve. In this connection it should be stated that not a little contention has arisen regarding the efficiency of lateral (longitudinal) implantation. Ballance, Murphy, and others claim that this plan is much inferior to the end-to-end method because of the impossibility, by the former method, properly to join together the respective anatomical constituents of the apposed nerve structures (axis cylinders, etc.).*

Various methods of transplantation are illustrated by Figs. 92–104 (pp. 419, 420, etc., of the present volume), which were copied from Vulpius' article and from other sources. Although these cuts were made originally for the purpose of showing the great variety of ways in which a divided tendon may be lengthened, spliced, etc., the methods shown are equally available in operations upon nerves.

Anastomosis; Neuroplasty; Implantation.—In cases where a large portion of a nerve trunk has been destroyed, and where consequently the gap which remains is too wide for the employment of any method of suturing, the proximal and distal ends should be inserted beneath the sheath of a neighboring nerve trunk and sutured there, in the hope that impressions received may be transmitted along the fibres and thence switched back to the original trunk. Richardson reports a case in which this plan was adopted by Park, with a degree of success which is certainly encouraging.†

The transfer of a portion or the whole of a nerve from a normal trunk to an injured or paralyzed one has been satisfactorily practised in a number of instances. The technique of the operation is sufficiently described on page 493,

* References: Kennedy, i Chipault's "l'Etat Actuel de la Chirurgie Nerveuse," vol. ii., p. 863; Payr: *ibid.*, p. 383; Esmarch and Kavalzig: "Surgical Technic," 1901, p. 297; Spitzy: Am. Jour. Orthop. Surg., ii., No. 1, p. 8 *et seq.;* "Internat. Text-Book of Surgery," p. 868; Amer. Jour. Med. Sciences, 1899, p. 377; Huber: Journal Morphology, 1895, vol. xi., No. 3, p. 629; Tillmanns: Berlin. klin. Wochenschrift, 1885, p. 375; Powers: Annals of Surgery, vol. xl., November, 1904.

† " National Text-Book of Surgery," Warren and Gould, vol. i., p. 871.

and the actual results obtained are of a promising nature. In confirmed paralysis from wounds, as well as in other forms of paralysis, great cosmetic benefit may certainly be secured by either nerve anastomosis alone or by this operation in combination with tendon transplantation.

In a case in which both the median and the musculo-spiral nerves had been destroyed at a certain point, but in which the ulnar remained intact, a healthy portion of the median was first implanted into the ulnar, and then later the musculo-spiral was anastomosed with the median.*

Consideration of Individual Nerves.

Pneumogastric Nerve.—This nerve may be carelessly divided in deep dissections of the neck, or it may be extensively damaged by bullet or stab or razor wounds; occasionally, but not often, it is divided in suicidal wounds. The symptoms, as indicated by Park, are difficulty in respiration and deglutition, followed by pneumonia or by other nerve disturbances. While not necessarily fatal, the injury is a grave one, nearly one-half of the cases proving fatal. Whenever wounded from any cause, the nerve should be searched for within the sheath of the vessels, as it lies behind and between the jugular vein and the carotid artery. It should be sutured with fine catgut or chromicized gut and the wound closed aseptically.†

Phrenic Nerve.—The phrenic nerve is most frequently injured in operative procedures in the neck, especially in the removal of deep-seated tumors, tuberculous glands, etc. This nerve, lying as it does directly in front of the vessels, should be carefully avoided, and it should be remembered that in deep growths of the neck it may be found in abnormal positions. Division of this nerve, while not necessarily fatal, may, nevertheless, unless the nerve be immediately sutured, give rise later to cough, difficulty of respiration, and sometimes bronchitis and pneumonia, as the result of the interference with the action of the diaphragm.

Recurrent Laryngeal Nerve.—This nerve may be interfered with by a deep-seated abscess of the neck, by pressure of a diseased thyroid or thymus gland, or by the presence of a malignant or benign tumor; or it may be injured in various traumatisms, or severed in the course of an operation for the removal of a goitre or some other variety of tumor. Pressure upon the nerve is indicated by alteration of the voice or by difficulty in respiration, sometimes so serious as to demand immediate tracheotomy. This laryngeal spasm, when permanent or serious, should be treated by tracheotomy, followed by the removal of the exciting cause, whether it be a tumor or an abscess. If the nerve shall have been

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* Jour. Amer. Med. Assoc., March 1, 3, 1906, p. 640.

† The various methods of nerve suturing will be found illustrated in the "National Text-Book of Surgery," edited by Warren and Gould, vol. i., p. 868.

accidentally divided, it should be at once sutured and the precautions usually observed in tracheotomy and thoracotomy should be carried out.

Sympathetic Nerve.—The cervical sympathetic may be injured in deep operations upon the neck, or by the pressure exerted by a tumor upon the ganglia. Injury to this nerve is followed by ptosis, and at the same time the pupils become irregular and the conjunctiva more vascular, while the nasal, salivary, and perspiratory secretions are diminished. In some cases there are paroxysmal
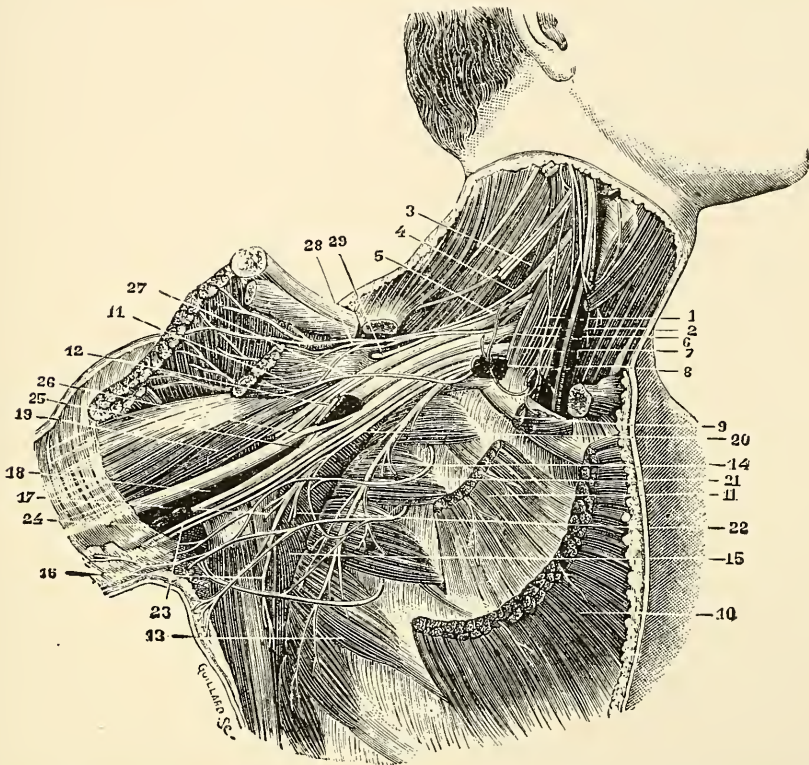
FIG. 143.—Brachial Plexus of Nerves. (L. Hirschfeld, in "Traité Elementaire d'Anatomie," par Ch. Debierre.) 1, Phrenic nerve; 2, anterior scalenus muscle; 3, posterior scalenus muscle; 4, 5, 6, and 7, the four last cervical nerves; 8, subclavian artery; 9, subclavius muscle; 10, pectoralis major muscle; 11, pectoralis minor muscle; 12, axillary artery; 13, serratus magnus muscle; 14, nerve to the serratus magnus muscle; 15, subscapularis muscle; 16, nerve to latissimus dorsi muscle; 17, nerve to teres major muscle; 18, humeral artery; 19, coraco-brachialis muscle; 20, accessory branch of the internal cutaneous nerve of the arm; 21, second intercostal nerve; 22, inferior subscapular nerve; 23, internal cutaneous nerve of the arm; 24, basilic vein; 25, cubital nerve; 26, median nerve; 27, nerve to the pectoralis minor muscle; 28, nerve to the pectoralis major muscle; 29, subscapular nerve.

pains behind the ear, dimness of vision, flushing of the face, increase of perspiration, etc. The superior cervical ganglion lies external to the sterno-mastoid and may be reached by an incision extending along the posterior border of this muscle, just below the mastoid process; at the same time the muscle itself, together with the internal jugular vein, should be displaced forward. The internal carotid artery is next to be lifted, and upon its posterior face will be found the superior sympathetic ganglion directly in front of the splenius and

rectus muscles. The ganglion should be removed and the nerve filaments traced downward to the lower ganglion. It must be remembered that the two ganglia named lie in close proximity to the thyroid vessels, and that the second and third are in close proximity to the first dorsal ganglion. The operation described may cause a disappearance of the symptoms, but a recurrence does sometimes take place.

Removal of cervical sympathetic ganglia for exophthalmic goitre, epilepsy, chorea, and chronic glaucoma has recently come into notice, but as the mortality seems nearly as great as that of thyroidectomy, and as the comparative results have still to be determined, the operation may be said to be in its experimental stage. To be of benefit, complete bilateral extirpation of the sympathetic cervical ganglia and of the upper thoracic is required, the safety of the operation being increased by operating on the two sides at different periods. Thyroid poisoning occurs in this operation as well as in thyroidectomy. It is possible that the benefit reported in exophthalmic goitre may be due to the cutting-off of lymph channels. Partial thyroidectomy, in the hands of Kocher, Mayo, and others, has yielded better results.

Brachial Plexus of Nerves.—The cords of the brachial plexus may be pressed upon by deep-seated malignant or benign tumors in the neck, by bony growths that spring from the clavicle or the vertebræ, by the pressure of an extracervical rib, or by the displaced head of the humerus, in all of which conditions there is apt to be pain—at times extreme—in the arm. The extensive distribution of the nerves arising from this plexus is well illustrated by the accompanying figures (Figs. 143 and 144). These cords may also be injured by accidental wounds, or by the surgeon during an operation upon the neck. In any case of wound they should be immediately sutured, and in cases of pressure the offending cause should be removed by operation, if possible. In a case of progressive muscular atrophy of the trapezius, Eisenberg sutured the scapulæ together and lengthened the clavicles. In cases of neglected and unreduced dislocations, the danger arising from adhesions of the head of the humerus to the vessels and nerves renders reduction by manipulation a dangerous procedure. In the *Philadelphia Medical Times*, 1880, I collected a series of such accidents resulting from forcible attempts at reduction, among which accidents there had occurred the tearing of the brachial plexus, the rupture of the artery and a vein, and even the complete evulsion of the limb. In old dislocations an open incision is often a safer operation, either with or without excision of the head of the bone. When, after the removal of a malignant tumor of the breast, the deeply infiltrated axilla is subjected to a thorough dissection for the purpose of removing all secondary foci of the disease, great care should be exercised to avoid these brachial cords.

The brachial plexus may be reached by an incision similar to that employed for the tying of the axillary artery, or the cords may be approached in the neck

by an incision above the clavicle and parallel to it, which incision may be supplemented by an upward cut along the posterior border of the sterno-mastoid. For the upper cords, from which the musculo-spiral arises, the incision may be parallel to and anterior to the edge of the trapezius.   Abbe successfully excised
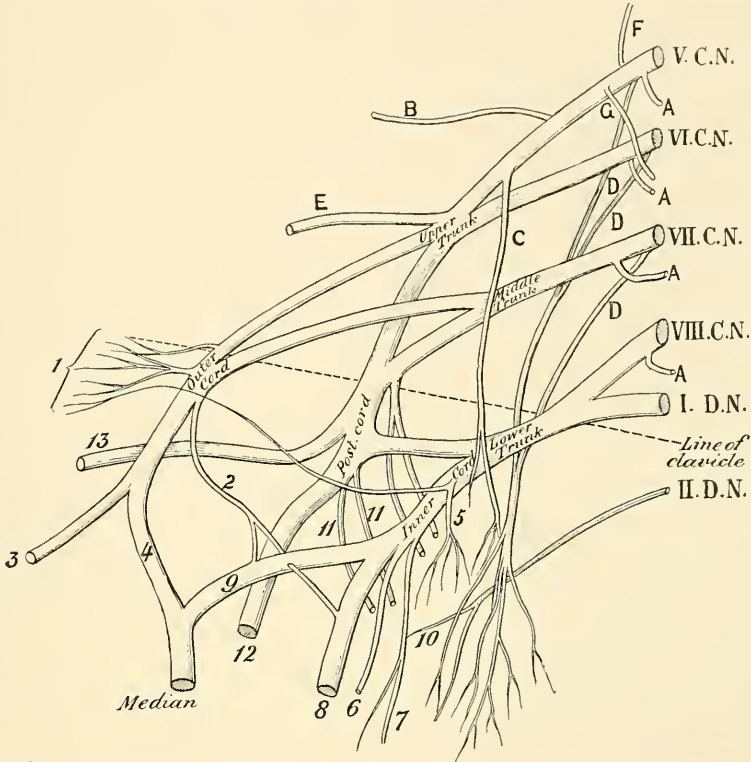
Fig. 144.—A Diagrammatic Scheme of the Brachial Plexus.   (After Harrison Allen.)

BRANCHES OF BRACHIAL PLEXUS.

Above Clavicle
- Muscular
  - A, Branches to Scaleni Longus Colli
  - B, To Rhomboidei
  - C, To Subclavius
  - D, To Serratus Magnus (Post. Thoracic Nerve) (External Respiratory Nerve of Bell)
  - E, To Supraspinalis a Infraspinalis—(Suprascapular N.)
- Communicating
  - F, From 4th Cervical Nerve
  - G, To Phrenic Nerve

H, One Subscapular Nerve

Below Clavicle
- From outer cord
  - 1, External Anterior Thoracic
  - 2, Communicating to Inner Cord
  - 3, Musculo-cutaneous
  - 4, Outer Head of Median
- From inner cord
  - 5, Internal Anterior Thoracic
  - 6, Internal Cutaneous
  - 7, Lesser int. Cutaneous (Wrisberg)
  - 8, Ulnar
  - 9, Inner Head of Median
  - 10, Communicating with Intercosto-humeral
- From posterior cord
  - 11, Two Subscapular Nerves
  - 12, Musculo-spiral
  - 13, Circumflex

intradurally the roots of the brachial plexus for septic paralysis and athetoid movements, an operation which should be performed, of course, only in intractable cases after other operations have failed.

Circumflex Nerve.—The circumflex supplies the delto-teres minor, the third head of the triceps, and the skin of the arm over the deltoid and shoulder. A branch which possesses a gangliform enlargement supplies the posterior border of the deltoid and teres minor. A cutaneous branch passes between the posterior border of the deltoid and the long head of the triceps.

The circumflex nerve is frequently contused by direct blows upon the outer part of the shoulder, the result being a deltoid paralysis. If the nerve is simply contused, it may recover its functions if it be treated first by rest, until the tenderness has passed away, then by gentle massage, electricity, regulated muscular movements, etc. If no improvement occurs and the atrophy is marked, the nerve may be cut down upon at its most superficial point below the acromion and the divided ends united. As the nerve is small, it is difficult to secure union if retraction has taken place.

Musculo-Cutaneous Nerve.—The external cutaneous perforates the coraco-brachialis muscle, while the internal cutaneous lies at the inner side of the median nerve. Incision should be made along the inner border of the coraco-brachialis muscle, and the nerve will be found at its outer border; it pierces the brachial fascia between the supinator longus and the biceps tendons, and sends its anterior and posterior cutaneous branches downward along the side of the tendon of the former muscle to the wrist. This nerve supplies the coraco-brachialis, the biceps, and the brachialis muscles.

Musculo-Spiral Nerve.—The musculo-spiral lies so close to the humerus that it is readily contused and also frequently torn or punctured, or involved in the callus that develops after a fracture of this bone. It is also a nerve that is very frequently injured by pressure upon the operating table during anæsthesia, or squeezed by the too-long-continued pressure of an Esmarch tourniquet. Dorsal arm anæsthesia with atrophic changes may also result from such pressure. This nerve is frequently injured in fractures in the upper or median portion of the humerus, which fact, together with the cutting-off of the nutrient artery, is the chief cause of non-union so frequently seen in this particular region. In compound fractures the nerve, if it should have been divided, should always be sought out and sutured. Secondary suturing with freeing of the nerve from the cicatrix is helpful, and, in cases of complete loss of power, nerve transplantation may be practised, a slip from the median being fixed to the distal end.

In paralysis of the musculo-spiral with contraction of the hand, nerve transplantation may be practised even in the arm or in the forearm.

In injuries to this nerve resulting from a compound fracture or from a wound, the nerve should be searched for and the divided ends united, or the nerve may be deliberately reached by an incision made at the point where it passes around the arm. This nerve, which in the upper arm lies posterior to the humerus, can be reached by an incision carried downward from the posterior axillary fold into the space between the outer and the long head of the triceps. These

heads should be separated and the nerve sought for at the point where it leaves the long head, its position being then between the inner and outer heads, with the profunda artery lying in front. At a point midway between the external condyle and the insertion of the deltoid it may be reached on a line joining these two points. The external tendinous head of the triceps should be located, and, by separating the fibres of the brachialis, the nerve can be both felt and seen, since it lies close to the bone with the profunda artery on the outer side, while behind it lies the musculo-cutaneous nerve running to the back part of the forearm. Paralysis of the musculo-spiral is indicated by wrist-drop, due to muscular paralysis and atrophy of the extensors with contraction of the flexors.

The combined musculo-spiral and radial nerve supplies the triceps, the supinator longus and brevis, the extensor carpi radialis longior and brevior, the extensor communis digitorum, the extensor carpi ulnaris, the extensor longus pollicis, the extensor brevis pollicis, and the extensor indicis, and is the sensory nerve to the dorsum of the hand and the fingers. The radial, its termination, has a superficial sensory branch which lies to the radial side of the artery and passes to the dorsum of the hand beneath the supinator longus. Its deep branch lies beneath the extensor carpi radialis longior. Loss of sensation will be marked on the outer side of the arm and the dorsum of the forearm, on the radial side. This nerve supplies especially the extensors and supinators of the forearm and wrist as well as the fingers and thumb. Injury to the nerve causes loss of power to extend the elbow, wrist, and first phalanges of the fingers. It should be remembered that supination is partially accomplished by the biceps, so that this action will not be lost unless some injury has been inflicted on those branches of the musculo-cutaneous nerve which supply this muscle. Wrist-drop in these cases will be excessive. Paralysis of sensation will be most profound upon the outside of the arm, upon the dorsum of the forearm (on the radial side in the upper and middle thirds), upon the dorsum of the thumb, index and middle fingers, and upon the dorsum of the metacarpal region on the radial side.

The nerve may be reached below the elbow by an incision made between the brachio-radialis muscle and the extensor communis. By drawing the muscles aside the nerve can be found as it emerges from the oblique fibres of the supinator radii brevis. The posterior interosseous nerve lies lower down. The radialis lies beneath the supinator longus and divides into two branches on the outer side of the brachial artery. At the lower border of the supinator longus the cephalic vein should be avoided. The musculo-cutaneous nerves lie to the outer side of the biceps tendon.

Median Nerve.—The median nerve is subject to the same injuries as the musculo-spiral. It lies in the arm along the inner border of the biceps; in the upper half it is to the outer side of the artery, then passes in front and to the inner side. It can be reached for suturing, stretching, or transplantation by the

same incision as that employed for the ligation of the brachial artery along the inner border of the biceps. In the forearm the median nerve lies to the outer side of the pronator radii teres and to the ulnar side of the artery. In the upper third of the forearm it can be reached by an incision between the supinator longus and the flexor carpi radialis. The radial artery should be located and, after the pronator teres has been divided, the nerve will be found on the ulnar side of the latter muscle. The nerve then pierces the flexor sublimis and, in the middle of the forearm, it may be reached by an incision between the flexor carpi radialis and the palmaris longus. The nerve lies beneath the flexor sublimis, which muscle must be turned aside. At the wrist the nerve lies to the radial side of palmaris longus between the tendons of the flexor sublimis. The median supplies the pronators, all the flexors (except the flexor carpi ulnaris and the ulnar portion of the flexor profundus digitorum), the adductor pollicis, the flexor brevis (except the inner side), the opponens pollicis and the lumbricales—practically, nearly all the flexors of the fingers and thumb. It is also the sensory nerve of the radial portion of nearly all the palm and all the inner surface of the fingers, except the little finger and half of the ring finger.

In paralysis of the median the thumb and little finger cannot be brought against each other. Flexion of the phalanges, especially of the second and third, will be impaired, and sensory changes will be evident in the radial half of the palm and in the palmar surface of the thumb, index and middle fingers, and the radial half of the ring finger. The median nerve supplies a large area of the hand. I have elsewhere reported the loss of eight inches of the median nerve by a lacerated wound, with an almost complete restoration of both motion and sensation ten years later, chiefly by the vicarious action of other nerve filaments. The transplantation of the branches of the median and ulnar is discussed in the section relating to operative procedures (page 493 *et seq.*).

Ulnar Nerve.—The ulnar nerve supplies sensation to the palmar aspect of the little finger and outer half of the ring finger. It supplies the flexor carpi ulnaris, most of the flexor profundus, the adductor and short flexor of the thumb, the muscles of the ball of the little finger, the two inner lumbricales, and the interossei. The loss of ulnar power produces inability to flex the first phalanges, also to extend the second and third phalanges, and it produces the claw-hand deformity; that is, the first phalanges are extended and the second and third are flexed. In persistent paralysis there is great atrophy of the muscles on the ulnar side—viz., the ball of the little finger, the interossei, the flexor muscles of the distal two phalanges, and the extensors of the first phalanges—together with other trophic changes.

The ulnar nerve, lying very superficially at the bend of the elbow, is frequently contused and often very seriously injured in fractures about this joint. In its course through the upper arm it may be reached along the

inner border of the biceps. In fractures of the elbow it is often injured behind the internal condyle. In the forearm it may be reached by a deep incision between the superficial and deep flexors and lower down on the median side of the flexor carpi ulnaris. Wounds of the ulnar and radial or their branches in the hand are very common, and if the nerves are not immediately reunited paralysis and subsequent atrophy are likely to follow. In a case of injury of the ulnar nerve inflicted with suicidal intent, I was able to restore both sensation and motion by a suture of the nerve and tendons many months afterward.

Ilio-Hypogastric, Ilio-Inguinal, External Cutaneous, and Genito-Crural Nerves.—The frequency of appendiceal, hernial, and kidney operations renders injury of these nerves of more than passing importance, and consequently their anatomical distribution should receive full consideration. The course of the ilio-hypogastric is usually along the border of the quadratus lumborum, and if it should be wounded in kidney operations the resulting damage may give rise to anæsthesia, but it is also frequently followed by pain along its distribution, more especially if the nerve has been included in a ligature and not divided.

The ilio-inguinal and genito-crural nerves are also frequently injured during hernial or spermatic-cord operations. The infliction of such an injury should be avoided as far as possible, as neuralgia of the testicle is an exceedingly annoying affection, sometimes requiring, for its relief, a search for the nerve and suturing, or even, at times, neurectomy or avulsion. Castration should not be performed until one of the less serious operations has been tested. In appendiceal operations which are performed in the interval between two attacks of appendicitis, and in which consequently the steps can be deliberately planned, the abdominal filaments of the ilio-inguinal, the hypogastric, and the external cutaneous nerves should be carefully avoided, as many patients complain of the loss of sensation resulting from section of these nerves. In the operative measures necessitated by acute and suppurative appendicitic conditions, the seriousness of the situation demands a larger incision; and consequently atrophy of muscular fibres and a condition of weakness of the abdominal wall, either with or without a positive hernia, are likely to result and to give the patient not a little subsequent discomfort. Of course, it is, in many cases, impossible to prevent this, but such results should be anticipated and avoided when practicable.

Anterior Crural Nerve.—This nerve is liable to injury by razor, gunshot, or other wounds. It may be reached through the incision and at once sutured, or it may be deliberately exposed by a longitudinal incision carried downward from the middle of Poupart's ligament, the nerve lying three-quarters of an inch external to the femoral artery. Its chief branch, the long saphenous, closely follows the femoral artery. Section of this nerve will cause loss of power in the quadriceps, sartorius, pectineus, and other muscles in

the front of the thigh, with paralysis of sensation on the inner side of both thigh and leg.

Internal Saphenous Nerve.—This nerve, a branch of the anterior crural, lies at the posterior margin of the sartorius muscle and behind the internal saphenous vein, opposite the tuberosity of the tibia and close to the internal malleolus, supplying finally the skin on the inner border of the foot and the great toe.

Sciatic Nerve.—The sciatic nerve is frequently involved in wounds and subjected to pressure from new growths. Sciatic neuralgia will receive consideration in another part of this work.

The sciatic nerve can be reached for operation at the lower edge of the gluteus maximus, midway between the tuberosity of the ischium and the great trochanter of the femur. The nerve will be partially covered by the gluteus and the biceps muscles. In the popliteal space one or two trunks will be found, depending upon a high or low division into the tibial and peroneal nerves. The injured nerve trunk may require suturing, stretching, avulsion, or transplantation, according to the nature of the injury.

In very painful conditions of the sciatic, that resist all other forms of operations, avulsion of the nerve should be performed, or the posterior nerve roots in the lumbar and sacral portions of the cord may be reached by laminectomy and resection of one-half inch of these roots performed. Such a course obviously results in serious impairment of the limb and should be undertaken only as a last resort. The x-ray may also be employed.

Peroneal Nerve.—The peroneal or external popliteal nerve, lying just inside the tendon of the biceps at the bend of the knee, is especially liable to section in a subcutaneous tenotomy of this tendon. With our present antiseptic methods an open incision is far preferable when such a tenotomy is required for the straightening of a contracted knee, especially as in old cases the bands of contracted fascia are not easily distinguishable and extensive division is therefore often necessary. The slanting incision across the popliteal space adds greatly to the safety of dividing these structures. Paralysis of the muscles of the front of the leg, with foot-drop, will follow such an accidental division of the nerve. Hence, the divided nerve should be immediately sutured as soon as the accident is discovered. Anastomosis may be made in the popliteal space, or the nerve may be secured a little lower down as it enters the groove between the biceps and the outer head of the gastrocnemius near the head of the fibula. The incision should be made along the lower border of the biceps tendon, and the nerve sutured before it pierces the origin of the peroneus longus, an inch and a half below the styloid process of the fibula.

Anterior Tibial Nerve.—The anterior tibial, the continuation of the peroneal nerve, may be reached, for transplantation or for suturing, as it passes around the head of the fibula, or it may be exposed lower down in the groove

between the tibialis anticus and the extensor longus digitorum. In the deeper portion the nerve lies between the tibialis anticus and the extensor proprius pollicis. The anterior tibial passes through the substance of the peroneus longus, beneath the extensor longus digitorum, to the outer side of the anterior tibial artery. In common with the musculo-cutaneous and the saphenous nerves, it supplies the external muscles in the front of the leg, the peroneus longus, and the skin of the dorsum of the foot.

Musculo-Cutaneous Nerve.—This nerve, a branch of the peroneal behind the head of the fibula, pierces the deep fascia on the outer side of the leg about the middle, supplies the peroneus longus and brevis, and terminates in the skin of the dorsum of the foot. It can be secured at the outer anterior face of the leg below the middle by an incision upon a line drawn from the front of the head of the fibula to the posterior border of the external malleolus.

The internal popliteal nerve lies to the outer side of the popliteal vessels and supplies the gastrocnemius, the soleus, and the popliteus.

Posterior Tibial Nerve.—This nerve is a continuation of the internal popliteal and supplies the gastrocnemius, the soleus, and the popliteal. In its upper portion this nerve lies very deeply, but if wounded by incisions or lacerations it should be reached by cutting away the attachments of the soleus, and then should be immediately sutured. It lies in close relation to the artery of the same name. Behind the internal malleolus it is easily reached for any operative procedure required, as it lies close to the border of the tendo Achillis. This nerve supplies the popliteus, the tibialis posticus, the soleus, the flexor longus digitorum, and the flexor longus hallucis, and terminates in the external and internal plantar nerves.

II. INFANTILE SPINAL PARALYSIS, OR ACUTE ANTERIOR POLIOMYELITIS.

Definition.—A form of paralysis occurring in early life, usually suddenly, affecting one or more groups of muscles, followed by atrophy, and later by the production of many deformities from contractions.

ETIOLOGY.

The cause of this form of paralysis seems to be clearly microbic. In this apparently epidemic form, in which considerable numbers of children are seized in a certain locality, such bacillary infection would seem probable, the disease occurring in healthy children without warning. At other times it follows cholera infantum, scarlet fever, or some other infectious disease. The fact that a large number of cases of infantile paralysis follow the digestive disturbances of children during the summer renders it extremely probable that there

has developed, during the course of the original disorder, a toxin which ultimately lodges in the spinal cord and renders it liable to inflammation. The disease is observed frequently during the period of first dentition. Sudden chilling by cold is a probable predisposing cause, as small children very frequently sit upon damp ground. Occasionally the disease begins with convulsions. It is a disease of both rich and poor and is specially common at the age when children are most active.

PATHOLOGY.

While the seat of the difficulty in the anterior cornua of the spinal cord has been long since proven, the exact reason for the location of the disease in this particular region has not even yet been ascertained. Spiller and other observers, however, have demonstrated that the primary lesion is in the gray matter of the anterior cornua and in the large multipolar cells. The anterior cornua being the most vascular part of the cord, it is in its blood-vessels that the cause for the inflammatory process has been sought. If it is in reality a microbe, it may be that this increased vascularity acts, as does the excessive vascularity of bone epiphyses, in determining the particular locality in the cord where these organisms shall display their activity. As the proliferation of the cells subsides, local degeneration and slow absorption take place, followed by destruction of the nerve cells with changes in the peripheral nerve branches. As the condition becomes permanent the muscles atrophy slowly, muscular fibrils being replaced by fatty globules, with an increase in connective tissue. When one group of muscles is paralyzed, the opposing muscles, having no proper force for maintaining equilibrium, become more and more contracted, thus producing deformity of various grades. Bone atrophy and shortening are common late results.

SYMPTOMS.

In the acute form of the disease the first symptom noted may be a total paralysis of one or more limbs, occurring in a single night and possibly preceded by slight restlessness and fever. In other cases this initial process may cover a period of a few days or it may follow digestive disturbances or any of the eruptive or debilitating diseases. The paralysis in a young child moderately ill may not be noticed by the mother for several days. Convulsions sometimes occur, but only rarely. Pain and tenderness of the affected muscles are quite constant symptoms during the first few days. The child may occasionally be delirious, but is more often drowsy. The first positive symptom is the loss of power. This may be confined to one group of muscles, or it may involve the entire limb, or, when the focus of disease is in the cervical and lumbar regions, both arms and legs may be involved. As a rule, the arms are the first to

recover their power as absorption progresses. Loss of power is usually immediate and is ordinarily greater at the onset than at any subsequent time, except in those cases in which the area that has been damaged in the cord is large and the alterations are of an irreparable nature. The anterior tibial and peroneal groups of muscles are most frequently affected. The calf muscles stand next in order of frequency, and next to these in turn comes the quadriceps femoris. Paralysis of the sphincters of the bladder and rectum is rare. The acute primary stage is followed by one of slow improvement in which a few muscles gradually regain their power, until at last certain groups will remain stationary and so continue for life. During the sensitive stage, a low degree of multiple neuritis exists and the hyperæsthesia is marked. This usually disappears speedily, but the evidences of impaired circulation and nutrition are soon evident. The circulation is sluggish, the limb is often dusky or purple in color, cold, and easily excoriated. In this early stage the response to electrical excitation by the continued current may at first be slightly increased, but it gradually lessens; by the application of the galvanic current the reaction of degeneration is secured. After six months or a year the disease may be said to have reached its chronic stage, and permanent atrophy of the muscles may be anticipated. Paralysis of sensation practically never occurs.

Diagnosis.

The diagnosis in typical cases, after the paralysis appears, is not difficult, but in certain forms of the disease the paralysis may resemble that which follows one of the acute cerebral palsies. Infantile spinal palsy is usually sudden in its onset; it is a paralysis of motion, not of sensation; and the tenderness disappears quickly. Antecedent convulsions are the exception and delirium is unusual. Later, the muscles undergo atrophy, the reflexes are lost or diminished, and deformity from unequal muscular action is common. These symptoms differ widely from the spastic conditions seen in cerebral paralysis, in which disease the reflexes are exaggerated, rigidity is common, and the intellect is often impaired. In the later stages, if the patient is examined entirely naked, the atrophy and the contractures will differ so decidedly from those of cerebro-spastic and other palsies that the differences will be readily noted. In the tardy development of rachitis the general weakness of all the muscles, including those of the trunk, will usually be sufficient to indicate the character of the disease. In acute transverse myelitis there will be loss of sensation as well as of motion. Hip-joint disease and congenital dislocation of the hip have their own definite symptoms. The diagnostic application of electricity is important. Electric excitability in the first few days may be excessive, but after this time slight response can be elicited by the faradic current.

Prognosis.

If, after several weeks, only a partial and diminishing reaction of degeneration is obtained, it is permissible to give a favorable prognosis, whereas, if this re-action of degeneration persists, the outlook for improvement is much less favor-able. If no response can be elicited, a very long course of treatment will be required, with the possibility of complete atrophy in the end. In the case of the muscles which are found to be completely paralyzed and atrophied after the lapse of six months, loss of power is likely to be permanent; but, so long as there is even a slight electrical or voluntary response, the case should not be abandoned. At the onset the prognosis of at least partial improvement always conveys hope, and it is permissible to make such a prognosis if a definite course of treatment is immediately instituted. Paralysis rarely increases after the first few days; it ordinarily diminishes. Complete recovery of all muscles is rare, but improvement is the rule.

Treatment.

Treatment has a decided influence upon the results of the lesions of the cord, although it can have no material influence upon the lesions themselves. During the acute and painful stage rest is to be observed. As soon as the paralysis is discovered, dry cups should be applied to the spine, at either the lumbar or the cervical region, in order to prevent further congestion. All causes of irrita-tion should be removed if possible, and ergot should be administered internally. Strychnine is contra-indicated. As soon, however, as the muscular tenderness passes away, very gentle manual massage and the use of electricity should be instituted, for the purpose of maintaining as far as possible the nutrition of the muscles. Massage should be given if possible by a skilled manipulator, but, in cases in which the expense is too great, rubbing and kneading with cocoanut or olive oil will be very helpful. Systematic massage by stroking, friction, knead-ing, percussion, etc., should be continued for a long period of time. If improve-ment is but slight at the end of a year, it should still be continued for another year at least before efforts at restoration are abandoned, especially if the muscles retain either voluntary or electric contractility. Vibratory and mechanical massage and voluntary movements of the limb in a well-equipped orthopedic gymnasium are of the greatest service, and every possible effort should be made to revive the muscle activity. Mild faradism should be commenced as soon as tenderness has disappeared, and should be continued for many months; if it fails to produce contraction, galvanism may be substituted. The voluntary use of the affected limb should be encouraged at as early a period as possible; at the same time, means for preventing deformity should be employed.

Mechanical Appliances.—While the employment of apparatus is to a cer-

tain extent detrimental, by reason of its weight and especially because it constricts the limb and exerts pressure upon muscles, yet in many instances its employment is imperative, especially when the unequal power of the muscles is rapidly deforming the limb.   This deformation is especially liable to occur at the ankle and knee joints; back-knee, with progressive elongation of the posterior ligament of the joint, being exceedingly common in paralysis of the quadriceps.   This deformity, especially when it is associated with change in the shape of the articulating surfaces, is one which is exceedingly difficult to cure by any surgical measure.   In-knee and out-knee can be corrected, but genu recurvatum can be cured only by arthrodesis.   An apparatus with stop-joint, limiting the degree of knee extension, is, however, helpful.

In flail-legs, the position of the child upon the floor is very liable to produce, in the neck and head of the femur, distortions which greatly interfere with locomotion.   Contraction of the tensor vaginæ femoris and of the rectus and sartorius may also take place.   These contractions should also be prevented, if possible, by continuous stretchings of the tissues and by the employment of mechanical apparatus.   At the ankle, support should be given, when necessary, for the purpose of preventing either outward or inward deviation; *i.e.*, it should be applied to the outer malleolus or tarsus in cases of varus and to the inner side of the ankle in cases of valgus.   The paralyzed muscles should be assisted by elastic straps or springs arranged so as to restore as far as possible the balance of power.   Inequality in the length of the limbs should be corrected by cork elevations, in order to prevent lateral curvature of the spine.   Close and constant supervision will be necessary to prevent the occurrence of these deformities.

Operative Measures.—When the contracture is persistent and has not been prevented by the measures employed, an operation becomes necessary. At the ankle, which is the most common situation of deformity, tenotomy or myotomy of all the contracted tissues should be employed.   In cases of acquired or paralytic equino-varus that have been neglected, it is frequently necessary to divide not only the tendo Achillis but also the posterior and anterior tibial tendons, together with the contracted plantar fascia.   Forcible correction should then be employed, and should be followed by fixation of the foot in a plaster-of-Paris cast which has been allowed to stiffen in a position of over-correction.   This cast may be removed at the end of three or four weeks and an apparatus applied which shall correct any remaining deformity and continue the improvement already gained.   Manipulation with the hands and massage are essential for a long period of time.   The patient must not be dismissed until he can walk easily upon the sole of the foot.   When the fascia upon the inner side of the foot is densely contracted and the tendons are shortened, an open section, commonly known as the Phelps operation, should be made, everything being divided that interferes with straightening of the foot.   The gaping wound must be left to heal by granulation, with the foot fixed in its normal position

for a long period of time. In valgus, tenotomy of the peroneal, combined with shortening of the tendon of the anterior tibial, is frequently required. The latter tendon may be cut down upon, shortened, and sutured while the limb is held in the varus position; or the insertion of the tendon may be dissected off from the scaphoid and internal cuneiform and attached lower down beneath the sole of the foot; or, finally, an opening may be bored through the scaphoid and the tendon carried through this opening and stitched to the periosteum of the plantar surface.

Astragalectomy.—In severe and neglected cases the distortion of the tarsal bones may be so great that the corrected position cannot be secured by multiple tenotomies and myotomies, or even by the open incision upon the contracted side. In these cases the removal of the astragalus should be performed. This operation—termed astragalectomy—necessitates an incision that should commence below the malleolus, in order that the cicatrix shall not lie over the superficial tip of the bone. This incision is to be carried forward in such manner as to avoid the peroneal tendon and the extensor of the little toe. If the dissection is carried close to the bone and the tendons and vessels are turned inward, no important structure need be divided. The ligaments between the astragalus, the scaphoid, the calcaneum, and the tibia and fibula are reached by short cuts with the knife, which should be kept close to the periosteum. If the bone is grasped with forceps it can be turned from side to side, but care must be exercised when the inner side is reached lest the posterior tibial artery be wounded at the point where it becomes the internal plantar. Great force will often be required, even after this operation has been performed, to stretch the contracted fascia upon the inner side of the foot. This can be usually accomplished by strong manual pressure applied over a wooden fulcrum. The tibialis posticus and the tendo Achillis may require tenotomy. While the application of an Esmarch bandage facilitates this operation, yet the danger of compressing the already enfeebled nerves is so great as to render it more advantageous not to employ the bandage. No large vessels should be divided, but the oozing will usually be sufficient to require gauze drainage. Catgut or silkworm-gut sutures are employed in closing the wound, and, if the work has been done in a thoroughly aseptic manner, the wound will not need to be disturbed for two weeks. Gypsum bandages will hold the foot in an over-corrected position. The plaster casts can be carefully removed at the end of two weeks, the packing taken out, and fresh aseptic gauze applied; after which the dressings need not be further disturbed for several weeks. The patient may walk upon his casts in the fourth week; voluntary and involuntary movements should be instituted early, in order that a movable joint may be secured, with the foot flat upon the sole, and also that apparatus may be dispensed with, at least after the first year. Locomotion is usually better than after tendon transplantation.

Arthrodesis.—In severe cases of extremely flexible joint, associated with loss of power of all the muscles about the ankle, a permanent ankylosis of the joint is desirable in order to prevent the necessity for the use of apparatus for life. This may be accomplished by opening the ankle joint upon either side by longitudinal incisions and then paring the cartilage from the astragalus and also from the articular facets of the tibia and fibula, in order that the opposing raw surfaces of these bones may contract a solid union. The wound should be closed without drainage and the ankle fixed at right angles to the leg for a period of ten weeks; after which the child may be allowed to walk about upon the cast. Later, an apparatus with a stiff ankle joint should be applied, and it should be worn by the child until firm consolidation has been secured; after which it may be dispensed with.

Amputation may occasionally be required, but only in extreme cases of deformity.

After-Treatment.—It must not be considered that a case of paralytic deformity has been cured by operation, even if this should result in placing the limb in a straight position. It will be necessary, afterward, to employ massage, electricity, forcible straightening and manipulation, gymnastic exercises, voluntary or involuntary motions, and such mechanical appliance as will re-establish and facilitate locomotion. It should be remembered that the best of all gymnastics for the individual will be found in the exercise of walking and running, and no pains should be spared to secure for the child this form of exercise. Apparatus that will give support to the weakened members should be provided. It often happens that a helpless case must first be taught to walk, after operation, by being supported by an overhead trolley with jacket, by supporting crutches, by canes, by lock-joints or stop-joints, by pads, by elastic straps, or by springs, any or all of which measures, if progressively and accurately applied, will ultimately—perhaps only after a lapse of months—put the patient in a condition favorable for self-locomotion; after which each day will show a steady improvement. Hundreds of these cases of deformities following infantile paralysis are neglected, and are permitted to become helpless cripples, through the failure of surgeons to apply the proper surgical and mechanical measures. There are very few cases, except those of absolute flail-leg, which cannot be ultimately made to walk. It is the duty of surgeons to give to these cases this needed attention. Usually the skilled orthopedic surgeon will accomplish this better than the general surgeon, since the former will apply both surgical and mechanical means of relief.

The Knee.—In contractures of the knee it is always advisable to do the open operation upon the biceps tendon, as the peroneal nerve lies so close that it is liable to be injured in a subcutaneous tenotomy. The internal hamstrings may be divided either by the open method or subcutaneously, according to the pleasure of the surgeon. In old cases the greatest difficulty will arise from the

shortened bands of fascia, which will require cautious division when they extend to the median line. The popliteal artery, vein, and nerve are preternaturally shortened and the forcible straightening after tenotomies must not be carried out too rigidly, lest rupture of the structures occur. Slow and patient pressure will usually acomplish the purpose without injury to their calibre. Only once have I caused an aneurism by manipulations of this kind. In young subjects, the hands of the surgeon, aided by a sandbag or by a wooden fulcrum, should be sufficient, the leverage wrenches so commonly used being dangerous to the integrity of the tissues. A posterior dislocation of the knee may readily be pro-. duced unless caution is exercised. After the operation the limb should be fixed in the straight position by means of a plaster-of-Paris dressing for six or eight weeks; after which an apparatus with either locked or stop-knee joint may be applied, as may seem necessary.

When the flexion at the knee has been of long standing and has commenced early in life, the anterior portion of the condyles may have become so elongated that the straight position of the knee cannot be secured without resection even after a tenotomy of the hamstring tendons has been performed.

Forcible straightening will accomplish much if the contractions are only fascial, but, when the deformity is due to alterations in the bony structures, a resection of the knee may be necessary.

If there is extreme paralysis (a flail-leg), permanent ankylosis of the knee may prevent permanent wearing of apparatus. In extreme back-knee, *excision* or *arthrodesis* to secure permanent ankylosis is helpful.

In extreme cases of in-knee, the result of malposition or of excessive contraction of the biceps, an *osteotomy* of the femur above the condyles will bring the leg into line for locomotion.

In moderate contractures at the hip, the tensor vaginæ femoris, the long head of the rectus, and the sartorius may one or all require division, just beneath the anterior superior spinous process. In severe and long-continued cases the connective-tissue shortening may extend so close to the anterior crural nerve that an open incision is preferable. This nerve is the important structure to be avoided, as the constriction rarely extends as far inward as the femoral artery. In the open incision the myotomy and the forcible straightening of the limb frequently result in the production of so large an open space that primary union is difficult to secure, but, by careful deep suturing and by the aid of pressure, a closure may be effected. All the contracted tissues should be divided in such a manner that the limb may be brought well into the straight line.

Transplantation of Muscles and Tendons.—In paralysis of the quadriceps extensor muscle a positive gain has been secured by transplanting the biceps tendon, upon the outer side, and the semitendinosus, upon the inner side, into the muscular fibres of the quadriceps in the lower portion of the thigh, the semimembranosus being left to accomplish the work of flexion. The sartorius

and the gracilis tendons may be employed for the same purpose. The most common transplantation is that of a portion of the extensor proprius pollicis to the tibialis anticus. If the peroneal muscle has lost its power while the extensor communis digitorum is active, the tendon of the little toe may be attached to the former muscle. In paralytic equino-varus the tendons that specially require division are those of the tibialis anticus and the tibialis posticus, the tendo Achillis, and the plantar fascia; in valgus the tendons of the peroneals should be divided and subsequently the foot should be forcibly adducted and then fixed in that position.

Tenoplasty; Tendon Transplantation and Shortening.—In the paralyses following infantile spinal paralysis, with relaxation and consequent elongation of the muscles, permitting contraction of the opposing group, shortening of the tendons of the defective muscles is frequently required after tenotomy of the contractured tendons, in order to bring the limb into a straight line for locomotion. Tendon shortening is also necessitated in many cases of hemiplegia, birth palsy, etc., of the arm, chiefly for cosmetic reasons, but it may also assist in giving a certain amount of voluntary finger or hand motion. The operation is performed by cutting down upon the tendon, slitting its sheath, dividing the tendon itself in an oblique direction, removing a section of it sufficiently long to bring the limb to the proper position, and then suturing the oblique overlapping raw surfaces together by means of carbolized silk, chromicized gut, kangaroo tendon, or celluloid thread. Several sutures will be required, and the sheath, especially in a large tendon like the tendo Achillis, should be separately sutured. Finally, the wound in the skin may be closed with catgut. Some surgeons perform a mortise-like incision in a large tendon, but it has no special advantage over other methods. In small tendons the portions which afterward become the divided ends should be secured before the division is actually made, lest retraction carry them out of the line of vision and prolong the operation. This is of special importance in the tendons of the fingers and forearms. It is also important that hæmostatic forceps should not be kept too long in position, lest the vitality of the tendon be injured by the compression. Folding or pleating of the tendon is of no advantage; on the contrary, it makes a larger lump in the skin and also does not present the two opposing raw surfaces which are furnished by an incision. The limb should always be dressed in the position best suited to secure relaxation of the sutured tendon; a plaster-of-Paris dressing being preferable. With catgut sutures in the skin, there would be no necessity for disturbing the wound for four or five weeks.

When the tibials are at fault, as in talipes valgus, and the extensors of the toe are capable of action, it is often possible to transfer one or more slips of the extensor tendons, or even the tendon of the peroneal, to the tibialis anticus tendon. The foot should be held in the position of varus during this transplantation, the suturing being best accomplished by passing the stronger tendon through a

slit in the weaker one and suturing it by chromicized gut or sterile silk. The foot should be fixed by plaster of Paris in the inverted position and kept in this position for six weeks, after which a supporting apparatus should be applied to maintain the corrected position.

Another method, which is practised chiefly upon the tibialis anticus in talipes valgus, consists in dividing the tendon at its insertion upon the scaphoid and internal cuneiform, and attaching it to the periosteum of the plantar surface of these bones; or, instead, a hole may be drilled through the scaphoid, and then the tendon, after it has been passed through this canal, should be attached to the bone upon its plantar surface, while the foot is held firmly in an inverted position.

The difficulty in severe cases is due to the fact that it is impossible to utilize the tendon of any muscle that has sufficient power to assist in correction. In talipes calcaneus, which is often associated with valgus, the tendo Achillis may be shortened to the extent of one or more inches by splitting its sheath, dividing the tendon obliquely, removing a segment, and passing several sutures of chromicized gut or celluloid thread first through the overlapping divided ends of the tendon and then separately through the opposing edges of the opening in the sheath. It is difficult to transplant advantageously to the tendo Achillis any other tendon except that of the peroneal or of the long flexor, but such transfers have often been made. Nerve transplantation is indicated if a vital nerve can be found in the immediate neighborhood. Various methods of tendon transplantation are illustrated by Figs. 92–104, page 419 *et seq.* of the present volume. The entire tendon of a sound muscle may be divided and its force transferred to the new work; or only one-half of the tendon may be borrowed. In calcaneus, the gastrocnemius is often practically useless. A certain amount of assistance may be gained by shortening its tendon (the tendo Achillis) and by transferring the peroneal tendon to its distal cut end; but the result is not certain. Nerve anastomosis is also of but slight benefit. When, however, the gastrocnemius is strong, a slip from the tendo Achillis may be transplanted with advantage to the extensors. In talipes equino-varus the tendon of the tibialis anticus can be attached to that of a feeble peroneal, or the tendon can be carried across and attached subperiosteally to the cuboid, on the outer side of the foot. The tendon of the sartorius, the gracilis, the semimembranosus, or the semitendinosus may be transferred to that of the vastus internus or into the patella. The tendon of the biceps can be transferred to that of the vastus externus or of the patella. Of course a considerable time will be required before intelligent control can be secured, but with education, massage, gymnastics, training, etc., much may be accomplished.

A slip from the tendo Achillis can be attached to the tendon of the peroneal muscle, and the tendon of the extensor proprius pollicis may be transferred to that of the tibialis anticus. Various supplementations of muscular action are

thus possible, provided some of the muscles retain their activity; unfortunately, in the majority of cases the paralysis is so extensive that borrowing is impossible.

A combination of tendon transplantation, nerve transplantation, and arthrodesis is often helpful.

Silver wire is occasionally used for suturing, but it has no special advantage over the absorbable ligature except that it is less liable to primary infection. When it is necessary to carry the tendon for a considerable distance across the limb—as, for instance, the extensor of the little toe to the tibialis anticus—a canal must be made through the connective tissue by hæmostats and the tendon drawn through the artificial canal. Accurate judgment and careful adaptation are necessary to secure exactly the proper length of new tendon, as ultimate success depends upon the proper amount of tension. The increase of muscular power that takes place subsequently to these operations is remarkable; patients who had previously been quite helpless often attain such a degree of strength that they are able to walk a distance of miles.

When transplantation is made to relieve the deformity of flexion of the wrist in hemiplegia, the tendons of the flexor carpi ulnaris and radialis may be borrowed from the anterior surface and carried across to be attached to the extensor tendons of the fingers on the back of the hand, the carpus being strongly extended while the suturing is being done. Split sections may be inserted into each of the individual tendons, or the two borrowed tendons may be attached to the bundle of extensors. Tenotomy of the flexor tendons may occasionally be required, and is justifiable when the hand is permanently flexed and useless, and also when the operation is performed simply for cosmetic effect. If the flexor tendons, however, still retain even slight power, it is better to do tendon splicing than to trust to subcutaneous tenotomy, since the tendons in front of the wrist do not unite as readily as in other parts of the body. In other cases, a careful dissection and myotomy of the flexor muscles at their origin from the internal condyle and in the upper forearm may be performed, the nerves and blood-vessels being carefully avoided.

Nerve Anastomosis; Nerve Transplantation; Neuroplasties.—While nerve transplantation has been practised for a considerable time, it is only recently that the procedure has assumed a definite place in the surgical treatment of paralysis and other nerve disorders. As an element in the assistance of weakened muscles in anterior poliomyelitis and in the paralyses following traumatism, it has now reached a stage when some positive benefit may be expected. The procedure is based upon the existence, in the neighborhood of the paralyzed muscles, of some nerve with fairly good transmitting power. Unfortunately, in a large proportion of cases the paralysis involves so many muscles that the entire limb is affected and no normal nerve remains from which even a slip can be borrowed. The most hopeful application of this therapeutic principle is in those cases in which one group of muscles only is seriously affected; the opposing

muscles, being unopposed, contract and cause deformities of various degrees. While these stronger muscles may not have even a normal amount of contractility, yet, as they overpower their opponents, the restoration of a balance or equilibrium of force will prove beneficial; it helps to transfer a portion of the nervous force supplied to them to the weakened group. When the peroneal group of muscles, for instance, is weakened, we find the anterior and posterior tibials constantly increasing the deformity at the ankle and foot. A transfer of a portion of the nervous power conveyed by the posterior tibial nerve to the peroneal muscle will therefore be of benefit. In the arm, where birth palsies and various paralyses result, the musculo-spiral is, as a rule, the nerve most commonly affected. Split sections from the ulnar or the median, or from both, may be advantageously transplanted so as to produce an increase of power in the weakened group of muscles, while the power of the opposing group is diminished. In confirmed cases, decided cosmetic and partial muscular gain may be accomplished by nerve anastomosis combined with tendon transplantation from the stronger muscles to the paralyzed group, by section or by plastic lengthening of the contracted tendons, or by myotomy. If operative interference fails, or if it is declined by the patient, an encasing apparatus, constructed either of leather or of celluloid or aluminum, and intended simply to hold the limb in position, may be applied to the forearm; or a more elaborate contrivance may be utilized— one in which there are elastic muscles and tendons running to the fingers through grooves upon the back of the appliance, and which is provided with a movable wrist joint and phalangeal parts.

Technique.

The most healthy available nerve should be selected. A section is split from the side in such a manner as to leave fibres enough for transmitting nerve force to the original muscle; or, under certain circumstances, an entire nerve may be utilized. Before cutting this slip of nerve fibres loose a loop stitch should be made in the sheath with a very fine round sewing-needle threaded with fine silk or fine chromicized gut or celluloid thread. A slit having then been made in the sheath of the paralyzed nerve, the graft is drawn across and inserted within the sheath alongside of the nerve itself, or the fibres of the affected nerve may be separated and the section intended for grafting inserted between the filaments. In this position the section is retained by suturing it to the sheath, tension being thus avoided. Oblique sutures are safer than cross-sutures, as constriction of nerve fibres would lead to degeneration.

In the division of a nerve a scalpel should always be employed; scissors are too blunt, and besides they are apt to contuse the nerve. The nerve should be handled as little as possible and it should never be pinched by hæmostats; it should be caught by its sheath only, and a fine suture should be inserted to

secure control. No provision for drainage is necessary, as prompt and primary union is essential. In the case of a mixed nerve, the transplantation of the entire trunk would improve both the motor power and that of sensation throughout a large area. In some instances, rapid restoration of function has been noticed; in others the restoration has been slow. In the latter case, it is impossible to determine whether the slowness is due to fresh transmission or to the vicarious action of other nerves.*

In Young's case † the incision was made downward from the head of the fibula, and just below the latter point the peroneal nerve was exposed. The fibres of the peroneus longus were then separated, exposing the distribution of this nerve. The tibialis anticus muscle was the one paralyzed, and, as this muscle is largely supplied by the musculo-cutaneous as well as by the anterior tibial nerve, the divided branches of the peroneal were inserted into the slit in the musculo-cutaneous and sutured there with fine formicized gut.‡

The tibialis anticus muscle is usually supplied by three small nerves before the division of the peroneal nerve into the anterior tibial and the musculo-cutaneous takes place.

Spitzy § gives many excellent directions in regard to the technique of neuroplasty; he also gives an account of his experiments in nerve regeneration. One of the operations which he has performed is that of establishing an anastomosis between the obturator nerve and the long saphenous branch of the anterior crural nerve.

Neuroplastic operations are to be recommended when the period of spontaneous regeneration has passed and other therapeutic measures have proved useless. The popliteal nerve may be transferred to the peroneal, or *vice versa*, behind the knee. In quadriceps paralysis the superficial branch of the obturator, at the point where it leaves the pelvis, can be implanted into the anterior crural, the anastomosis being made high up below Poupart's ligament.

Anastomosis of the nerves of the arm is often of the greatest advantage. A most careful neurological study of the innervation of each set of muscles is essential, before any attempt is made to transfer nerve filaments. (As the distribution of the nerves of the arm has been fully described on pages 479 and 480, a repetition of these details will not be necessary here. The proper lines for incision, etc., have also been mentioned in the same section.)

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* Zeitschrift für Orthop. Chir., Bd. 13, Heft 2.
† Young's " Orthop. Surg.," p. 198, edition of 1906.
‡ Amer. Jour. Orthop. Surg., August, 1904, vol. ii., No. 1; Jour. Nerv. and Ment. Dis., June, 1903, p. 369, Spiller.
§ Amer. Jour. Orthop. Surg., vol. ii., No. 1, August, 1904.

III. PARALYSIS FOLLOWING INJURIES.

Anæsthesia Paralysis.—Paralysis of the lower arm not infrequently follows the pressure upon the musculo-spiral, the median, or the ulnar nerve when the arm is allowed to hang over the edge of the table during the administration of an anæsthetic. The position of the arms, therefore, should receive careful attention from the anæsthetist, as these paralyses sometimes last for weeks and are very alarming to the patient and very discreditable to the surgeon. It should be remembered also that the toxic effect of the anæsthesia may be at least partly the cause of the paralysis.

Pressure on the shoulders in the Trendelenburg position during anæsthesia may also produce paralysis.

Prognosis and Treatment.—As the pressure has been but temporary, these cases usually recover under proper treatment. During the stage of neuritis the part should be kept at rest; afterward, massage, with active and passive muscular movements and electricity, should be carefully instituted.

Paralysis Following the Application of an Esmarch Bandage.—The tight pressure of an Esmarch tourniquet, if required for a long or even for a short period, makes the application of this method of hæmostasis undesirable when it can be avoided. Paralysis has not infrequently followed even short operations and such as were of slight importance. This danger should, therefore, always be remembered by the surgeon, as the loss of power may in some cases persist for months.

Paralysis from Ligation of a Nerve.—The accidental inclusion of a nerve within the ligature when an artery is tied may lead either to tetanus or to subsequent neuritis or paralysis. The more thorough isolation of blood-vessels now practised and the almost universal use of catgut ligatures have lessened the frequency of this form of paralysis.

Paralysis of Muscles from Loss of Nerves.—When a nerve is divided or injured, as during the removal of a tumor, loss of both power and sensation in the area supplied by it is likely to result. While immediate suturing of the divided ends of the nerve should be the rule, the fact of the speedy restoration of function, in some cases in which such suturing has not been done, shows that there must exist, in the human economy, some sort of provision for transmitting nerve impulses by other than the usual routes—something not unlike that which is furnished by the anastomosis of blood-vessels.

Crutch Paralysis.—Numbness and paralysis from the improper use of axillary crutches is not uncommon. The symptoms may come on slowly or rapidly. The musculo-spiral is the nerve most frequently involved. The prognosis is usually favorable, provided the patient shall avoid for a time the use of the crutch. The patient can soon learn to avoid any pressure in the axilla

by taking all the weight upon the cross-bar of the crutch with his hands. In young children who cannot be taught, perineal or ischiatic crutches can be utilized by means of a Thomas knee splint or by the employment of perineal straps with the Taylor brace for hip diseases. Pressure exerted upon the brachial plexus through dragging a child by the arm may also produce paralysis.

Paralysis Following Parturition.—The pressure of the child's head upon the pelvic nerves or the pressure of forceps occasionally yields a paralysis of considerable severity in the nerves of the lower extremity. The pain, loss of power, and sensory and motor disturbances may present themselves at once or they may come on at some later period, the interval being different in different cases. Foot-drop is the most common variety of paralysis, but the pain may be located in either the sciatic or the gluteal region or in that of the thigh. In another group of cases multiple neuritis develops as a result of a septic or toxic puerperal auto-infection. Mild cases may recover speedily, but the toxic and more severe ones often require long treatment, first by rest and afterward by massage, electricity, and anodyne applications. The prognosis will depend upon the fact whether the affected muscles do or do not manifest the reaction of degeneration.

Paralysis Due to Pressure from the Callus of a Fracture or from a Dislocation.—Complete or partial paralysis due either to entanglement of a nerve in the callus resulting from a fracture, or to a direct injury of the nerve at the time of the accident, or, as sometimes happens, to the too tight application of splints, may manifest itself in the muscles peripheral to the seat of the injury. Such a condition is always difficult to relieve; for, although it is often practicable to dissect the nerve out from its constricted environment—neurolysis,—yet the cicatricial contraction that follows the healing is very liable to reproduce the paralysis. This is best prevented by throwing over the nerve a band of fascia, or by inserting silver foil. The pressure of a dislocated bone upon the sciatic, the musculo-spiral, or some other nerve may be followed by complete or total loss of power, together with great pain. If reduction cannot be accomplished, an open incision, with or without resection of the head of the bone, should be practised.

Deltoid Paralysis.—A blow upon the outer side of the shoulder is not infrequently followed by a more or less complete paralysis of the deltoid, and at times this paralysis proves to be very obstinate. In these cases the nerve injured is the circumflex. During the painful stage the arm should be kept quiet, and warmth and anodyne mixtures should be applied to the part. Later, it will be found advantageous to employ massage, electricity, and gymnastics.

Birth Paralysis.—This is particularly apt to follow injuries of the brachial plexus, such injuries as may be inflicted by the fingers of the accoucheur, by steel hooks inserted into the axilla during the birth of the child, or by violent traction upon the arm. It is apt to prove very resistant to treatment, and is usually

accompanied by marked inversion of the upper arm, with extreme pronation of the forearm and hand. Deficient growth of the limb is another common result, and this most disabling deformity may continue throughout life.

Treatment.—During infancy, massage, together with gentle and rapid eversions of the forearm and arm, is requisite; later, these movements may be carried out more vigorously, and at the same time gymnastic exercises, and voluntary and involuntary movements, may be instituted. Among the available surgical measures may be mentioned open myotomy of the invertors of the humerus, section of the pectoralis major, and nerve transplantation in the shoulder or the arm, the choice between these measures depending upon the particular muscles involved. In the forearm, tenotomy or myotomy of the contracted muscles should be practised, and transplantation of tendons may be employed in such a manner as will afford assistance to the supinators. In some cases nerve transplantation, as described on a preceding page (p. 476), may prove of value. Benefit has also followed suturing of the fifth and sixth cervical nerves.*

Pressure Paralysis.—Pressure paralysis may be caused by sleeping upon the arm, by allowing the limb to lie for too long a time across a chair-back or across any hard body. A low form of neuritis may result, with loss of power.

Treatment.—Pressure paralysis which does not speedily recover, and which is dependent upon a removable cause, should be subjected to surgical interference. In traumatic cases the earlier the pressure is removed the sooner the nerve repair will occur and the better will be the prognosis.

Rest is the first indication in the painful stage of neuritis. Later, massage, electricity, voluntary and involuntary muscular movements, gymnastic exercises, etc., must be continued for a long period.

Nerve Dislocation.—The peroneal and ulnar nerves are the ones most likely to be thrown from their beds in fracture or injury about the ankle and elbow joints. As a rule, cutting down upon the nerve, and fastening it in its original position by a flap of periosteum or of strong fascia cut from the neighborhood, will prove serviceable.

IV. NEURITIS.

Hyperæmia, either of the sheath or of the substance of a nerve, may give rise to a series of symptoms varying in degree with the extent of the congestion and the character of the nerve implicated. In multiple neuritis the disease is located in various portions of the body, and is usually caused by toxins from infectious diseases, by metallic poisonings, by chronic alcoholism, or by extreme anæmia. Beriberi is an epidemic form of multiple neuritis, probably due to a special organism.

* British Medical Journal, October 22d, 1904. Kennedy.

Etiology.

Injury to a nerve is the most common cause of neuritis, but sudden exposure to wet or cold, some exhaustive illness, alcoholism, metallic poisons, etc., may also give rise to this disease. Other frequent causes are: the pressure of tumors, especially those of the malignant type, of a fracture callus, and of cicatricial contractions; joint disease; and constitutional conditions, such as rheumatism, gout, sepsis, etc.

Pathology.

The hyperæmia may be parenchymatous (in the substance of the nerve fibres), interstitial (in the sheath), or confined mainly to the connective-tissue surroundings. Lymphoid infiltration may take place in or around the sheath or between the bundles of nerve fibres themselves. The myelinic sheaths of the nerve fibrils become fragmented, the nuclei of the sheath of Schwann proliferate, and the axis cylinders degenerate.

Symptomatology.

When a sensory nerve is implicated, the pain is usually of an aching character, somewhat remittent in type, but not periodical to the same extent that is observed in neuralgia. The pain is rarely situated at the chief point of involvement, but is felt especially in the peripheral terminations, and may be darting itching, or tingling in character, especially at night. Numbness, great weakness, impaired nutrition, and trophic changes follow. Distal effects are often observed in cases of spinal caries or of tuberculous disease of the hip. In these cases pain in the abdomen, the knee, or the ankle, is quite frequently complained of, and yet on examination no evidence of local disease can be discovered in these regions. When a motor nerve is involved, twitching, spasm, or contraction of the muscle which it supplies is frequently observed, or there may be a partial or complete paralysis which finally results in atrophy or in a contracture. A common after-result of neuritis is one that creates great uneasiness or even alarm in the mind of the patient, giving rise to the impression that paralysis is imminent. I refer to the symptom of tingling or "going to sleep," a sensation similar to that which is experienced when a nerve is compressed. This sensation, which is not indicative of pressure paralysis, occurs most frequently in the night, or on waking, or it may be aroused by sewing or by writing. Ascending neuritis is accompanied by an increase of the symptoms, and if it reaches the spinal column it may induce myelitis. It is, however, very rare.

Trophic changes in the skin are a very common accompaniment of neuritis; they consist of the characteristic glossy appearance and of the various eruptions (Figs. 145, 146, and 147). The nails become irregular and curved through faulty

nutrition, and the secretions of the perspiratory glands are often either diminished or increased. In the area of distribution of the affected nerve there are often œdema and atrophy, and it is not an unusual occurrence for a neuritis to be followed by the formation of adhesions in, and the pouring out of an effusion into, an adjacent joint cavity. In multiple neuritis the alterations in motor, sensory, reflex, and trophic functions, due to the general toxæmia, are most marked. Multiple neuritis is most frequently found in chronic alcoholics.

Beriberi, or kakke, is caused by a bacillus which gains entrance to the alimentary canal in contaminated food or drink. The infection is confined chiefly to the pyloric end of the stomach and the duodenum. As a result of
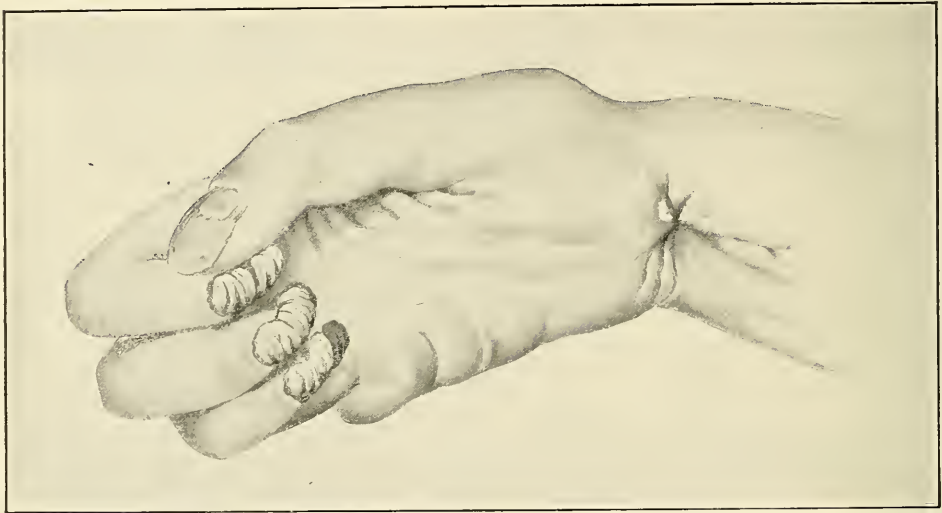
Fig. 145.—A Hand Showing Trophic Changes in the Nails and Swollen Ankylosed Joints after Injury to the Median Nerve at the Wrist. (A. A. Bowlby: " Injuries and Diseases of Nerves, and Their Surgical Treatment." London, 1889.)

the infection there is formed a toxin which affects the peripheral terminations of the fibres of the nerves, producing bilateral vasomotor paralysis, as well as both motor and sensory paralysis.

Diagnosis.

Acute anterior poliomyelitis in children is occasionally, at its outset, mistaken for acute peripheral neuritis, but the speedy loss of muscular power in the former, and the marked sensory symptoms in the latter, are the chief distinguishing points. It is sometimes very difficult to establish the diagnosis between chronic neuritis and neuralgia, especially as neuralgia is often but a symptom of neuritis. Neuralgic pains are more intermittent than those of a true neuritis; and, besides, the muscular spasm, paralysis, atrophy, and trophic changes are absent in neuralgia.

Prognosis.

The outcome is usually favorable, but one should always give a guarded prognosis, especially in the chronic cases and in the rare cases of ascending neuritis.
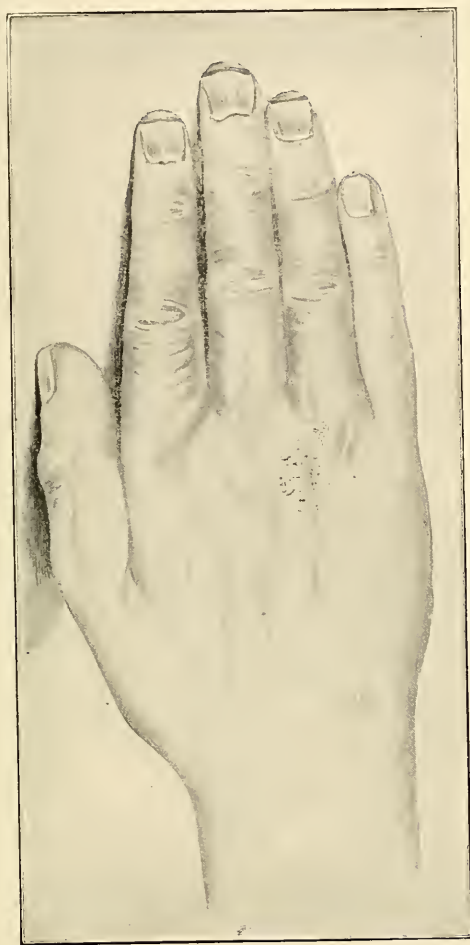
Fig. 146.—Normal Right Hand.   Fig. 147.—Affected Left Hand.

Figs. 146 and 147.—These figures show the difference between the two hands of the same patient nine months after section of the median nerve at the wrist. The left hand (Fig. 147) shows the glossy, shiny, and tightly stretched skin and the curved fibrous nails which are characteristic of nerve injury. (From A. A. Bowlby: "Injuries and Diseases of Nerves, and Their Surgical Treatment." London, 1889.)

Treatment.

Nearly all the methods employed for neuralgia, as already detailed in the section that treats of that disease, may be advantageously employed for neuritis. In all cases of neuritis it is important that the cause should be earnestly sought

for and removed, since the area of pain in a peripheral nerve may represent merely a phenomenon of reflection, while the real focus of the disease is centrally situated. Frequent illustrations of this fact are seen in the pains at the knee from hip disease; in the abdominal pains and the pains that extend down the thigh from spinal caries, etc. In the primary stage of a neuritis the two important elements in the treatment are rest and the application of heat. Splinting of the arm or leg, or the use of a sling, is of importance especially during the inflammatory stage. Either dry or moist heat may be employed, as may happen to be most convenient. The usual method is to envelop the part in cotton or lamb's wool, over which is spread waxed paper or oiled silk or rubber tissue: but in some instances hot poultices or the dry hot-air oven or the electrically heated pad will be found serviceable. Ethyl chloride may be sprayed upon the part to produce violent revulsion. Blisters and counter-irritation by chloroform or other stimulating liniments will relieve pain. After the acute symptoms have passed, gentle massage and the application of a weak galvanic current will be found helpful; faradism often increases the pain. In chronic neuritis the galvanic current of medium strength is most serviceable. The employment of the x-ray also sometimes proves beneficial. Hypodermic injections of strychnia, $\frac{1}{30}$ gr. twice daily, are often beneficial; and in obstinate cases a good result may sometimes be obtained from injections of the remedy directly into the sheath of the nerve. Chloroform and osmic acid in one-per-cent solution have both been employed hypodermically with benefit. Alcoholic neuritis is best treated by strychnine; the syphilitic form, by the ordinary constitutional treatment. Neuritis from metallic poisonings—such as arsenic, mercury, etc. —requires not only the removal of the cause, but also the elimination of the drug from the system. Endemic multiple neuritis or beriberi belongs rather to the domain of internal medicine.

Surgically, the freeing of an affected nerve from the pressure of a bone callus or from cicatricial contractions is a matter of prime importance. In order to reach a nerve embedded in callus it is often necessary to expose it above and below the point of compression and then cautiously to follow the fibres into the scar tissue.

In cicatrices following wounds, a portion of the nerve may have been obliterated; in which case secondary nerve suturing, grafting, or transplantation, as elsewhere described, should be practised. In trophic changes, also, some one of these operations may prove of decided benefit.

Exostoses and benign or malignant growths that cause pressure should be removed. Nerve stretching has not proven of much service.

In some cases where the compression of the nerve is marked, exposure of the nerve by incision, and the forcible injection of saline solution between the sheath and the nerve fibre, will often remove adhesions that may exist and afford relief.

Rheumatic and Gouty Neuritis.—An excess of uric acid is the favorite explanation given for many cases of neuritis. Certainly there exists in both rheumatism and gout at least a functional disturbance of the liver and the kidneys, and from this disturbance are likely to result a faulty metabolism and the production of toxic and excrementitious ferments. Sodium biurate is only feebly soluble, and produces gout with crystalline deposits in the smaller joints. When the deposit is semi-crystalline or colloidal, then rheumatism results. Toxins are undoubtedly formed and these may be in association with the xanthin bases.

The free use of water is of course indicated as a means of flushing out these materials. Carlsbad and other spring waters, which for so long a period have been in great repute, are undoubtedly helpful, but a large proportion of the benefit obtained is due to the rigidly prescribed exercise and diet. The pains in rheumatic and gouty neuritis can often be greatly relieved by the application of cloths wet in a saturated solution of sodium carbonate or sodium biborate.

Puerperal Neuritis.—As the result of pressure upon pelvic nerves, either from the impingement of the head of the child or from the pressure exerted by forceps, a neuritis or a paralysis (motor or sensory) in one or both legs is occasionally observed. The external popliteal or the peroneal is the nerve most frequently involved. This condition, however, is more fully discussed under Puerperal Paralysis.

V. NEURALGIA.

The term neuralgia simply indicates nerve pain; *i.e.*, a symptom rather than a disease. It is a general term and frequently implies that the cause has not been discovered. Hence it is difficult to draw the line between neuritis and neuralgia. In all cases, therefore, it is important to make a careful examination of all the facts, in order that the cause of the disorder may, if possible, be ascertained.

ETIOLOGY.

Nerve pain may be due to a neuritis, or it may arise from some temporary or permanent local interference with the function of a sensory nerve—as from pressure, from irritation, or from traumatism; or it may be an expression of a constitutional condition, such as gout or rheumatism. Frequently it develops suddenly, either in an explosive manner or in the form of a collapse from nerve exhaustion or from some mental disturbance. General anæmia is a frequent cause. On the other hand, a hyperæmia, due to paralysis of the vasomotor nerves, may produce an attack. A sudden change of temperature may excite a paroxysm, and so also may cicatricial contractions or the entanglement of a nerve either in the skin or in a callus. A renal stone may give rise to pain in the

testicle, and a vesical calculus to one at the end of the penis. Spinal caries and joint disease are also frequent causes of reflex pains.

SYMPTOMATOLOGY.

The pain in neuralgia is frequently sudden in its onset; it is usually paroxysmal in character, darting or lancinating in its form, often violently throbbing. It may appear suddenly at a certain hour each day, especially in malarial subjects, or it may be continuous or remittent. The most intense paroxysms are usually observed when the disease is situated in the trifacial nerve; in these cases the cause may be of dental, bony or malignant, or of non-discoverable origin.

DIAGNOSIS.

Pressure of the palm of the hand frequently allays the pain, but superficial pressure by some pointed object like the end of a finger is exceedingly painful. In neuritis the pain is more continuous, and deep pressure increases the pain and distributes it over a larger area. Malarial and syphilitic neuralgias yield more readily to treatment. As the pain may be due to any one or more of a variety of causes so will its manifestations be multiplied indefinitely. The pains of central or of peripheral origin should be carefully diagnosticated. The pains of myelitis and of locomotor ataxia do not especially follow the course of nerve tracks and are not increased by pressure.

TREATMENT.

Treatment by Means of Drugs.—The first therapeutic effort should, of course, be directed toward the amelioration or cure, by proper medication, of any constitutional disorder that may be present—such, for example, as anæmia, gout, syphilis, or malaria. Climatic and sanitary conditions and environments should be carefully studied, and outdoor life, with nutritious food, insisted upon. Locally, veratrine ointment (6 to 10 grains of the drug to one ounce of lanolin) or an ointment of aconitine (3 grains to the ounce) will relieve pain. Menthol and camphor or chloral and camphor, equal parts, are good analgesics. For the control of the pain, local deep injections of chloroform, atropine, etc., are indicated. Atropine is less likely to induce the drug habit than is either morphine or cocaine. The most deplorable individual to be imagined is the victim of the morphine or cocaine habit, who has become accustomed to resort, upon the slightest excuse, to the hypodermic personal use of one of these anodynes. Physicians, unfortunately, are more addicted to this practice than are persons of any other class in the community, largely because they have the requisite means always at hand.

Almost every drug in the pharmacopœia has been tested for the relief of neuralgia. The milder forms of pain are usually influenced favorably by acetanilid, antipyrin, etc., but these remedies should be used with caution, it being rarely safe to give more than 5 grains of any one of these coal-tar derivatives at a dose, unless the effect has been previously tested. I have seen injurious and almost fatal results from the administration of so small a dose as 4 or 5 grains of phenacetin, and the danger of the so-called headache powders is very great. The deleterious effect of these analgesics may be lessened by the administration of caffeine or strychnine. Iron, arsenic, phosphorus, etc., should always be administered, and it is well at the same time to try a change of scene and perhaps electricity. Gelsemium has been greatly lauded, and, as a matter of course, all the newer remedies have been given a trial. Acupuncture and counter-irritation are useful. Heat, applied by a hot-water bag or by an electrically heated pad or an electric bulb, is comforting. A solution of adrenalin chloride (1 : 1,000), applied with a brush, will sometimes give relief. Injections of osmic acid (10 to 30 minims of a one-per-cent or a two-per-cent solution of the acid dissolved in distilled water and glycerin) have been successfully employed; * the object of the injection being to produce a condensation of connective tissue about the nerve—i.e., a sufficient degree of constriction to prevent transmission of nerve impulses. This acid stains the tissues permanently dark. The nerve should be exposed and the injection made into its substance, as well as around the sheath; a neurotomy even being sometimes advisable. While the relief is not always permanent, yet, if repeated injections can take the place of the more dangerous excision of the Gasserian ganglion when the trigeminal nerve is the seat of pain, it should certainly be tested. Injections of osmic acid should not be practised on motor nerves, except in amputation-stump neuralgias.

Treatment by Means of Electricity.—Pain in the superficial nerves of the body may be relieved by the use of various substances such as chloroform, aconitine, veratrine, cocaine, morphine, etc., to be applied over the painful area by means of the anodal diffusion electrode—a procedure termed *cataphoresis.* Mercury, iodine, etc., may also thus be driven into the tissues as alteratives, or as local anæsthesics for the relief of the pain. The medicaments must be placed on the anode, as the current carries substances only from the anode to the cathode. Anæmic cataphoresis may be employed by cutting off the supply of blood by an Esmarch bandage or by compression by the disc-shaped electrode. High-frequency currents from an *x*-ray coil will sometimes afford benefit, and so also will the Finsen rays in certain cases. Temporary relief of pain may be secured by a rapidly interrupted faradic current, a method which has long been used by dentists. The alternations of the current should be at the rate of two hundred or three hundred per second; such an alternating current producing

* Jour. Amer. Med. Assn., February, 1906, 556, and October 8th, 1904.

a benumbing effect upon the sensory nerves. Static electricity is also sometimes employed with benefit.

Surgical Measures.—Surgical measures for the relief of neuralgia will include the removal of tumors, bone callus, cicatrices, teeth, foreign bodies, and calculi, together with nerve stretching, neurectomy, avulsion and excision of spinal roots or ganglia. The careful freeing of a nerve from a surrounding and compressing callus is often productive of immediate relief.

Avulsion and excision of ganglia are measures which are especially employed for neuralgias of the fifth nerve. This will be discussed in another article, as will also the subject of spinal accessory spasm in spasmodic torticollis and facial spasm. *Splitting of the sheath of the nerve* has occasionally given relief, both in neuralgia and in neuritis. *Severe forcible compression* over the most painful spot, to be repeated several times a day, has been employed with advantage. In severe cases of sciatica the intra-arachnoid injection of cocaine has given permanent relief.

Neurectasia, or *nerve-stretching,* at one time believed to be one of the most important operations for the relief of permanent neuralgia, while sometimes of decided benefit, yet frequently fails of its object. The object aimed at in nerve stretching is especially to elongate the nerve fibres and to break up adhesions between the sheath and the fibres, and also to elongate connective-tissue adhesions. An incision having been made upon the nerve, the latter should be disturbed as little as possible. The operation should always be done so aseptically that the wound can be closed at once without any provision for drainage, and the part be put immediately upon a rigid fixed dressing. It is better to employ the finger than a blunt hook or grooved director for stretching. Scales may be used to indicate the amount of force exerted. Tension should be exercised both upon the distal and upon the proximal end of the nerve. In no case should the power employed in the traction exceed one-half that which would be required to rupture the nerve. Safe surgery does not sanction the exercise of the amount of force recommended by certain authors—an amount which may easily cause a rupture of the nerve. Death from spinal meningitis or myelitis has occurred as a result of such a rupture.

Nerve stretching is practised upon the sciatic chiefly for sciatic paralysis and neuralgia, and also at times for locomotor ataxia. An incision below the gluteal fold downward, midway between the great trochanter and the tuberosity of the ischium, will expose the gluteus maximus and biceps. These muscles are then to be turned aside, and the nerve will be found lying below and in close proximity to the sciatic artery. Behind the knee the nerve is easily reached in the lozenge-shaped popliteal space.

The sciatic may be stretched without incision, by forced flexion of the thigh upon the pelvis with the leg extended, the nerve being drawn across the posterior surface of the neck of the femur. In order to produce any decided effect,

however, the administration of a general anæsthetic and the application of considerable force will be necessary.

The genito-crural nerve has been successfully stretched for neuralgia of the testicle. Other nerves of the body may be exposed in the same way, and a tension of from five to twenty pounds made upon them according to the size of the nerve. The brachial plexus may be exposed in the neck, the incision being made parallel to the course of the plexus and care being taken to avoid the other anatomical structures in this region. The median, the ulnar, and the musculo-spiral nerves can be exposed at any portion of their course. In the case of the median, the brachial artery, which lies upon the outer side, and the brachial vein, which lies in front, must be carefully avoided. In the leg the popliteal, the peroneal, and the tibial may also be readily reached. The anatomical and surgical relations of special nerves are discussed on page 475 et seq.

Intraspinal Division of Posterior Roots.—Neuralgia of the brachial plexus is an exceedingly stubborn and painful condition, resisting all ordinary methods of treatment, even stretching, neurectomy, and sometimes amputation. As early as 1873 Sands excised the cervical nerves for obstinate neuralgia.* For division of the posterior nerve roots in extreme cases, Abbe† recommends the making of an incision down to the laminæ and the cutting away of the spinous processes at their base. The laminæ are then gnawed away with rongeur forceps and the dura exposed. The roots of the affected nerves may then be picked up within the dura, and from one-fourth to one-half of an inch of them excised; after which the dura should be sutured. If the ganglia and nerve are avulsed, the chances of non-return will be increased. In another case, in which there was pain with spastic movements, Abbe ‡ excised both anterior and posterior roots of the lower cervical region with benefit. The sacral nerves have also been divided within the canal, and so too have the thoracic, but the results have not been satisfactory.

Neurotomy was formerly quite extensively employed, but reunion of the ends took place so frequently that the method has now been practically replaced by neurectomy.

When reunion is undesirable, excision of from two to three inches of the nerve—*neurectomy*—should be practised. It is probable that the power of reuniting, in the case of divided nerve ends, does not extend beyond a distance of three inches. The best procedure for preventing such reunion is to cover the cut ends with flaps of fascia, or to fold them backward, or to interpose celluloid tissue or silver foil. Neurectomy for trifacial neuralgia will be elsewhere considered.

* Henry B. Sands: Archives of Scientific and Practical Med., i., 1873; see also Maury: Amer. Jour. Med. Sci., 1874, 29.

† Abbe: Boston Med. and Surg. Jour., October. 1896, p. 329.

‡ Abbe: Annals of Surgery, January, 1895, p. 53.

It has been shown that the complete tearing out of a large section of a nerve by violent traction—*avulsion* or *evulsion*—not only prevents restoration of function, but also produces such an effect upon the spinal and cerebral ganglia that preside over these fibres that they undergo more intense degeneration and atrophy, thus favoring the prospect of a cure of the neuralgia. Laplace has recommended *gradual torsion* of the trigeminal nerve, the operation to extend over a period of from ten to twenty minutes. He believes that by this means one may remove the nerve in its totality down to the smallest filaments, which are thus dragged from their ultimate ramifications. Neuralgia of amputation stumps requires excision of the bulbous fibro-neuroma or the injection of osmic acid.

Unusual Forms of Neuralgia.

Metatarsalgia Anterior.—Various theories are held in regard to this form of neuralgia. According to one, it is due to a subluxation of the metatarsophalangeal joint, with a resulting ostitis; according to another,—and this is the view held by Morton,—it is due to the pinching of these nerves, which results from their close relation to the metatarsal bones, especially the fourth; and according to a third, the pain is caused by weakness and relaxation of the anterior arch in the direction from one side of the foot to the other. The normal supports are the first and fifth metatarsal bones, and, if the ligaments are stretched or relaxed, the central portion of the arch is brought down upon the ground and there is produced an abnormal pressure which results in callosities, pain, etc. The false position of the foot caused by high heels, the compression of the anterior part by tight shoes, and the abrogation of all use of the toes by the stiff sole—all these tend to produce the condition just described. In individuals who dispense with shoes and walk on their bare feet the toes are brought actively into use; in our civilization, on the other hand, the foot has been forced to adapt itself to the shoe, instead of the shoe to the foot. The overriding of the bones, which is a frequent result under these conditions, necessarily brings the nerves into false positions. This is well illustrated in the hand, in which member extreme pain may be produced by even temporary compression in violent hand-shaking.

Treatment.—Low-heeled, wide shoes, that permit full expansion, are usually sufficient to afford the desired relief, especially if rubber heels and soles are used, and if hair or felt insoles are added. The lateral anterior arch may be supported by a bevelled leather pad. All callosities should be removed and, if flat-foot coexists, it should be supported by a celluloid or steel arch, with a sole sloping outward. To this measure should be added massage and regulated muscular exercises. In stubborn cases, excision of the head of the metatarsal bone, with or without amputation of the toe, will give relief.

Erythromelalgia.—This peculiar affection, which is characterized by a painful condition of the hands and feet and by a congested and dusky appearance of the skin of these parts, is doubtless due to neuritis and vascular disease. It comes within the domain of surgery only in relation to possible modes of treatment. The nerves leading to the parts affected have been stretched and resected, and toes and fingers have been amputated with relief to the symptoms in some cases. It must not be forgotten, however, that such operative procedures have been followed by gangrene in some cases; and in this connection we may recall Dana's statement that in his experience erythromelalgia is closely associated with diabetes.

VI. JOINT NEUROSES; HYSTERICAL JOINTS.

The knee seems to be the joint most frequently involved in the form of disease to which the terms hysterical joint, joint neurosis, and neuralgia of the knee are applied, but the hip, ankle and shoulder are likewise subject to the same symptoms. The diagnosis of this condition is one of the most difficult problems which the surgeon is called upon to solve, requiring, as it does, not only a careful consideration of all the anatomical and pathological conditions present, but also a study of the individual patient. When the latter presents himself to the surgeon, probably after he has been under treatment for a long time for so called "rheumatism," the difficulties are not so great as they are at an earlier stage of the trouble. At this late date it will doubtless be evident that the severity of the symptoms of which the patient complains is out of all proportion to the seriousness of lesions actually present. And yet one must be very careful not to overlook any evidences of the presence of a tuberculous or other destructive process. As already stated, the difficulties encountered by the surgeon in the earlier period of the attack are many. The picture that will then be presented to him will be that of a swtleon and painful joint, and he will be told that these conditions, which bespeak an arthritis, developed after the patient had experienced a slight trauma. The treatment to be adopted in such a case, in its earlier stages, is, very properly, rest and fixation of the inflamed part; but there will come a time, in all joint inflammations that are not of a tuberculous or a destructive nature, when motion is advisable. Motion is the normal condition of a joint, but motion will, after any inflammatory trouble, at first be somewhat painful and, in a neurotic individual, the estimation of the pain may be exaggerated. It will therefore be very difficult to estimate just how much importance should be attached to these painful sensations. If they are merely the expression of a hypersensitive condition, it will be found possible, by simply diverting the patient's mind, to move the affected part gently, and without causing any noticeable

degree of pain. On the other hand, if the pain really depends upon the fact that an actually inflamed part is being disturbed, the mere diversion of the mind will not suffice to prevent the patient from responding to the painful impression in the natural manner. By bringing the patient under the influence of an anæsthetic the surgeon will be able to estimate in a fairly accurate manner to just what extent the mobility of a joint is restricted by the conditions growing out of an arthritis. If the hip joint or the knee joint is suspected of being the seat of tuberculous disease, a valuable piece of confirmatory evidence will be found in the existence of marked flexion and of doughy deposits in the vicinity of the joint. The presence of loose bodies, of torn ligaments, and of displaced or fatty fringe growths in the knee joint, in association with more or less synovitis, will be very likely to prove a puzzling element in the diagnosis of affections of the joints. Under such circumstances a surgeon is rarely justified in reaching a final conclusion until he shall have observed the case a number of times and shall have brought to his aid the x-ray and other known methods.

Treatment.—Any injured joint primarily requires rest and fixation until the inflammatory conditions shall have passed; consequently, a positive diagnosis is the important element in deciding as to when this period has arrived. If a tuberculous or other destructive disease is present, irreparable damage may be done by motion, but, in a really neurotic joint, motion must be insisted upon. The confidence and co-operation of the patient must be secured, and then, after this has been accomplished, slight movements of the joint should be commenced —usually with the aid of a general anæsthetic. Following this, hot and cold douching, massage, electricity, and gymnastic movements in a well-equipped orthopedic gymnasium, under competent supervision and encouragement, will be found most helpful. The patient should be assured that, although locomotion is at first painful, it is not at all harmful, but beneficial. Constitutional treatment and change of scene and companions, especially if the latter are over-sympathetic, are measures essential to the attainment of a successful result.

VII. OCCUPATION PALSIES; WRITERS' CRAMP, ETC.

Writers, pianists, tailors, violinists, shoemakers, and typewriters—in fact, any individuals in whom the constant use of the same set of muscles is necessary —are liable to have, as a result, a nerve tire and a muscle exhaustion which may be tremulous, spastic, or paralytic in character. The first symptom is a sensation of weariness or weakness in the affected muscles, followed by cramp and pain. In the tremulous type of the disorder, the tremor may be excited at any time by the resumption of muscular action. The movements become irregular and uncertain. In the spastic type the spasms may be either tonic or clonic in character. The paralytic type is more severe and permanent in

character. Unfortunately, sometimes even the opposite hand is similarly affected. It is in some cases a local expression of muscle and nerve fatigue; in other instances it is a reflex neurosis, accompanied by a permanent interference with co-ordination, and may become a permanent paralysis.

The *prognosis*, in well-marked cases, is unfavorable, unless the person affected can take a long rest of six months or a year, and can change his occupation.

Treatment.—Early and entire cessation of the use of the affected muscle or group of muscles is of prime importance. This should be accomplished by placing the fingers and hand upon a splint, thus giving them entire rest; and at the same time attention should be given to constitutional conditions, and a change of air and scene should, if possible, be secured. When the pain and the tendency to spasm have disappeared, massage and electricity will be found most helpful measures. When circumstances permit, the patient should be advised to change his occupation. Where this cannot be done, various mechanical measures have been advised for the transferring of the work to other muscles. In scrivener's palsy the best contrivance is a socket which is to be attached to the fingers and which does not require constant tension of the smaller flexors of the fingers, but will permit the use of the larger muscles of the forearm. Many instructors of penmanship, recognizing the danger of acquiring this form of paralysis, teach their pupils how they may employ, in writing, the larger muscles of the arm rather than the smaller ones of the hand. Neither for typewriters nor for pianoforte players has any form of remedial appliance yet been devised. When one hand alone is affected, the other should be educated to take the place of the weakened member. That a right-handed individual can educate his left hand to perform any or all of the required movements is well illustrated in individuals who lose the right arm by amputation.

Slow voluntary muscular movements are helpful. Massage is helpful in stimulating nutrition, but rest is also of prime importance. Mild galvanic or faradic currents employed in a descending direction, the anode being placed in the axilla and the cathode over the ulnar nerve, or the positive pole over the median nerve and the negative on the flexors, together with light gymnastics, will frequently benefit this form of nerve exhaustion. Tenotomy has not proven of much use.

VIII. REFLEX PARALYSES.

There have been hundreds of cases of cerebro-spastic and other forms of paralyses which have been incorrectly diagnosed and for which some relief has been promised through the operation of circumcision, when, as a matter of fact, no benefit is attainable through any form of treatment. Adhesion of the prepuce to the glans is practically a normal condition at birth,

but in a large majority of cases a separation can easily be effected during the first month of life. If the prepuce be thus made freely movable over the glans, it will be an easy matter to cleanse these parts, and the sensitive glans will thus be permitted to receive the protection to which it is entitled during the early years of life. Apparent contraction of the prepuce is common, while true contraction is rare. Only the latter condition requires circumcision.

Epilepsy and chorea occasionally follow wounds of the peripheral nerves, these disorders being attributed to entanglement of filaments in the cicatrix. In cases of this nature excision of the contracted and condensed cicatricial tissue sometimes effects a cure.

IX. PSEUDO-HYPERTROPHIC MUSCULAR PARALYSIS.

This form of paralysis is observed particularly in early childhood and is characterized by an enlargement of certain muscles, while atrophy is demonstrable in other groups.

Etiology.—Heredity plays an important part, as is shown by the fact that the disease may be transmitted through several generations. It is sometimes seen very early in life, but is usually noticed between the ages of two and eight years.

Pathology.—The morbid changes consist in atrophy of the muscular fibres and their replacement by fat particles, some of the muscles as a whole being increased in volume. This increase in volume is largely due to an increase of the connective-tissue elements—an increase which tends to interfere with muscular contractility.

Symptoms.—Difficulty or inability in walking, particularly a lack of power to raise the limb, is the first indisputable sign. If the disease has commenced early, the child will be late in attempting to get upon its feet. The gait is usually feeble and uncertain; the child falls easily, grasps any convenient object for assistance, and maintains its erect posture usually by curving the spine forward in a decided manner, while the shoulders are thrown far back. When the child is placed upon all fours, it is soon observed that the muscles of the back are weak and that they have not the power to lift the trunk into an erect posture. The gastrocnemius muscles are usually the first to become hypertrophied; then follow the muscles of the shoulder-blades and the deltoid muscle. At a later stage atrophy takes place, particularly in the muscles of the back. The feebleness of these particular muscles is sometimes so great that the lumbar spine and pelvis occupy a position at right angles to the femora, thus throwing the abdomen far forward, while the buttocks are markedly protruded backward. The gait becomes very feeble. As the disease progresses, some of the muscles undergo

contraction, and thus the feet and hands are likely to become distorted. It will also be found that muscular contractions cannot be excited by electrical currents. Knee-jerks disappear and there is increasing failure of both motion and sensation. In other cases the atrophy begins in the muscles of the shoulders or of the face.

Diagnosis.—These cases cannot be properly studied unless the patients be stripped of all clothing. Without this precaution, an extensive infantile spinal paralysis or a spastic paraplegia may be mistaken for this disease. In young children of tardy development, from rickets and other diseases of malnutrition, a careful analysis of all the symptoms is necessary.

Prognosis.—The prognosis as regards recovery is hopeless, as regards arrest of the process it is extremely unfavorable, but death rarely takes place, except from some intercurrent affection, until total loss of power has occurred. The individual, as a rule, lives many years.

Treatment.—Massage, electricity, and systematic gymnastics may afford a certain amount of relief; and some advantage may be gained, if the patient still possesses the power of locomotion, from the division of those muscles which have undergone contraction. Mechanical appliances for the support of the spine are occasionally serviceable in assisting the patient to maintain a fairly erect position.

X. PROGRESSIVE MUSCULAR ATROPHY, OR WASTING PALSY.

This disease is a slow form of atrophy of individual groups of muscles and is not preceded by motor or sensory paralysis, nor by a poisoning dependent upon one of the poisonous metals. It often leads, however, to great deformity. This disease usually appears in middle adult life. The symptoms are undoubtedly due to lesions in the anterior horns of the spinal cord. Isolated muscular fibres are found to be atrophied and to have undergone fatty degeneration.

Symptoms.—The inability to use the affected muscles properly is the first symptom, and with it will be found associated a limited area in which the muscular tissue has become wasted. The muscles of the ball of the thumb are usually wasted first. These changes may advance through successive groups of muscles, and as a result there will soon be visible a marked degree of deformity. When one set of muscles overpowers the other, contraction will take place at the various joints.

Diagnosis.—In the very beginning of the disease and when only a single group of muscles is affected, the condition may be confounded with neuritis, with lead palsy, or with nerve injury. In infantile spinal paralysis the onset is usually sudden, while in this disease the invasion takes place slowly. The age of the patient also is of diagnostic importance.

Prognosis.—This is unfavorable.

Treatment.—Constitutional measures and the removal of all debilitating causes are essential. Massage, performed with the hands or by means of some mechanical contrivance, may, if continued persistently but not too vigorously, be found of some benefit in restoring nutrition. Electricity is of doubtful value. As long as any power of locomotion exists, tenotomies and myotomies may be performed for the purpose of equalizing the different groups of muscles and permitting locomotion.

XI. NEUROPATHIC CONDITIONS IN LOCOMOTOR ATAXIA AND SYRINGOMYELIA.

Arthropathies.—Joint degenerations from either locomotor ataxia or syringomyelia are especially common at the knee, hip, and shoulder. In mild cases, after a slight trauma, painless effusion occurs, but this, under proper treatment by rest, fixation, and support, may recede and permit the patient to walk about. In the more severe form the joint goes on rapidly to destruction: the cartilage and bone become softened, dislocations and even fractures may occur, and villous growths and bony deposits appear around the joint.

In tabes the alterations in the joint develop slowly; an effusion takes place first, then the ligaments become relaxed, and finally the bone itself undergoes a slow form of destruction. The larger joints are more commonly affected than the smaller ones. Suppuration is rare. A slight injury is usually the exciting cause, but sometimes the disease develops simultaneously in two corresponding joints without any demonstrable exciting cause. In the carpus or the tarsus there is usually at first a dull pain, and this is followed soon by evidences of an effusion and later still by deposits which give to the joint an appearance like that seen in arthritis deformans. In the case of the hip, the joint surfaces are usually rapidly destroyed and spontaneous subluxation may occur; or there may be a proliferation of bone similar to that seen in arthritis deformans; eventually the capsule and head of the femur may be entirely lost. The hip is rarely involved in syringomyelia; in tabes, on the other hand, this occurs more frequently.

In syringomyelia ulcers often appear without the patient's knowledge of their existence. The destruction of the joint takes place rapidly, but the bony deposits which form around the joint are not as dense as those found in arthritis deformans. At the shoulder, painless spontaneous dislocation may occur, and there is apt to be considerable deformity.

Trophic disturbances due to syringomyelia—alterations in the skin, death of bones, perforating ulcers or gangrene—are found in both hands and feet. In locomotor ataxia the most common indications are alterations in the skin and

nails, perforating ulcers, fractures of bones, and the various arthropathies which more commonly accompany this condition of the cord than they do syringomyelia. In the knee the existence of abnormal conditions may be noticed before the diagnosis of tabes has been made. As a rule, however, the painless onset does not lead the patient to complain until a noticeable amount of effusion is present. Often the patient continues to walk about until the destructive changes in the joint are well advanced. In advanced cases the detached fragments of cartilage and bone can be felt as movable irregular bodies, like those
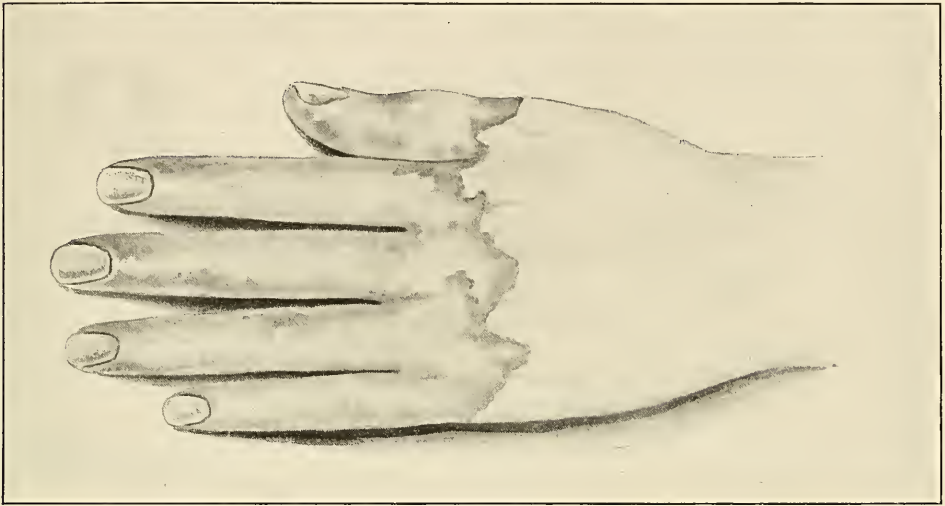
Fig. 148.—A Hand Showing a Peculiar Eruption of an Eczematous Nature in a Case of Multiple Neuritis Following an Injury to the Back. (A. A. Bowlby: " Injuries and Diseases of Nerves, and Their Surgical Treatment." London, 1889.)

observed in arthritis deformans. Crushing of the articular surfaces of the bone from a fracture is not a common occurrence.

The shoulder joint is rarely affected in locomotor ataxia; it is more frequently involved in syringomyelia. Spontaneous dislocation of the shoulder joint does not often occur in the later stages of syringomyelia. On the other hand, the articular surfaces of the bone are sometimes destroyed, and yet, in the absence of pain, the patient is often able to use the arm even after extensive destruction has taken place.

Treatment.—Unfortunately, treatment does not accomplish very much; nevertheless, it is advisable to employ fixation of the joint by means of a plaster-of-Paris dressing or a leather splint or by some other form of apparatus, in order to prevent further injury or deformity. Resection, especially at the hip, accomplishes but little; at the knee, however, it may give temporary relief. Amputation is sometimes helpful, especially if suppuration has occurred.

Neuropathic Ulcers.—In spina bifida, with paralysis of the lower limbs,

a neuropathic ulcer may occur. It is most frequently found in locomotor ataxia. It is usually situated on the foot, but it is also sometimes seen on the hand or on the buttocks. Its usual seat is in the sole, at some point which is especially exposed to pressure. An ulcer in this locali⁺y is usually designated by the term "perforating ulcer of the foot." Its course is slow, it is usually unattended by pain, its edges are thickened, and it offers a stubborn resistance to treatment. The accompanying analgesia usually results in lack of attention until a large area is involved. Other neuropathic lesions—such as trophic changes in skin, nails, etc.—are common, especially when the disease is in the peripheral nerves. (Figs. 146, 147, 148.) This form of neuritis, with trophic changes, is frequently associated with diabetes.

Treatment.—It is desirable to trim the thickened edges of the ulcer, to slit open freely all undermined edges, to remove any diseased bone that may be present, and to cut away, with scissors or curette, all sloughing tissue. Locally, thymol diiodide or some similar astringent antiseptic dressing will be found most helpful. Iodine, protonuclein, pepsin, are also beneficial.

Nerve stretching has been employed with indifferent results in a few cases, but general constitutional measures are of the greatest importance.

XII. TRAUMATIC NEUROSES.

The psycho-neuroses associated with an injury of the spine, or of any portion of the body, present most complicated and multiform symptoms, many of them purely functional in character, while others are the outward expression of some actually demonstrable pathological lesion. The separation of these real and unreal symptoms requires a discriminating and careful study on the part of the surgeon, since it is important that the condition of chronic invalidism be avoided. Such a condition is readily acquired after a serious injury, not alone by those individuals who are seeking compensation from a corporation, but also by those who have no pecuniary interest in the matter. Injuries of joints other than those of the spine develop a neurosis similar to that which is now under consideration. It is but reasonable to expect that a certain amount of pain will be present whenever a joint has been long retained in one position; particularly is this true where there has been laceration or contusion of ligaments, muscles, and fasciæ, or a condition of sprain. Consequently, a patient who complains of these symptoms without any positive lesion should not be looked upon as a simulator, nor is it to be necessarily inferred that the symptoms are hysterical. Any patient who has lain long in bed, especially one who has been carefully nursed and more or less indulged, will find it difficult to rise and make the exertion necessary for locomotion. It is an easy matter for any patient to lapse into a state of acquiescence with a situation in which others care for

all his wants, and his sympathetic relatives stand ready to exaggerate the ills from which he suffers.

Shock plays a part in the cases which we are now considering. It manifests itself in such various forms and at such unexpected times that the keenest surgeon may be unable to separate the real from the unreal. Again, the element of shock, mental, physical, bodily shock, is a factor of most uncertain nature. It may occur at the moment of the accident, producing most profound nervous changes; it may come on only after the lapse of days or weeks. The shock of a railroad accident is great, even though there be no actual injury except a contusion; and when to this shock is added an actual injury—perhaps a concussion of the spinal cord alone, or such a concussion in addition to some injury which, temporarily at least, leaves soreness and pain in the muscles —one can readily see how the beginning of an invaliding process is started. Further, sudden and forcible bendings of the spine in any direction may add actual laceration of fasciæ and ligaments and even lesions of the bone. After such an injury, therefore, we have a right to expect that there will be inflammatory deposits about the roots of the nerves, and that these deposits will give rise to pains varied in character and wide in distribution. Furthermore, hemorrhages within the canal, actual injuries to the cord, dislocations and fractures of the vertebræ, may add temporary or permanent paralyses to the list of symptoms. The railway spine, therefore, is not to be lightly considered, nor is it to be inferred that the case is one of unnecessary exaggeration.

Simply a pain—a subjective symptom, not visible, not palpable, not audible —can only be judged by the accompanying symptoms. A dysmenorrhœa is not a demonstrable pain, nor an intestinal colic, nor a myalgia, nor a neuralgia. One patient will endure great suffering without furnishing much external evidence of the fact; another will writhe under the smallest amount of pain. There is undoubtedly a great difference between individuals as regards their susceptibility to pain. For instance, it may be fairly inferred that uterine contractile labor pains are somewhat similar, yet the manifestations of those pains will vary as widely as the number of women observed. So, in injuries, the differences of expression with regard to the amount of pain suffered will be great, even though there be no exaggeration nor simulation.

Etiology.—The most common cases of accident at the present time are those occasioned by railroads, trolleys, automobiles, and other vehicles. The extreme tension of thought and quickness of action demanded by our rapid and dangerous methods of progression are likely, from the excessive nerve strain which they produce, to result, in many instances, especially among the chauffeurs and motor men, in nerve exhaustion, neuritis, etc., even after slight accidents. The constant effect of noise is also an important element in the wear and tear of the nervous system of every individual. The resultant injuries may be complex in character. Temporary unconsciousness may deprive the individual of the

ability to give a coherent history of the events that have occurred, especially as the actual details, in the case of a severe accident, are always more or less confused. These uncertainties are often as fully manifest in cases in which no medico-legal question is involved as in those in which exaggerations might naturally be expected.

Diagnosis.—Injuries of the spine produce symptoms which are the genuine expression of a spondylitis, a spinal caries, or a spinal hemorrhage, or are merely feigned for the purpose of deceiving the observer. The cord itself may be actually injured, or there may be a lesion of muscles, ligaments, or bones. The existence of rigidity is an important point in diagnosis, and at the same time it is one that cannot be estimated unless the patient is stripped. Local tenderness is of but little diagnostic value, as it is often more severe in a small contusion of the soft parts than it is in actual lesions of the vertebral column or of the cord. Thorough and repeated tests for pachymeningitis, myelitis, and other cord degenerations must be made, and the conditions of the knee-jerks, ankle-clonus, toe reflexes, etc., must all be carefully investigated. Even though there may be no paralysis, the above-named evidences of irritation of the cord or of a lesion in this organ should be carefully weighed, as they cannot be readily simulated. The question whether or not anæsthesia or hyperæsthesia or paræsthesia is present should be carefully investigated; and so also should the evidences of any existing paralyses. Sprains, tearing of ligaments, etc., of the spinal column are often followed by lightning-like pains of the most excruciating character. Neurasthenic complications may be expected. In an emotional individual, pain may be elicited in almost any portion of the body; the patient becomes irritable, is poorly nourished, eats and sleeps badly, and becomes a chronic invalid unless wisely treated and encouraged. The effect of mental influence is seen in the fact that injuries acquired in sports and in ordinary work are not as serious in their consequences as those in which the question of damages plays a certain part. The long waiting for a settlement of the claim for damages and the concentration of one's thoughts upon one's own affairs are sufficient to demoralize almost any individual. After the settling of a suit for damages real simulators rapidly recover; but, unfortunately, many have by this time become so addicted to invalidism that the wisest and most thorough efforts of the surgeon are needed to bring them to a state of health.

Hysteria is a term covering a multitude of sins, yet we should not class all hysterical evidences as necessarily simulative. There are many hysterical symptoms that are real and positive. We may have, as a result of an injury, a combination of neurasthenia and hysteria with the symptoms which legitimately belong to the injury inflicted.

XIII. CEREBRO-SPASTIC PALSY.

Cerebro-spastic palsies consist of rigidity and paralysis of muscles, usually associated with imperfect cerebration varying from a slight defect to complete idiocy.

Etiology.—Syphilis and chronic alcoholism in the parents are potent causes, and drunkenness, even at the time of conception, certainly has a positive influence in the production of the disease. The union of two highly neurotic individuals is also likely to result in children who possess these defects. Consanguineous marriages, hereditary tendencies, insanity, and all nerve disorders are certainly predisposing. Among prenatal causes are traumatisms to the mother, possibly terrifying conditions, lightning strokes, excessive anxieties, and exhausting diseases during pregnancy. Among the causes that originate at birth is severe compression of the head by forceps or by long retention in the pelvis, often producing subdural hemorrhages even though fracture of the skull be not present. During infancy, convulsions from any cause, meningitis in its various forms, any of the infectious or contagious infantile diseases, etc., may give rise either to cerebral hemorrhage or to such other lesions as may induce defective cerebral control. Sepsis, congenital absence of the cerebrum, porencephalus, etc., will also be found among the causes.

Pathology.—Embolism, hemorrhage, atrophy, cysts, and porencephalon are the most common conditions encountered at the post-mortem examination. The pyramidal tracts frequently show descending degeneration extending from the cortical lesion.

Symptoms.—The condition of muscle spasticity is the most prominent and early absolute symptom; it may be discovered soon after birth, or may not be noticed until the child attempts to walk. The loss of control may be paraplegic, diplegic, or hemiplegic. In slight cases the child may be able to sit and also to use its hands in an uncertain manner, although it acquires the ability to do these things only tardily; but later attempts to make the child stand increase the spasm, and the feet immediately assume the equinus position, the knees and thighs being flexed and the legs often crossed in the scissors position from contraction of the adductors. As a matter of course, walking in this position is impossible and the children, if unrelieved, remain a long time helpless in bed. Their growth is frequently not retarded, the limbs being rounded and of full size. As regards lack of mental development, all grades will be observed, from the slightest indication of faulty cerebration to extreme idiocy. These defective mental conditions will generally remain unrecognized by the mother and will frequently escape the observation of the surgeon. The speech may be thick and unintelligible. Irregular and inco-ordinate, choreic and athetoid movements are frequent. In some cases the spasticity is almost tetanic. In

many cases lead-pipe contraction is marked. In adult life many individuals are seen walking either on crutches or with flexed knees and hips, and with staggering, jerky, and irregular gait. The arms are usually flexed and pronated, and the hands and fingers are sometimes capable of irregular and uncertain use. The facial expression usually gives some indication of the lack of mentality.

Diagnosis.—The differential diagnosis of cerebro-spastic palsy from infantile spinal paralysis is usually easy, as in the latter disease we have atrophy of muscles instead of fairly normal development, flaccidity in the place of rigidity, and absence of cerebral defects, while electrical muscular reaction is lost. In cerebral palsy the reflexes are increased and the electrical reactions are normal. In cases of muscular dystrophy it is possible to identify this disease by the lack of spasticity and by the atrophy or hypertrophy of individual sets of muscles, although the milder forms in young children are not easy to separate. Muscular dystrophy, furthermore, usually occurs later in childhood.

Prognosis.—The prognosis will depend almost entirely upon the condition of cerebration. When brain power is absent or porencephalus or microcephalus exists, or when a subdural hemorrhage becomes permanently organized, the condition cannot be changed. Neurologists are inclined to look upon these conditions as hopeless. Upon the surgeon, therefore, rests a great responsibility in rendering these individuals capable of locomotion, thus bringing the individual in contact with the world and educating his muscles. To surgery, then, we must turn for relief. It is not to be expected that normal conditions can be secured, but if 5, 10, 20, or 40 per cent of improvement can be secured, the simple operations required are justifiable. Unfortunately, many of these individuals attain adult life, although they are of course less resistive to disease than the normal patient.

Treatment.—All discoverable causes should be investigated and removed if possible. In early life systematic gymnastic exercises of the muscles, having for their purpose to assist and develop co-ordinate movements, are essential. Massage and electricity, together with manipulation, stretchings, etc., are helpful. Circumcision should be performed when there are evidences of genital irritation, but the effect of this operation is of no marked benefit. Tenotomy and myotomy are of the greatest service, and they should be unhesitatingly employed even in cases which are apparently hopeless, the parents, however, being made acquainted with the fact that in the severe cases, in idiots, only slight improvement can be expected. In the majority of cases, however, a very decided gain may be anticipated. It would be impossible for a strong man to walk in the cross-legged equinus position so frequently found in these patients. A tenotomy of the hamstring tendons, of the tendo Achillis, and of the tensor vaginæ femoris and rectus muscles, together with a division of the adductors at their insertions into the pubis, usually results in bringing the

legs into such straight position with the body that they will become capable of weight-bearing and to a certain degree of locomotive effort. The adductors, as a rule, do not need an open incision, but, as the wound is near the urinary organs, and as these patients are frequently unable to announce their necessities, a subcutaneous tenotomy is advisable, the puncture being made as far as possible from the urethra by first drawing the skin well toward the median line so that the puncture may return to its position well toward the middle of the groin. The division of these adductor muscles requires a long, cutting-faced, blunt tenotome, and will be followed by considerable hemorrhage, but no large arteries will be divided. These operations have been described in other places in this treatise. To prevent reunion of the adductor muscles and the reproduction of the flexions at the knee and foot, plaster of Paris should be applied from the toes to the perineum. The legs should then be widely separated and fastened to the bed rails in order that the gap in the adductor muscles may be filled with a large quantity of new material and that recontraction may not occur. This position must be maintained for three or four weeks, after which the patient may be allowed to walk about with or without apparatus, as occasion requires. Locomotion in bad cases can be assisted by suspending the individual in an overhead trolley; then further aid can be afforded by crutches, canes, and other suitable apparatus, together with manipulations, massage, electricity, gymnastic exercises, etc., until the patient can himself employ his powers of locomotion. Systematic, regulated movements are essential for a long period of time—at least for a year.

Tenoplasty is of great benefit, especially in the upper extremity, as a means of removing the deformities of the hand. The head of the pronator radii teres may be detached from its origin at the internal condyle and carried across to the external condyle; or the tendons of the flexor carpi radialis and ulnaris may be divided at the wrist and attached to those of the extensor communis digitorum, the tendons being carried through the fascial space by a hæmostat and then united to the bundle of extensor tendons, the hand being held in extreme extension during the suturing. The sutures should be of fine chromicized catgut or silk. Trephining of the skull has been employed in a number of instances, but except in the early stages of hemorrhage it will necessarily be of only slight benefit. Craniectomy has been advised, but has not proven of service.

The operation of *neuroplasty*, or *nerve anastomosis*, has opened up a new field for benefiting the hitherto hopeless cases of athetosis. A careful study of the nerve supply of the too vigorous muscles must first be instituted before any operative interference is undertaken. In Spiller and Frazier's case the median nerve was exposed and isolated above the point at which it crosses the brachial artery. A section of the musculo-spiral nerve of equal length was also exposed in the same manner. "After the introduction of four sutures into

the ulnar nerve,—two on either side, about one centimetre apart,—the nerve was divided between the two sets of sutures, and the proximal and distal ends, respectively implanted into the musculo-spiral. Four sutures were introduced in a similar manner into the median nerve, and after the nerve had been divided the central end was implanted into the musculo-spiral nerve and the distal end into the ulnar nerve." Farther on, the same report states (with reference to another operation): "The median and ulnar nerves were then divided, and a lateral anastomosis effected between the distal portion of the median and the musculo-spiral and between the ulnar and the median."*

The whole or a portion of a nerve may be transferred, the prime object being the equalization of muscular power so as to secure voluntary movements. In athetosis, of course, the original disease remains, but even a slight improvement is welcomed, especially if purposeful movements can be increased. In the leg, also, nerve anastomosis may be made, as described on page 482 et seq.

In the axilla all the nerves of the arm are in such close proximity that anastomosis is not difficult, but the grafting may readily be made at any point in the arm.

Various forms of transposition—end-to-end, lateral, complete and partial anastomosis—are illustrated on pages 470 and 472.

In carrying out the operation a round sewing-needle only should be used and loop stitches should be made, principally through the sheath, the nerve fibres being pierced as little as possible. Fine chromicized gut or celluloid thread should be used, preferably the former. At the point of later implantation the sheath should be divided and the transplanted nerve inserted within, so that nerve fibre may come directly in close contact with nerve fibre. As rapid healing of the wound is important, the utmost precaution should be taken in regard to asepsis. The nerve should not be pinched by forceps, but should be handled with the greatest care.†

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* Transactions of College of Physicians of Philadelphia, third series, vol. xxvii., Phila., 1905; Amer. Jour. Med. Sc., April, 1906.

† As the subject of plexiform neuromata belongs in some measure to the domain of surgery of the nerves, I will add here a very brief reference to an article on this subject which has recently (June, 1906) appeared in the Deutsche Zeitschrift für Chirurgie. The author, Max Strauss, gives a careful review of all the cases of "Rankenneurom" which have thus far been reported, and from this study he draws the following conclusions:

"A great deal of confusion exists with regard to the precise nature of the tumors to which the terms Rankenneurom and plexiform neuroma are commonly applied. Of the 112 cases recorded, only 32 seem rightly entitled to be called plexiform neuromata, in the stricter sense of the term, whereas the more general and less precise term, Rankenneurom—or false neuroma, can with appropriateness be applied to the remaining 80. In both groups of cases a new formation of connective tissue around pre-existing nerve fibres—or, more rarely, around newly formed nerve fibres—constitutes the most characteristic histological feature. In the cases of plexiform neuroma (sensu strictiori), on the other hand, it is a noticeable fact that the tumor is always found to have more or less close relations with structures belonging to the central nervous system (as, for example, in the case reported by the author [Strauss], in which the posterior bony wall of the spinal canal was lacking in the immediate vicinity of the tumor)."

Briefly stated, the history of the case referred to above is as follows:—The patient, a boy of twelve, was the son of parents who seemed to be perfectly healthy. At the time of his birth a small tumor was noticed in the middle of his back. This tumor, so far as could be learned, had given him no trouble until he had reached the age of nine, when he began to complain of pain in the back, especially after walking. Three months before he was first seen by Dr. Strauss, the pain had become so distressing that the parents decided to consult a physician. Although in the main the boy's general health had been good, and although he had manifested no symptoms indicative of disease involving the sensory or motor organs, his power of speech had developed very slowly. In fact, he was not able to speak properly until he reached his seventh year. The tumor, which at the age of two was no larger than a hazelnut, increased very slowly in size. At the time of the operation it measured a little over two inches in breadth. An examination of the mass after it had been removed revealed the fact that it was composed of bundles of nerves lying in a matrix of fibrous tissue, and that this fibrous tissue varied very greatly in character in different parts of
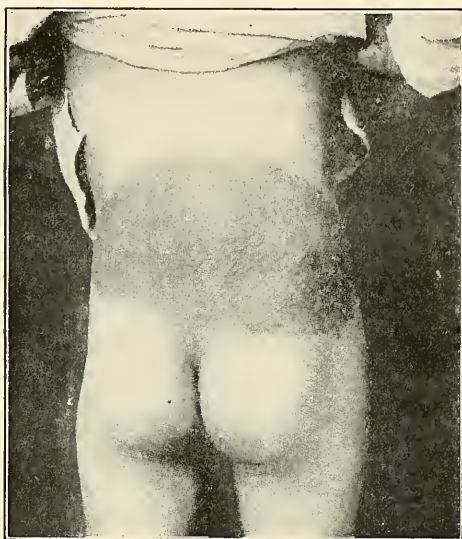
Fig. 149.—Strauss' Case of Plexiform Neuroma of the Lower Part of the Back. Note the well-defined area of discoloration of the skin and hypertrichosis. (*Deutsche Zeitsch. f. Chirurgie*, June, 1906.)

the tumor. In some places it was quite tough and distinctly fibrillated, while in others it had evidently undergone a myxomatous change. As to the medullated nerve fibres, many of them were found in a decidedly degenerated state. The tumor, as a whole, represented an aggregation of numerous cylindrical cords, which were intricately intertwined like a mass of earthworms, and which at intervals expanded into bulbous knobs. It was found at the operation that the tumor was directly connected with a *spina bifida occulta*.

The operation itself calls for no special remarks.

The accompanying cuts show the appearance of that portion of the patient's back from which the tumor was removed (Fig. 149), and the cutaneous aspect of the growth after its removal by operation (Fig. 150).

A second case of plexiform neuroma has still more recently been reported by Jaboulay in the Gazette des Hôpitaux, etc., Aug. 28th, 1906. The Medical Record of Sept. 29th, 1906, gives the following résumé of this report: " Jaboulay gives an interesting and detailed description of this growth. The patient, a man twenty-three years old, sought medical aid merely for æsthetic reasons. The tumor was the size of a mandarin, flattened, and triangular in shape. It was pediculated. The mass was soft, with a surface lobulated like that of a lipoma or deep angioma. By pressing it between two fingers there could be f lt tiny particles like small grains, connected by little threads. The pedicle of the tumor was condensed into a hard cord. The precise

insertion of this pedicle could not be determined by palpation. The growth was not painful. It was situated on the forehead, falling down in front of the eye. The patient gave a history of the appearance of the tumor at the age of two years. It grew slowly in size for three years, when an operation was performed. Whether the operation was complete or partial, the tumor rapidly reappeared, and continued to increase slowly in size. A systematic examination of the rest of the body revealed a series of tumors and pigmentations. These tumors were all subcu-
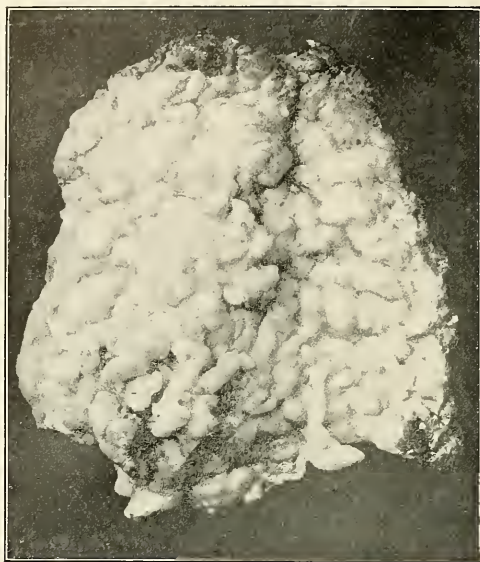
FIG. 150.—The Cutaneous Side of the Tumor Shown in Fig. 149, after the Removal of the Connective Tissue which Separated it from the Skin. Natural size. (*Deutsche Zeitsch. f. Chirurgie*, June, 1906.)

taneous, and movable between the skin and the deeper tissues. The pigmentations differed in appearance in different locations. The frontal tumor was benign and congenital. This rare and curious affection is less a tumor than a malformation of the peripheral nervous system. It may persist indefinitely without affecting the general condition. However, malignant degeneration may occur. The tumor was removed and the patient went away cured, eight days later. The structure of the tumor was that of a pure plexiform neuroma."

SURGICAL DISEASES OF THE LYMPHATICS.

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THE field of lymphatic surgery has greatly broadened in the last few years, especially in the treatment of tuberculosis and cancer. Tuberculous inflammation of the lymph nodes is one of the most common surgical diseases of children, and it is also common in adults. The class of cases which formerly was treated by constitutional measures, and allowed to pass through prolonged suppuration and the production of ugly cicatrices, is now regularly referred to the surgeon. The surgical treatment of cancer, too, depends very largely on the recognition of the path of its extension through the lymphatics, and, since surgery still offers the best prospect for the cure of this too common disease, the study of the infected lymphatics and the determination of the proper method of removing them are very important. Also, the lymphatic involvements in acute pyogenic infections, and in venereal and various other constitutional and parasitic diseases, frequently call for surgical treatment, as do various malformations and injuries.

Fischer,* in classifying the subject, considers the diseases of the lymph vessels and lymph nodes separately. He considers the lymph vessels under six headings:

1. Acute inflammation of the lymph vessels.
2. Chronic, not specific, inflammation of the lymph vessels.
3. Tuberculosis of the lymph vessels.
4. Lymphangitis syphilitica.
5. Carcinosis of the lymph vessels.
6. Dilatation of the lymph vessels (lymph varices).

The lymph nodes he considers under seven headings:
1. Acute inflammation of the lymph nodes.
2. Chronic, not specific, inflammation of the lymph nodes.
3. Tuberculosis of the lymph nodes.
4. Syphilis of the lymph nodes.
5. Primary tumors of the lymph nodes.
6. Secondary tumors of the lymph nodes.
7. Lymphadenocele.

* Fischer: " Krankheiten der Lymphgefässe, Lymphdrüsen und Blutgefässe," Deutsche Chirurgie, Lief. 24, a.

This classification makes an excellent basis for the consideration of the sub-ject, but for the purposes of this article the writer prefers a classification according to localities, believing that it will be more convenient for readers who may consult it with particular clinical cases in mind. In the study of the separate localities, however, he will follow Fischer's classification so far as possible.

I. SURGICAL DISEASES OF THE LYMPHATICS OF THE HEAD AND NECK.

This locality furnishes the majority of the lymphatic conditions which call for surgical treatment, probably three-fourths of the total number. In no other part of the body are there so many lymphatics collected in so small a space, and nowhere else are infections so common.

Anatomical Arrangement.—The general arrangement of the lymphatics of the head and neck is shown in the accompanying illustration, taken from Sappey (Fig. 151).

It will be seen that the lymphatics from the superficial structures and from most of the mucous membranes of the head lead to certain groups of lymph nodes, which form a sort of collar about the upper part of the neck. These groups, from behind forward, are: The occipital, the mastoid, the parotid, the submaxillary, and the submental. They are the first lodging places for infections from above. The areas which drain into each group are indicated in Sappey's illustration. The lymphatics from the posterior part of the scalp lead into the occipital group; those from the mid-scalp, into the mastoid and parotid groups; those from the upper part of the forehead and posterior part of the face into the parotid group; those from the lower part of the forehead, the nose, part of the lips, and most of the cheeks, into the submaxillary group; and those from the lower lip and chin, into the submental (suprahyoid) and in part into the submaxillary groups. The lymphatics from the front portion of the mouth lead in part into the submental and submaxillary groups, and in part backward into the deep cervical chain of nodes. Those from the back part of the mouth and pharynx lead into the deep cervical chain. There are numerous communications between these groups. Frequently infections from in front are carried backward, and those from behind are carried forward. Fig. 152, from Delamere, Poirier, and Cuneo, gives a diagrammatic view of the arrangement of these groups.

They have much clinical importance, since the site of infection can usually be determined by noting the place of first lymphatic enlargement, and the treatment can be definitely planned with this in mind.

The *deep cervical chain of lymph nodes* is the common collector of infections from the various superficial groups and from the lymphatics in the pharynx

and part of the mouth.   It is of great surgical importance and calls for special consideration.   Most of the cervical lymphatic infections come from the pharynx, and accordingly are first noticed in the upper part of this deep cervical chain. The appearance of these early infections is characteristic and is as nearly uni-
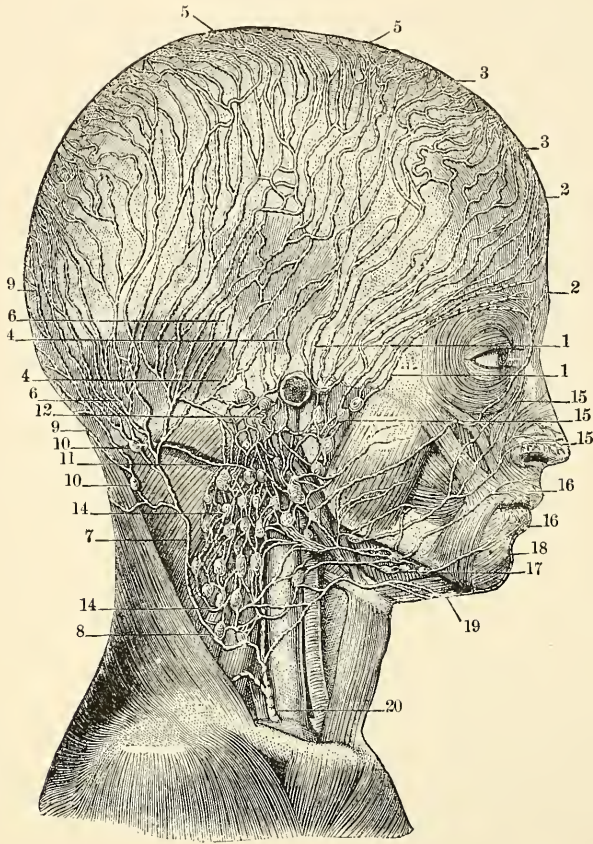
Fig. 151.—Ectal Lymphatics of the Head and Face, the Ental Lymphatics of the Neck, and the Right Common Lymphatic Trunk.   (Sappey.)   1, Lymphatics from the frontal region going to the parotid lymphatic nodes; 2, 2, vessels arising near the middle of the forehead, the upper ones going to the parotid, the lower ones to the submaxillary lymphatic nodes; 4, 4, vessels from the parietal and temporal regions extending to the mastoid lymphatic nodes; 6, 6, vessels from the parietal and occipital regions joining the occipital plexus; 7, trunk from occipital plexus to the supraclavicular nodes; 8, trunk from the occipital to the cephalic ental (superior deep) cervical nodes; 10, 10, occipital lymphatic nodes; 11, cephalic ental (superior deep) cervical nodes and plexus; 12, mastoid nodes; 13, parotid lymphatic nodes; 14, part of supraclavicular nodes; 15, 15, lymph vessels from the nose to the submaxillary nodes; 16, 16, lymphatics from the lips to the same nodes; 17, submaxillary nodes; 18, vessels from the lip to 19, the suprahyoid node; 20, right common lymphatic trunk opening into the veins at the angle formed by the junction of the subclavian and internal jugular veins.

form as any clinical symptom which we are accustomed to see.   Fig. 153 shows the location and appearance of these nodes in a comparatively early state of inflammation.   They can be felt just below and behind the angle of the jaw.

Wood* has recently published a most interesting study concerning the relation of these nodes to the tonsils. He has found that fluid injected into the tonsil passes through the lymphatics to one of these nodes, the same one as that marked A in Fig. 153. He described this as "placed just beneath the anterior border of the sterno-cleido-mastoid muscle, where it is crossed by the posterior belly of the digastric muscle, external and slightly anterior to the internal jugular
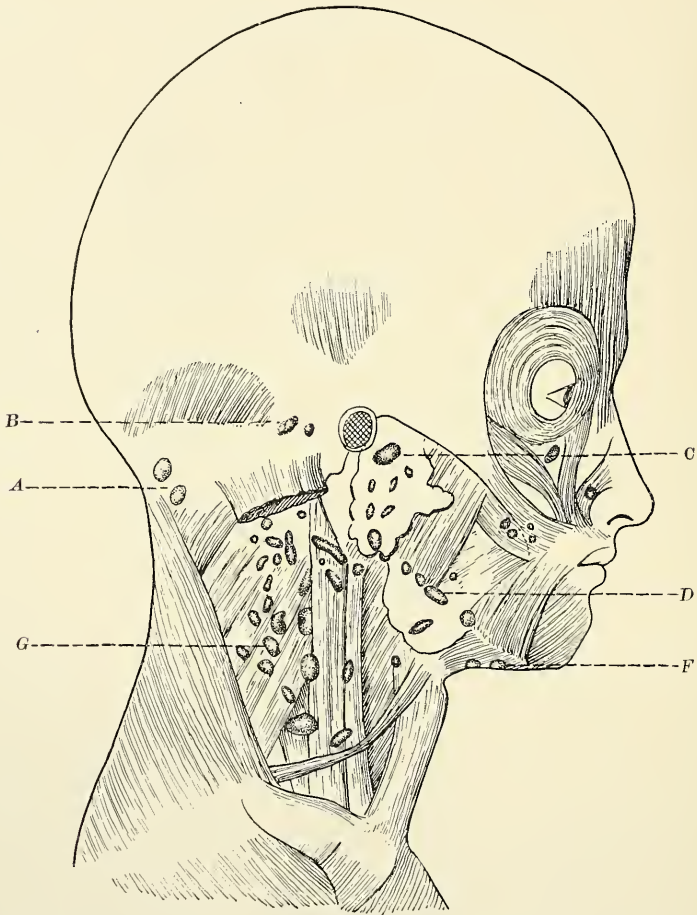
FIG. 152.—General Arrangement of the Lymph Nodes in the Head and Neck. (From "The Lymphatics," by Delamere, Poirier, and Cuneo.) A, Occipital group; B, mastoid group; C, parotid group; D, submaxillary group; F, submental group; G, deep cervical chain.

vein, embedded in loose areolar tissue containing more or less fat." He calls this the "tonsillar lymph gland." Since it is a structure of such great importance, it surely is well to accept this name; if not in its entirety, at least the term "tonsillar." (For designating these structures the word "node" is replac-

* Geo. Bacon Wood: "The Lymphatic Drainage of the Faucial Tonsils," in Am. Jour. Med. Sc.; Aug., 1905, p. 216.

ing "gland" in the usage of many authors.) Clinically, this node seems to be constant, and can be felt in the necks of most children.

Figs. 154, 155, and 156, taken from his article, show the location of this and the adjoining nodes. In a later communication he* records the results of injections of the pharyngeal tonsil; he finds that it drains into nodes under the sterno-cleido-mastoid, near its posterior upper border. The communications between these nodes and the adjoining ones are abundant. In operating for slowly progressing inflammations the surgeon has the op-
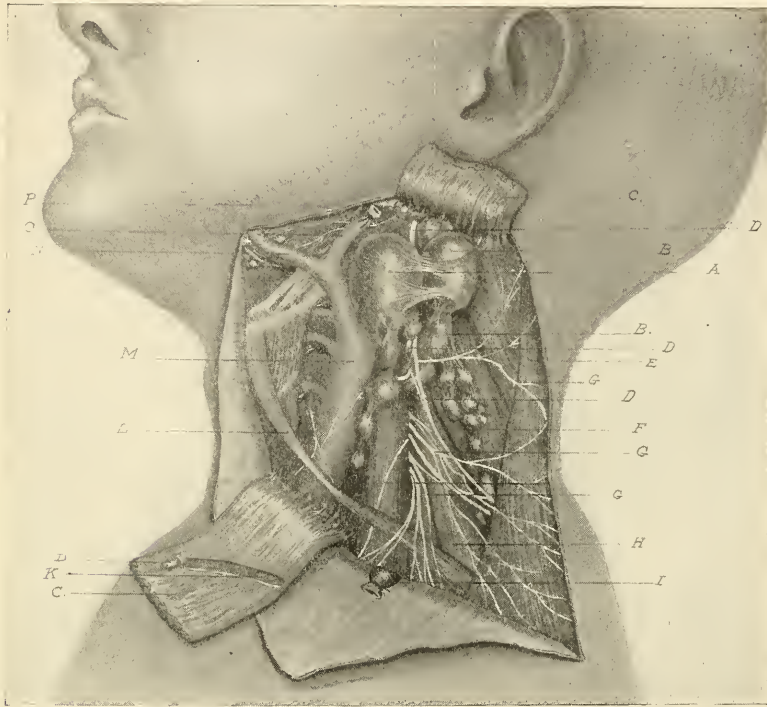
FIG. 153.—Early Tuberculous Infection of the Deep Cervical Chain of Lymph Nodes. *A*, Most prominent caseous node; *B, B*, caseous nodes under sterno-mastoid muscle; *C, C*, sterno-mastoid muscle; *D, D, D, D*, spinal accessory nerve; *E*, trapezius muscle; *F*, levator anguli scapulæ muscle; *G, G, G*, branches of cervical plexus; *H*, scalenus posticus muscle; *I*, external jugular vein; *K*, course of posterior branch of spinal accessory nerve cut from sterno-mastoid muscle; *L*, omo-hyoid muscle; *M*, internal jugular vein; *N*, facial vein; *O*, posterior facial vein (anterior division of temporo-maxillary); *P*, parotid gland. (*Annals of Surgery*, July, 1905.)

portunity of observing the path of infection. The upper nodes of the deep chain are regularly in a condition of more advanced inflammation than the lower nodes. The path of infection is downward along the internal jugular vein, and downward and backward on the insertions of the splenius, levator anguli scapulæ, and scalene muscles. Although the lower nodes of this group are affected less often than the upper, they still are capable of enlargement,

* Geo. B. Wood, in Amer. Jour. Med. Sc., April, 1906, p. 620.

and then form dense masses, mostly under the sterno-cleido-mastoid or the anterior part of the trapezius muscles. Frequently, enlarged nodes are found near the level of the clavicle, being near the apex of the lung and giving support to the theory that many cases of pulmonary tuberculosis receive their infection through the cervical lymphatics.

Acute Inflammation of the Lymph Nodes.—This is the most common of all the lymphatic affections of the neck. As a sequela of sore throat it is frequently seen, particularly in children. If the infection is not too virulent, swelling of the subparotid nodes, tenderness, possibly dysphagia, and moderate fever
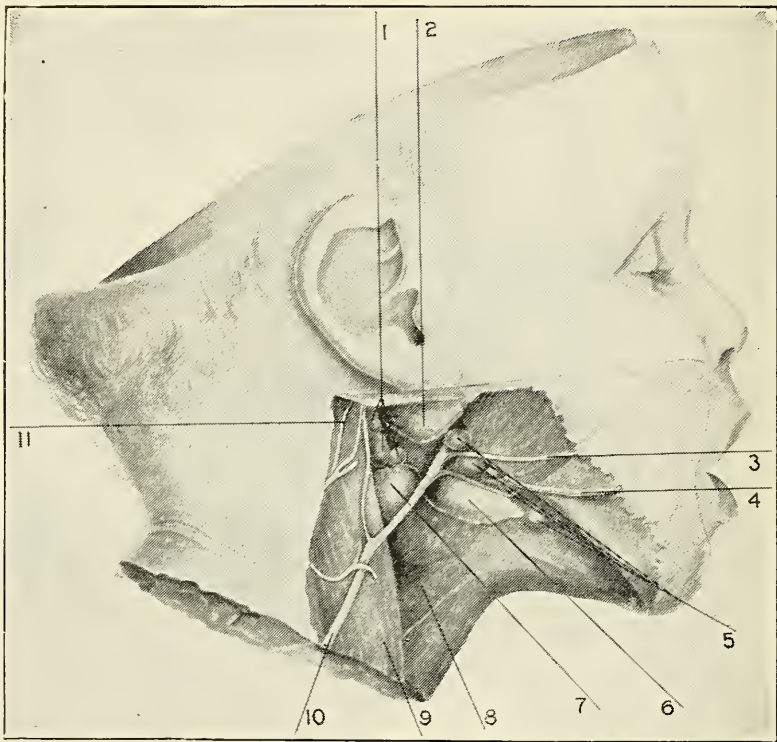
FIG. 154.—Superficial Dissection Showing Portion of Tonsillar Lymph Gland and its Relation to the Sterno-cleido-mastoid Muscle and the External Jugular Vein. 1, Lymph glands of the internal jugular group; 2, parotid lymph gland ; 5, submaxillary lymph gland; 6, submaxillary salivary gland; 7, tonsillar lymph gland; 8, omo-hyoid muscle; 9, sterno-cleido-mastoid muscle; 10, external jugular vein; 11, great auricular nerve. (Wood, in *Amer. Jour. Med. Sc.*, August, 1905.)

are the main symptoms. If the infection is derived from carious teeth, from sores in the mouth or on the lip, face, or scalp, or from the irritation of pediculi, eczema, etc., the site of the first swelling corresponds to the arrangement of lymphatics already given; the swollen nodes being, in a general way, below the site of infection. The enlargement and soreness usually appear suddenly and are often accompanied by a moderate elevation of body temperature.

The condition illustrates well the dual functions of the lymph nodes—as

filters and as germicides. The nodes are enlarged because the bacteria lodge there in their course through the lymphatics from the infected area, and, having gained a lodgment, they develop and cause a reaction. One may well picture a combat there: the growing power of the bacteria on one side, the inhibitive power of the phagocytes and the bodily cells and fluids on the other. Various forms of micro-organisms have been found in the lymph nodes during this stage, and sometimes chemical and mechanical irritants which have lodged there. The result of this combat will depend upon the virulence of the bacteria
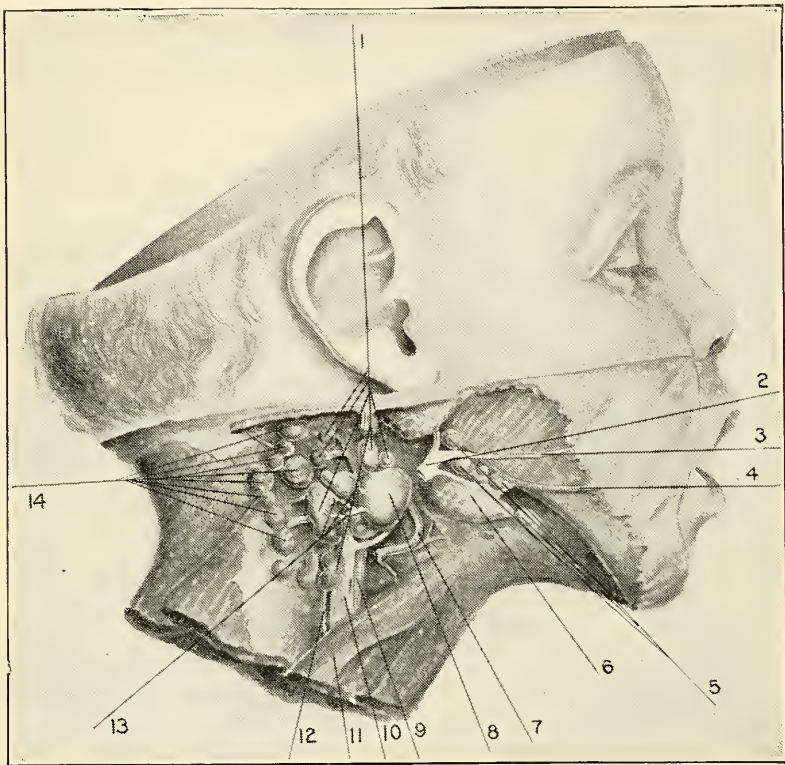
Fig. 155.—Deep Dissection of the Same Specimen, Showing Position of Tonsillar Lymph Gland and its Connection with Other Glands of the Substerno-mastoid Group. 1, Internal substerno-mastoid lymph glands; 2, external jugular vein; 5, submaxillary lymph glands; 6, submaxillary salivary gland; 7, superior thyroid artery; 8, tonsillar lymph gland; 9, common carotid artery; 10, internal jugular vein; 11, omo-hyoid muscle; 12, jugular lymph trunk; 13, efferent vessels of tonsillar lymph gland; 14, external substerno-mastoid lymph glands. (Wood, in *Am. Jour. Med. Sc.*, August, 1905.)

and the germicidal power of the patient's tissues. If the latter is great enough the inflammation will quickly subside. If the former is too strong for the latter, abscess formation will result. Or, if neither preponderates sufficiently, chronic hyperplasia will result.

Treatment.—The quick subsidence of the inflammation is, of course, the desideratum, and this should be promoted first of all by treating the local spot of infection. Local germicidal or cleansing sprays and applications for pharyn-

gitis or tonsillitis or rhinitis, incision and drainage of alveolar abscesses, suitable treatment or extraction of carious teeth, the incision of furuncles, the suitable treatment of eczemas and herpes, the removal of pediculi, are among the measures which are to be used for this end.

External applications at the site of the swelling are also usually employed. Ice bags or cold moist compresses, or ointments, such as ungt. Credé, emplast. kaoli, and ungt. plumbi iodidi, surely may make the patient more comfortable, and they probably tend to promote the subsidence of the inflammation. In the
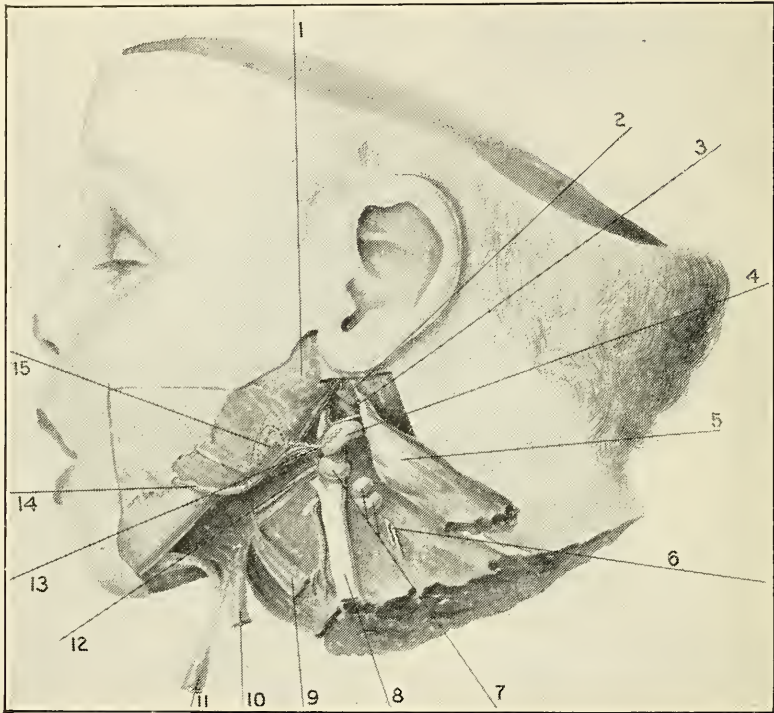
Fig. 156.—Deep Dissection of the Same Specimen, Showing the Efferent Lymph Vessels of the Faucial Tonsil Entering the Tonsillar Lymph Gland. The posterior belly of the digastric muscle and the whole of the stylo-hyoid muscle have been reflected downward. 1, Parotid gland; 2, stump of the stylo-hyoid muscle; 3, stump of the posterior belly of the digastric muscle; 4, tonsillar lymph gland; 5, reflected sterno-cleido-mastoid muscle; 6, brachial plexus of nerves; 7, substerno-mastoid lymph glands; 8, internal jugular vein; 9, omo-hyoid muscle; 10, stylo-hyoid muscle; 11, posterior belly of the digastric muscle; 12, hypoglossal nerve; 13, efferent lymph vessel of the faucial muscle; 14, facial artery; 15, position of faucial tonsil. (Wood, in *Amer. Jour. Med. Sc.*, August, 1905.)

use of external applications, however, one should avoid those agents which unduly irritate the skin and prevent a proper appreciation of the signs of deep inflammation.

Internal medicines and hygienic measures are to be advocated so far as they increase the strength and vigor of the patient, and iron, arsenic, and various forms of iodides are constantly being employed for this purpose, but those forms of iron which injure the teeth are distinctly to be avoided. In a fair propor-

tion of the cases the inflammation will subside under these measures, leaving nodes which are barely palpable.

Suppuration of the Cervical Lymph Nodes.—This condition, which represents the second possibility of acute inflammation, is a more serious affair, and presents many difficult problems. After the inflammation in the nodes has progressed sufficiently, soft spots of suppuration appear in their interiors, more and more of the node tissue is replaced by pus, until finally the capsules are ruptured, and abscesses, frequently of large size, are formed within or without the deep cervi-

Fig. 157.—Abscess of the Neck, beneath the Deep Cervical Fascia, Following Carious Teeth. (Photograph of patient in St. Mary's Hospital for Children, New York.)

cal fascia according to the location of the infected nodes. This process of abscess formation is most common in young children, among whom it is frequently seen. In adults cervical abscesses are rare, excepting those of the submaxillary form, which owe their origin to carious teeth. The diagnosis of beginning suppuration in enlarged cervical nodes is very difficult; one cannot tell whether the feeling of tension which the distended node gives is due to the pressure of pus or to the swollen node tissue, which is naturally soft. After pus has formed it is still difficult to determine its presence if it is under the deep fascia. The swelling and general sense of tension, however, are often an evidence of the existence of pus long before distinct fluctuation appears.

Treatment.—If the inflammation is mostly confined to a single node which has begun to break down into abscess cavities, the ideal treatment is to remove it before a general abscess results and at the same time to remove the adjoining enlarged nodes. Healing is very prompt after this procedure, the patient is saved from the depressing effect of progressive abscess formation, and the resulting scar, if properly placed, is insignificant. The dissection, however, is a delicate one and is not entirely free from danger, and a general anæsthetic is necessary; hence this method is not likely to be generally practised. Unless there is a reason for doing otherwise, it is better to keep the patient under careful observation until the abscess has formed, or at least until the disease has

Fig. 158.—Abscess of Neck beneath the Deep Cervical Fascia, Caused by Carious Teeth. (Photograph of patient in St. Mary's Hospital for Children, New York.)

advanced to the point where an incision will liberate some pus. The time of making the incision will vary with the diagnostic and operative skill of the surgeon. It is, for instance, not often necessary to permit an abscess to go unrelieved until the condition reaches the stage which is shown in Figs. 157 and 158— photographs of a boy recently admitted to St. Mary's Hospital. His suffering is unmistakably revealed in his face, as well as in the appearance of his neck.

The selection of the site of incision of cervical abscesses is important and varies with the variety of abscess. In little children, as has already been stated, these abscesses usually follow suppuration of the subparotid nodes, and are located under the deep cervical fascia and sterno-cleido-mastoid muscle. The

pus comes near the surface in two localities: (1) Behind the upper margin of the muscle, close to the hair line; and (2) in front of the middle of the muscle at about the level of the larynx. The former is the preferable site for incision, since at this spot there are no important structures which are likely to be injured; since an opening made here drains well when the patient is in the recumbent position; and also because the resulting scar is inconspicuous. If the abscess has perchance burrowed far forward, an instrument or the finger may be introduced through this posterior incision and carried to the anterior part of the neck, where a small transverse counter-opening may be made. This anterior incision is necessary only in a part of the cases, perhaps in one out of three or four. Drainage should be used. If two openings are made, six or eight strands of silk thread or silkworm gut may be run through the cavity, into one opening and out of the other, and tied outside. If there is only one opening, a thin-walled rubber tube or a strip of gauze covered with rubber dam may be used. The dressing should be kept moist, so that the discharge will be absorbed.

Occasionally, in these subparotid abscesses, the primary incision should be made in front of the sterno-cleido-mastoid muscle. Much care should then be used, since the large veins are not far distant, although they are pushed inward by the abscess.

Nitrous-oxide anæsthesia is usually sufficient for making the incisions. They are frequently made under chloride of ethyl spray locally applied.

The submaxillary type of cervical abscesses usually occurs in older children and adults, and forms deep phlegmons, which occupy a position farther forward than the subparotid type. Simple alveolar abscesses can, of course, be successfully incised from within the mouth, but the abscesses which come from the breaking down of the submaxillary lymph nodes can seldom be successfully treated without external incision. Figs. 157 and 158 show the appearance of these abscesses in an advanced stage. The point where an abscess of this character should be incised is also a matter of importance, since the branch of the facial nerve (ramus colo-mandibularis) which supplies the depressor labii inferioris is often cut in incising them. (See the section on Tuberculous Nodes.) The incision should be made at least a finger's breadth below the border of the jaw, or in front of the place where that border is crossed by the facial artery.

Retropharyngeal abcesses, at least the form which is due to suppuration of the retropharyngeal lymph nodes, should also be considered in this connection. These lymph nodes, which were described many years ago (Texier: *Centralblatt für Chirurgie*, 1904, p. 585), lie symmetrically on each side of the median raphé at the back of the pharynx. They are contained in aponeurotic pockets which lead downward toward the mediastinum, and which are separated from the large vessels and nerves of the neck by aponeurosis. These vessels, therefore, are pushed outward when an abscess forms. The nodes

undergo atrophy at about the third year, and therefore the abscesses occur before that time. Holt quotes Bokai as reporting that 42 out of 60 retro-pharyngeal abscesses occurred in the first year, 11 in the second, and only 7 at a later period. These nodes become infected from the pharynx and nose. The rhino-pharyngitis which follows epidemic influenza, or which is associated with a syphilitic coryza, with scarlet fever, or with tuberculosis, may give the infection.

Symptoms.—There may be an interval of a few days between the acute pharyngitis or rhinitis and the appearance of the retropharyngeal swelling. This swelling usually comes on with a moderate rise of body temperature, and often in little children the first local symptom which will be noticed is dyspnœa. There are usually some prostration, a change in the quality of the voice, and sometimes difficulty in swallowing. The dyspnœa may increase until it is alarming. It is in this stage that the diagnosis of diphtheria is often made. One of the Health-Department inspectors in this city recently told the writer that he had seen twenty of these cases which had been reported to that department as probable diphtheria. The diagnosis can be made by putting the finger in the mouth and pressing on the posterior pharyngeal wall, where a soft fluctuating swelling can be felt.

Prognosis.—The prognosis is good if the pus is promptly evacuated, although the general mortality has been reported as from 5 to 10 per cent.

Treatment.—The incision should be made with a scalpel, the edge of which has been protected nearly to the point by a wrapping of adhesive plaster. This may be guided on the finger and the incision easily made from within, an assistant in the mean time holding the head and quickly turning it over after the incision has been made, so that the pus may readily escape from the mouth. The pus that is thus set free seldom amounts to more than two or three drachms and the quantity is sometimes less than that. These retropharyngeal abscesses are to be distinguished from the retropharyngeal swellings which may accompany large cervical abscesses of the kind previously described, and which promptly subside when those abscesses are opened from without. They should also be distinguished from the retropharyngeal abscesses which are due to tuberculous disease of the cervical vertebræ, and which contain very much larger amounts of pus. The diagnosis of these vertebral abscesses can be made by distinguishing the rigidity of the cervical spine. They should be incised from without, as it is dangerous to open them into the throat and liberate the large amount of pus which they sometimes contain, and it is not well for the patient to have a tuberculous abscess discharging into the pharynx, nor is it well to incur the likelihood of infection being conveyed to this abscess cavity from the throat.

Ludwig's angina should also be referred to in this place. This term dates from 1836, when Ludwig, a Stuttgart surgeon, described a series of submaxil-

lary phlegmons of much severity. It has been applied to various forms of severe inflammations in this locality. Although the inflammation may spread through the abundant lymphatics of the locality, it also spreads by continuity of tissue and hence cannot be considered strictly a lymphatic disease. (Ludwig thought that the lymphatics were not involved.) In the typical cases the "floor of the mouth and the intermuscular and subcutaneous tissue of the submaxillary region" are involved in a tense phlegmon which tends toward gangrene.* The onset of this inflammation is usually sudden, being characterized by dyspnœa and dysphagia; and severe constitutional reaction may follow. Of the early cases reported the mortality rate was 43 per cent. In a case which the writer observed there was an old syphilitic history and the phlegmon progressed to a fatal issue in spite of early and extensive incisions and drainage, which were repeated as the inflammation extended. The case had all the characteristics of a profound streptococcus infection in a patient of slight resisting power. Other cases reported † ‡ suggest similar conditions, although the Staphylococcus pyogenes aureus, alone or in addition to the streptococcus, has been found.

Teeth which were carious or otherwise abnormal have usually furnished the point of infection.

It is doubtful whether this form of phlegmon should have a distinct name or be assigned to a distinct classification; but, as the name has held for seventy years and as the condition which it designates is one of a most serious nature, causing great anxiety to those who are familiar with it and with the mortality rate, it is thought best to retain it. The employment of such a special term emphasizes the seriousness of these severe submaxillary infections and the importance of making a prompt incision and establishing drainage when the disease is discovered.

The acute inflammations which come from pediculosis or from furunculosis of the scalp usually show themselves in the posterior part of the neck, and are more superficial than those already described. Deep abscesses seldom form under these circumstances; when they do, they are usually about the nape of the neck and heal promptly after an incision.

Chronic Non-Specific Inflammations of the Cervical Lymph Nodes.— Chronic enlargement of the lymph nodes of the neck is very common. It has been found that the vast majority of school children in ordinary health have palpable subparotid lymph nodes, and they are not uncommon in adolescents and adults.

Etiology.—These enlarged lymph nodes seem due to infection from the throat, mouth, nose, ear, face, or scalp. Frequently they follow the acute in-

*Newcomb, in N. Y. Med. Journal, Nov. 23d, 1895, p. 652.
†Rose, in Annals of Surgery, June, 1901, p. 720.
‡Davis, in Am. Jour. Med. Sc., Feb., 1904, p. 263.

fections already described, but occasionally they are chronic from the begin-. ning. The distribution and the points of infection are the same as in the acute forms. Enlarged tonsils and pharyngeal adenoids, carious teeth with inflam- mation of the gums about them, eczemas, ear inflammations, and pediculosis are the most common causes.

Course.—These enlarged nodes are usually subject to variations, increas- ing with new infections and diminishing with their subsidence. They frequently last for years and then subside. Tuberculosis sometimes intervenes.

Pathology.—Fig. 159 indicates the gross appearance of some of these nodes which were removed during an exacerbation. On section they show simple hyperplasia. In cases of long standing the connective tissue of the capsule and trabeculæ is increased much more than the parenchyma of the node. The cut surface is pale red, with the fibrous markings usually well shown; sometimes

Fig. 159.—Hyperplastic Cervical Lymph Nodes which had Reached an Unusual Size without Pus Formation. Diameters of largest node: $1\frac{2}{3}$, $1\frac{3}{4}$, and $1\frac{1}{8}$ inches. (Drawing of specimen; St. Mary's Hospital for Children, New York. *Annals of Surgery*, July, 1905.)

pigment or even fatty or calcareous degeneration or advanced fibrous change may be seen.

Diagnosis.—The main interest in this condition hinges on the difficulty in making the diagnosis between chronic simple hyperplasia of the cervical nodes and tuberculous disease of these structures. This difficulty and other elements in the question of diagnosis are considered in the section on Tuberculosis of Lymph Nodes. Suffice it to say here that the diagnosis cannot always be cor- rectly made without the removal of one or more of the nodes, and in cases of much doubt it is far better to do this than to incur the risk of an advancing tuberculosis.

Prognosis.—The prognosis of this condition is good if the source of infec- tion can be removed. The enlargement subsides after such removal. One must, however, always bear in mind the connection between chronic hyper- plasia of the nodes and tuberculosis. Clinically, we often see tuberculosis in nodes which have been long enlarged. Pathologically, we do not know whether they were tuberculous from the start or whether the tuberculous infection was added to nodes that were simply enlarged. Probably both of these processes

occur. In giving a prognosis in individual cases, however, the physician must bear in mind the possibility of tuberculosis.

Treatment.—The treatment is to be carried out on the lines already given for acute inflammation of these nodes. It comprises:

1. The removal of the local source of infection.

2. The local application of substances which are believed to promote absorption.

3. The use of those measures which will increase the resisting power of the patient.

4. The removal of the nodes by operation when they do not subside under treatment, or when there is fair reason for believing them to be tuberculous.

The first three of these measures are considered in the section on Acute Inflammation of Lymph Nodes. The ablation of enlarged tonsils and adenoids and the treatment of middle-ear disease and carious teeth are the most important elements in this treatment.

Tuberculosis of the Cervical Lymph Nodes.—This is the most important surgical disease of the lymphatic system. It is more common in childhood and adolescence than in adult life; it is very rare in children under two years of age. Fischer's collection of 1,484 cases, reported by nineteen authors, gives the following age distribution:

Age in Years.	No. of Cases.	Age in Years.	No. of Cases
1– 5	59	31–35	63
6–10	120	36–40	43
11–15	233	41–45	25
16–20	469	46–55	29
21–25	282	56–66	18
26–30	130	Not stated	13

Tuberculosis is more common in the cervical lymph nodes than in those located in any other part of the body. Wohlgemuth,* Poisson, and Von Noorden† found, respectively, 93, 90, and 88 per cent of their cases of lymph-node tuberculosis located in the neck.

Among 212 consecutive cases of surgical tuberculosis in St. Mary's Free Hospital for Children in New York there were:

    49 located in the cervical lymph nodes;

      6 in the inguinal lymph nodes;

  146 in bones and joints;

     5 in the peritoneal cavity;

     3 in the epididymides;

     2 in the skin;

     1 in the kidney.

*Wohlgemuth: Inaug. Dis., Berlin, 1889.

† Van Noorden, in Bruns' Beiträge, vi., p. 607.

It occurs with the greatest frequency among those who live in bad hygienic surroundings; and yet, out of 100 cases recently reported by the author, 26 were living under fairly good hygienic conditions. The throat seems to be the most common point for the ingress of the infection. In 86 per cent of the previously mentioned 100 cases the distribution indicated that the infection had come from the throat. Wood's articles, previously referred to, show the direct enlargement of the subparotid and submastoid lymph nodes from injection into the faucial and pharyngeal tonsils, and many observers have found tuberculosis or tubercle bacilli in the pharynx. Among them we may mention Lewin and Dieulafoy. The former found tuberculous infection in 5 per cent of the pharyngeal adenoids removed from 200 patients; the latter inoculated guinea-pigs with material derived from the faucial tonsils of 61 children apparently non-tuberculous, and tuberculosis developed in 16.4 per cent of the pigs. Wright* and Cornet† report that they found tubercle bacilli in nasal mucous membrane which was apparently healthy, and there is abundant evidence that these bacilli can pass through the mucous membrane without leaving visible change, and can be taken up by the lymphatics.

It is also noteworthy that a large proportion of the patients with tuberculous cervical lymph nodes who come to operation in this city and vicinity present themselves for treatment in the late winter and early spring; i.e., at the period immediately following that in which throat inflammations are so prevalent.

The infection occasionally comes from lupus about the face or head; also from the front part of the mouth; carious teeth and the inflammation of the gums about them furnishing the apparent site of infection.

Course of the Disease.—In most of the cases it will be found that enlarged lymph nodes have existed for months, or even for years, before the diagnosis of tuberculosis is made. In 58 per cent of the writer's cases the duration was given as more than a year. Occasionally, however, an acute history is given, the attention of the patient or his parents being first called to the fact by a rapidly enlarging node in the neck. The suddenness of this onset not infrequently leads to a wrong diagnosis. In many such instances the nodes must have been enlarged longer than the patient or his parents knew, for, back of the one which has suddenly enlarged and softened, there will be found others with tubercles which are apparently of long standing. The appearance of the cases which are not far advanced is shown in the accompanying photographs (Figs. 160, 161, 162, and 163).

Fig. 160 is the most characteristic.

Occasionally cases are seen in which the infection localizes itself in the parotid, the submaxillary, or the submental nodes, as shown in Figs. 164–166. All of

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*Wright, in Med. News, Jan. 19th, 1901.
†Cornet, in Trans. of Chirurg. Cong., 1899, i., p. 138.

Fig. 160.—Tuberculous Cervical Lymph Nodes at a Comparatively Early Stage. The condition is most marked in the subparotid group. (Photograph of patient in St. Mary's Hospital for Children, New York.)

Fig. 161.—Tuberculous Cervical Lymph Nodes. The condition is shown particularly well in the subparotid group. (Photograph of patient in St. Mary's Hospital for Children, New York.)

these conditions may exist for many months without much apparent· change. The tendency, however, is toward the involvement and gradual enlargement of a constantly increasing number of nodes. Fig. 167 shows the appearance of a case in which a deep cervical abscess had developed; and in Fig. 168 is shown the appearance of a case in which the disease had made a still farther advance without abscess formation. In many instances one or more of the nodes will break down and suppurate if not otherwise treated. These nodes will slowly discharge for a long period and may finally heal, only to be followed by the breaking down of one of the others of the group. This process may keep on for years if general infection does not previously take place.

FIG. 162.—Tuberculous Cervical Lymph Nodes, Those in the Subparotid Group being the Ones Chiefly Affected. (Photograph of patient in St. Mary's Hospital for Children, New York.)

The disease is a serious one; its slow course has often led to the statement that it does not involve much danger to other structures, but studies which cover long periods of time show that other organs are frequently involved.

Demme, in reviewing the first twenty years' work in the Jenner Children's Hospital in Berne, found the following results from 1,692 children with lymph-node tuberculosis*:

Developed tuberculosis of	lungs,	145	= 21 per cent.
" "	intestine,	24	
" "	pia mater,	25	57 = 8.2 per cent.
"	kidneys,	6	
" "	epididymis,	2	
Total,			29.2 per cent.

There have been many other studies on the subject, among which we will mention those of Von Noorden, Blos, and Fischer. The former ascertained the histories of 149 patients from the Tübingen clinic, and found that 28 had died

* "Bericht ueber die Thätigkeit des Jennerschen Kinderspital in Berne," 1882.

Fig. 163.

Fig. 164.

Fig. 163.—Tuberculous Cervical Lymph Nodes, the Largest Number being in the Subparotid Group. (Photograph of patient in the General Memorial Hospital, New York).

Fig. 164.—Tuberculous Inflammation Starting from the Lymph Nodes in the Parotid Gland. (Photograph of patient in St. Mary's Hospital for Children, New York).

Fig. 165.

Fig. 166.

Figs. 165 and 166.—Tuberculosis of Submaxillary and Submental Lymph Nodes. (Photographs of patients in St. Mary's Hospital for Children, New York. *Annals of Surgery*, July, 1905.)

of tuberculosis and that 14 were suffering from the disease at the time when they were examined; that is, 28 per cent in all.

Blos* followed the histories of 160 cases from the Heidelberg clinic. Twenty-six per cent had lung tuberculosis, 14 per cent had tuberculosis in other organs.

Fischer tabulated the literature from 1,273 cases, including the above. The results were: 57.65 per cent cures and 21.84 per cent of local recurrences, while 13.5 per cent died almost entirely from tuberculosis. These statistics, which represent the results obtained after careful treatment, indicate beyond question the seriousness of the disease.

Pathology.—Observers differ in their beliefs as to the beginning of this inflammation, some maintaining that tuberculous inflammation is added to

Fig. 167.—Tuberculous Cervical Lymph Nodes, with Deep Abscess due to the Breaking Down of the Nodes. (Photograph of patient in St. Mary's Hospital for Children, New York.)

nodes which are already in a hypertrophied condition as a result of simple inflammation, while others believe that hypertrophy of the nodes follows the tuberculous infection and is simply one of the evidences of its presence. One may well believe that both of these processes occur; that nodes which are hyperplastic also become tuberculous; and that hyperplastic inflammation is one of the accompaniments of tuberculous inflammation.

Several observers* have found that enlarged nodes, in which tuberculosis was not detected by the microscope, have nevertheless given rise to a tuberculous infection when injected into guinea-pigs. This indicates the probability that much of the so-called simple hyperplasia is really in a large measure due to tuberculous infection.

* Blos, in Mittheil. aus den Grenzgebieten der Med. und Chir., iv., p. 520. See Posenberger, in Am. Jour. Med. Sc., July, 1905, p. 95.

The nodes manifest great differences in the extent to which they are adherent to the surrounding tissues. When the inflammation has existed for a long period the adhesions are usually much firmer and much more abundant than in the recent cases; indeed, the prognosis can in a measure be based on the density of these adhesions for the cases in which dense adhesions surround the
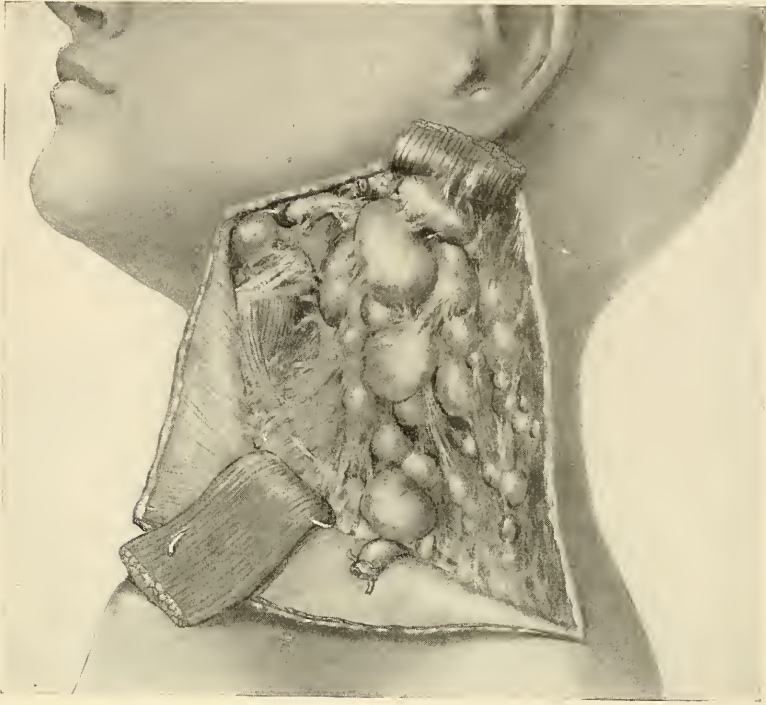
Fig. 168.—Appearance of Lymph Nodes in State of Extensive Tuberculosis. (*Annals of Surgery,* July, 1905.)

tuberculous focus offer a better prognosis than those in which such adhesions do not exist. Occasionally a node is adherent to a vein, as shown in Fig. 169. The tuberculosis is usually confined to the nodes and does not extend to the surrounding tissues until rupture takes place.

Fig. 169.—Capsule of Tuberculous Lymph Node Adherent to Internal Jugular Vein. (Drawing from Patient at St. Mary's Hospital.)

If the enlarged nodes are cut across and the cut surfaces inspected, it will be found that at least three varieties exist, viz.:

1. Those showing soft pinkish-gray surfaces of almost uniform consistency, but with the trabeculæ of the nodes faintly marked.

2. Those showing spots of necrosis of greater or less extent, the tissue surrounding these spots being similar to that already mentioned.

3. Those showing the interior entirely broken down into granular grayish material which is retained by the node capsule.

1. The *first variety* is usually only shown in the early stages of the inflammation, and is often seen in groups of nodes in which the second variety is also found. Occasionally, however, one sees masses of nodes which have been enlarged for long periods and which range in size from large hickory nuts to beans, which do not show necrotic spots, but which look like hyperplastic nodes. Nevertheless, on microscopical examination these nodes, which seem to be the seat of a simple hyperplasia, prove in reality to be studded with miliary tubercles.

Fig. 170.—Tuberculous Lymph Node, showing Caseous, Necrotic Areas. (Drawing of specimen; St. Mary's Hospital for Children, New York.)

2. The *second variety* is by far the most common. Fig. 170 indicates the appearance of a group of such nodes. The spots of necrosis extend until almost the entire node is caseous (Fig. 171), and then soft material breaks through the node capsule.

3. The *third variety* is not common; the writer has seen only one case, a rapidly growing one. Each node capsule was filled with material which looked like caked meal, no proper node parenchyma being apparent. On microscopical examination this soft tissue was found to be studded with tubercles.

Diagnosis.—The diagnosis of this condition is not always easy, particularly in its early stages. The chief difficulty is in making the distinction between simple hyperplastic inflammation and tuberculosis. One frequently sees patients with nodes half or three-quarters as large as those shown in Fig. 160, and may be greatly puzzled to determine whether they are tuberculous or not. The writer has followed such nodes through periods of two or three years, has finally removed them, and has found that they were tuberculous. Other nodes, perhaps smaller in size and less subject to enlargement after sore throats and colds, he has seen disappear; or, on removal, he has found them free from tuberculous disease.

The great majority of nodes which are located in the classical subparotid region, which are as large as hickory nuts, and which have been present for several months, are tuberculous. If one is not able to make the diagnosis in such cases it is surely permissible to remove a node for the purpose of making a diagnosis.

The resulting scar can hardly be seen, and the absolute diagnosis can then be made. When one of the nodes has softened and has discharged caseous matter or pus through the skin, and a sinus exists, one may be practically sure that the fundamental disease is a tuberculosis. When, in the presence of an unbroken skin the upper nodes are found to be soft, even though the softening has appeared suddenly, and when the lower nodes extending toward the clavicle are progressively smaller, tuberculosis is also indicated. This is quite differ-
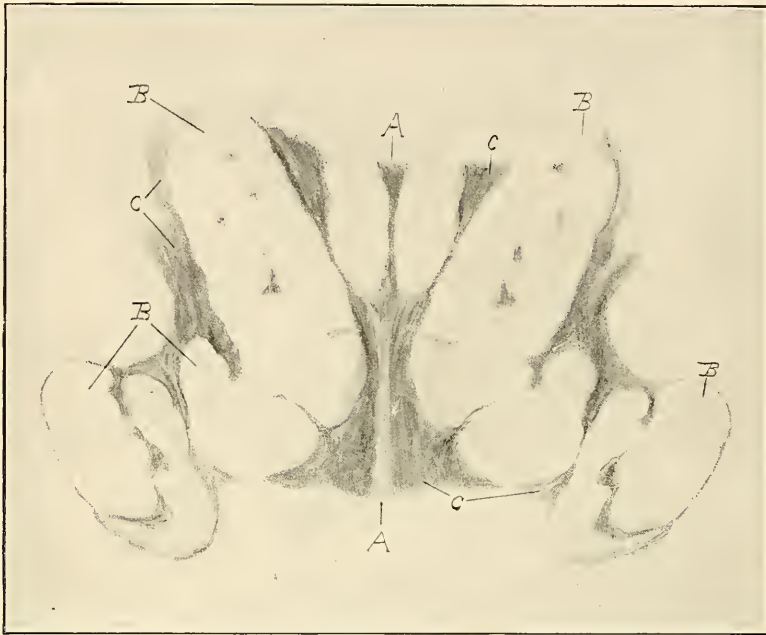
Fig. 171.—Split Group of Tuberculous Nodes, showing the Extent to which Caseation May Progress before Rupture of the Capsule takes place. (Drawing of specimen; General Memorial Hospital, New York.) A, Edge of incision on which the nodes are laid open like a hinge; B, tuberculous tissue of soft consistence, smooth surface, and pale yellow color; C, unperforated capsule of a node, and small remaining part of the parenchyma which is not in a caseous state.

ent from the non-tuberculous deep abscess formation which occurs in young children, and from the submaxillary abscesses which owe their origin to carious teeth.

Lymphosarcoma and the enlarged nodes in Hodgkin's disease may also closely resemble tuberculous nodes. Under these conditions, however, the nodes are much more nearly uniform in size; they do not soften and break down, and nodes in other parts of the body are likely to be affected at the same time. In suitable cases, after the removal of nodes which seem to be lymphosarcomata, animal injections should be made, since Fischer records a case in which abundant eosinophilic cells, lymphocytes, and a few epithelioid cells were found, but no giant cells, retrograde changes, or tubercle bacilli. Yet inoculation of rab-

bits demonstrated the existence of tuberculosis, and the clinical course of the disease supported the diagnosis.

Syphilitic nodes may resemble tuberculous nodes, but they are usually accompanied by other signs of syphilis. These signs should always be looked for, and in doubtful cases antisyphilitic treatment should be used.

Branchial cysts are often mistaken for tuberculous nodes. They are usually single, however, but are frequently situated in the subparotid region. When such a cyst is situated lower down or farther forward in the neck, it is usually accompanied by a sinus which opens near the median line.

FIG. 172.—Photograph of a Patient with Tuberculous Cervical Lymph Nodes who had been treated for one year by lancing the separate nodes as they softened and dressing the running sores. The disfigurement from this treatment is far greater than that which comes from prompt operation. Fig. 173 shows how many diseased nodes still remained after this course of treatment. (St. Mary's Hospital for Children, New York.)

Actinomycosis is uncommon in this locality. It is usually accompanied by a granulating surface, and the ray fungus can be found.

Treatment.—Many forms of treatment have been used for this disease, all the way from the "king's touch" to radical removal, and the history of medicine might be well sketched in studying the methods which have been devised for the treatment of "scrofula." Medication and hygienic measures are followed by a cure in a certain proportion of cases. Iodide of potassium, arsenic, and iron have been the most commonly used medicaments, and a few physicians strongly advocate their use at least for a time in all cases. Counter-irritants,

the injection of various substances, and incision and drainage of softened nodes have been the most commonly used palliative local measures.

The effect of seaside air has its advocates, but the writer has been unable to find statistics giving the ultimate results of such treatment; and, besides, operations have been very largely used in these institutions. In fact, some of the best descriptions of operations have come from them. The x-ray is also used, but it is surely more dangerous and much less certain in its results than operative interference.

Surgical measures are being more and more widely acknowledged as furnishing the most successful method of treating the disease.

The operation required is safe; the mortality rate being nil or less than one per cent in the hands of many operators of large experience. The results are better than those which have been recorded from other methods of treatment after long periods of observation. The resulting scars are far less disfiguring than those which come from suppurating nodes and open sinuses. (See Fig. 172.) It must appeal as the rational method to any one who notes how large is the proportion of caseous and necrotic nodes among even the moderately extensive cases of tuberculosis of cervical nodes. It seems far better to remove them than to trust to uncertain methods which leave dangers of further infection from each of the tuberculous foci.

Before giving the details of the operation, I may be permitted to call attention to a custom which is so prevalent that it must fall under the observation of all physicians—the custom of believing, when such nodes are discovered in the neck, that only one or two are enlarged, and that consequently the removal of a single node, or possibly two nodes, through a small incision is sufficient. In other words, the operation is considered a minor affair, a procedure that may be carried out by those who are unaccustomed to surgical work. From this position the writer dissents vigorously, as the nodes located under the sterno-cleido-mastoid muscle should be removed in every case when the node in front of it is also removed, and this is an operation of some delicacy, since the internal jugular vein and spinal accessory nerve are both in close apposition to the nodes.

Operative Measures.

The details of the operation may be considered under the following headings: *Incision ; Relation of the operation to nerves, vessels, and muscles ; Method of wound treatment.*

The Incision.—The incision which is shown in Fig. 174 is an important one in these cases. A transverse incision is to be desired in neck operations because the resulting scar is insignificant. In almost all necks there are creases which run transversely, and, if an incision is made in one of these creases, or parallel to it, the resulting scar will not stretch, since there is no tension on the skin.

On the other hand, longitudinal incisions tend to stretch; and in a neck in which there are both longitudinal and transverse incisions, the writer has frequently seen the longitudinal scars a quarter or even a half inch in width, whereas the transverse ones were hardly to be seen. Dr. Mayo, of Rochester, Minn., has called attention to the efficiency of firmly stitching the fascia to prevent this stretching of longitudinal scars, and the writer has had the pleasure of seeing very fine linear longitudinal scars which he had secured in this way. The firm stitching of the fascia is surely to be advocated, whatever form of incision may be adopted. The transverse incision shown at A, Fig. 175, may well be used in cases of moderate severity. A posterior incision (B, Fig. 174) or a posterior and transverse incision (B, Fig. 175) may be used as an aid if a thorough enucleation is not possible through the upper incision.

Fig. 173.—Tuberculous Lymph Nodes Removed from the Patient Shown in Fig. 172. The number and size of the nodes indicate the futility of this method of treatment, at least in this instance. The larger nodes were $1\frac{3}{4}$ and 2 inches in diameter.

Where, however, there is a very extensive involvement of the nodes in the neck it is usually better to make a longitudinal incision either along the posterior border of the sterno-cleido-mastoid muscle and forward above the clavicle or along the anterior border of that muscle and backward above the clavicle, thus giving the first access to the nodes from below and removing them from below upward. In certain instances it may be necessary to extend any incision which is used, and this may be done to meet the emergency of the case.

Nerves Exposed in the Operation.—The nerves which come into the field are, first, the *great auricular*, which runs upward, parallel to the external jugular vein and a little back of it. Its section is not important, since the anæsthesia which results is usually temporary. The other superficial branches from the cervical plexus which send sensory filaments to the skin of the entire vicinity are also unimportant, since they soon regain their function after being cut.

The branch of the *facial nerve* which supplies the depressor labii inferioris and which passes below the border of the jaw, is, however, of much importance. Fig. 176 shows a dissection of this nerve. It is called in some of the anatomies the supramaxillary branch of the facial nerve. It has been particularly studied

by Jaffé * and Frohse and Bockenheimer.† It runs about half an inch below
the angle of the jaw. Jaffé made many dissections and found that it runs some-
times three-quarters of an inch, or even more, below the angle of the jaw. It
then goes gradually upward and forward and crosses the border of the jaw at

Fig. 174.—An Incision which Gives Access to the Upper Nodes of the Deep Cervical Chain which are
Usually First Enlarged. (*Annals of Surgery*, July, 1905.)

about the location of the facial artery, and is finally inserted into the depressor
labii inferioris (quadratus menti).

When this nerve filament is cut, a very awkward paralysis of the mouth
results, which is shown in the accompanying photograph (Fig. 177). The trans-
verse incision should, therefore, be made at least a finger's breadth below the

* Jaffé: "Isolirte Lähmung des Musculus Quadratus Menti," etc., in Archiv für klin. Chir.,
lxvii., p. 736.
† Bockenheimer, in Langenbeck's Archives, Band lxxii., p. 461.

angle of the jaw. It should then be carried through the platysma and deep fascia, which should be retracted upward, carrying the nerve which lies between these structures. In more than forty operations which the writer has done in this way with this particular paralysis in mind, there has been no permanent evidence of nerve injury. Even when the nerve is cut, it often reunites, but

FIG. 175.—Two Incisions which Give Access to a Large Part of the Neck and Leave only Faint Scars Above the Line of the Collar. The lower incision gives access from behind if the nodes under the sterno-mastoid muscle are not removed through the upper one. (*Annals of Surgery*, July, 1905.)

the number of paralyses which one sees in patients whose necks have been operated upon indicates that this nerve injury has frequently been permanent.

The *spinal accessory nerve* runs directly through the group of lymph nodes which are most frequently enlarged, and it should be guarded with the greatest care during their removal. If this bunch of nodes is removed *en masse* the

nerve must be taken with them. Therefore, a most painstaking separation of the nodes must be made until the nerve is detected. It emerges from the jugular foramen, close to the spinous process, and passes into the under border of the sterno-cleido-mastoid muscle. (See D, Fig. 153.) It also emerges from the sterno-cleido-mastoid muscle at the junction of its middle and lower thirds, and passes into the trapezius. In this locality it lies beside the branches of the cervical plexus, and may be easily cut in dissecting out nodes of the posterior chain.

Fig. 176.—Dissection showing Lower Filaments of the Facial Nerve, Especially the "Ramus Anastomoticus Collomandibularis" (Jaffé), which Supplies the Depressor Labii Inferioris. A, Cervicofacial division of the facial nerve; B, ramus anastomoticus collomandibularis; C, filament to platysma myoides; D, parotid gland; E, deep cervical nodes; F, platysma myoides. (Drawing from a dissection by Dr. Draper, Columbia University, New York. Annals of Surgery, July, 1905.)

Its section in the upper locality may be followed by an atrophy and paralysis of the sterno-cleido-mastoid muscle and the trapezius, with a very awkward drooping of the shoulder. Section in the lower location gives a weakness of the trapezius and drooping of the shoulder.

This nerve is the one most commonly injured in neck operations. The deformity is not necessarily permanent after section of either part of it, but the writer has seen several patients who have shown this deformity some years after the operation, and, from the conversations which he has had with

other surgeons who have performed these operations, he is confident that insufficient attention is frequently paid to this matter.

The *hypoglossal nerve* is frequently seen, but there is less danger of injuring it. The injury of both hypoglossi at the same operation has been recorded, and the resulting paralysis of the tongue was so distressing that the organ had to be removed. The filaments known as the descendens and communicans hypoglossi—or, under the old nomenclature, descendens and communicans noni—may

Fig. 177.—Paralysis of Depressor Labii Inferioris from Section of Lower Filament of Facial Nerve more than Ten Years Previously. (Photograph of a patient in the General Memorial Hospital, New York. *Annals of Surgery*, July, 1905.)

easily be injured. The writer has never known of any ill result following such injury.

The *sympathetic* and *pneumogastric nerves* are not often disturbed, since they lie deeper than the field which is ordinarily explored.

The *phrenic nerve* is frequently seen and is sometimes injured; but, according to Schroeder and Green,* who have investigated the subject most thoroughly, and also according to other surgeons who have watched patients after section or injury of the nerve, this injury is not so serious as is generally supposed. The diaphragm is not an essential muscle of respiration in man, and, further-

* Am. Jour. Med. Sc., February, 1902, p. 196.

more, it receives a partial innervation from the intercostals. It is recorded that patients, after phrenic-nerve injuries, have shown no bad symptoms. The lower part of the corresponding lung must, however, suffer somewhat and might show less resisting power to infection; and surgeons will surely continue carefully to avoid injuring the nerve.

Veins Exposed in the Operation.—The arrangement of veins in this region should be carefully considered. The *internal jugular* is frequently exposed throughout a large part of its course; it is occasionally cut, although this accident is a rare one. The cutting of some of the branches which run into it is a much more common accident. There are occasional branches running in from behind which may easily be cut in the course of a dissection, and this may be followed by hemorrhage so severe that the operator will believe that the main vein itself has been cut.

The *common facial vein* may easily be injured, and the branch which runs forward from the external jugular or the temporo-maxillary to help form it is probably more often injured than any other large vein in the vicinity. All of these veins may be so flattened out from traction or from pressure of the node that they will not be recognized. If troublesome hemorrhage occurs from an unknown source during the dissection, it is wise to pack the wound with gauze and give attention to some other part of the dissection. When, at some later moment, the gauze is removed, the hemorrhage will often have ceased entirely or will have diminished to such an extent that its exact source can be distinguished. If it is found to come from one of the smaller branches, this vessel can be ligated. If it comes from the internal jugular it is usually better to clamp the opening, and then take a running stitch of fine silk or fine catgut through the walls of the vein. The tying of this will in most cases entirely control the hemorrhage, and the lumen of the vein will not be closed. This method of treating vein wounds is now so commonly used that its efficacy is very well known.

Muscles Exposed in the Operation.—The sterno-cleido-mastoid muscle is the one which is most often cut, and its section may be necessary in order suitably to expose the infected field. It may be cut in two localities: either above the insertion of the spinal accessory nerve, or below the exit of that nerve. The latter position is the one of choice. A good exposure is obtained and rapid dissection is promoted by cutting the muscle, and the method is to be advocated in certain cases in which the nodes are very extensively involved. The muscle, however, after it has been divided and subsequently sutured, is not always as good as it was before, and the period of convalescence is thereby somewhat prolonged. With increased experience, the operator will less frequently find it necessary to cut the muscle, and the ultimate result will therefore be a little better.

Treatment of the Wound.—The wound should be so treated that there will be provision for the abundant serous discharge which usually takes place after

these operations. Many lymphatics are cut, and much more serum or lymph comes from these wounds than from the wounds which are made in the average operation. This may be partly due to a real flow of lymph—a lymphorrhœa—which sometimes takes place from the cut lymphatics, and partly to the removal of the absorbent apparatus which would otherwise carry away the exudate. Whatever the cause of this trouble may be, the treatment is easy—the providing of a small but efficient drain. The best drain for the cases of moderate severity is composed of a few strands of silk or silkworm gut, which are carried under the muscle and out through a posterior counter-opening. The margins of the incision may then be brought together by subcuticular catgut stitches, a very small exit for drainage being left. If a moist dressing is then applied, covered with rubber-tissue protective, and changed twice on the first day and once on each succeeding day, the discharge will be well carried out into the dressing, and healing will then usually follow, even after the dissection of broken-down lymph nodes, almost by first intention, with little fever and without complications.

RESULTS.

Early Results.—The immediate results of this operation are most gratifying. Many long series of cases have been reported with little or no mortality. Jordan, Wohlgemuth, and Blos report, respectively, 429, 167, and 328 cases without operation mortality, and Finkelstein reports 160 cases with one death. There was no mortality in seven of the ten series of cases which Blos reviews. The writer has operated upon more than 200 cases with 1 death, which occurred a week after operation from hemorrhage from the internal jugular vein, this occurrence being probably due to the breaking through of a spot weakened by tuberculosis.

The recovery from the operation is very rapid; patients are usually sitting up within three or four days, and, as a rule, they have little pain and only a slight febrile reaction. In the majority of the cases the healing takes place promptly. Among the 100 cases which the writer reported in 1905, many of them actively suppurating at the time of operation, there were 2 in which there were spots of lupus which were not completely healed at the time of the report; 2 more were removed from the hospital before healing was complete. With regard to the remaining 96 patients it was found that 164 operations had been performed upon them with healing in the first month in 109, in the second month in 43, in the third month in 10, and at a later time in 2 instances. In the operative cases which have come under the writer's care since that report was published, the average time of healing has been much less, because the patients presented themselves in much better condition at the time of the operation. When the tuberculous tissue can be entirely removed the healing takes place very promptly, the wound being firm within a week or ten days. But

when there is infected tissue or thickened tissue about the nodes there may
be a delay.   Most of the cases which were slow in healing had, before operation,
sinuses which led to areas of tuberculous inflammation.

Later Results.—It is difficult to know exactly the final result of the opera-
tions, because so many patients are lost sight of.   One cannot well follow all
the patients who are operated upon, through their various movements from one
tenement house to another through a long period of years.   Many efforts, how-
ever, have been made to trace these patients.   Fischer's tabulation of 1,273
cases, which has already been given, indicates about the average of the reports.
The cases were observed after periods of from one to sixteen years; 57.65 per
cent were recorded as cured; 28.84 per cent had local recurrences; 13.51 per
cent were dead mostly from tuberculosis.   These cases, however, include opera-
tions of varying degrees of thoroughness; some of them being only curettings.

Jordan, in von Bergmann's "System of Surgery," has tabulated results as
follows:

"Of 328 cases treated between 1886 and 1895 (Blos), 140 were subsequently
examined, and of these 82 were of value in forming an opinion as to the final
results, for six years or more had passed since the operation; 43 of the 82 patients
(52.4 per cent) were permanently cured—that is, were free from any glandular
swelling whatsoever.   If eight years free from recurrence be demanded for a
final result, there remained 45 cases with 25 cures, *i.e.*, 55 per cent.   On the
other hand, if the final result is based on cases in which at the seat of operation
no recurrence had taken place after six years, then 17 cases may be added to
the above, *i.e.*, 20 per cent.   The percentage of those permanently cured by the
operation is therefore about 73.1.   These results appear especially favorable if it is
taken into consideration that, of 140 operative cases, periadenitic processes (ad-
hesions and abscesses) were present in 90.   Excision was performed in 85 cases,
curetting in 43 cases, in 5 cases incision, and in 7 cases combined methods.   In
69 cases a permanent result was obtained by one operation, whereas secondary
operations were necessary in the others.   On subsequent examination recur-
rences in the vicinity of the wound were observed 42 times, *i.e.*, in 30 per cent
of the cases; and recurrences in the widest sense of the word, *i.e.*, glandular
swellings anywhere, in 72 cases, or 51.4 per cent.

"Fränkel collected the material of Billroth's clinic in 1885 and was able to
determine the final result in 48 of 148 cases.   Of these 48 patients, 34, *i.e.*, 71
per cent, were cured, but only 12 for more than three and a half years.   Local
recurrence was present 7 times, *i.e.*, in 14 per cent of the cases.

"Wohlgemuth, in 1890, had a similar percentage of permanent cures in 81
children operated on during the first decade of life.   After 45 total excisions
he obtained 26 permanent cures, *i.e.*, 70 per cent; and after 36 incisions and
curettings, 17 successful results, *i.e.*, 63.9 per cent; and of 46 cases not operated
upon, recovery was observed only 11 times, *i.e.*, in 24 per cent.   From these

statistics the superiority of operative treatment and the advantage of excision over incision and curetting are apparent.

"Fürnrohr obtained the following results at Erlanger's clinic: Of 87 patients in whom the final result could be obtained, 36, *i.e.*, 41.4 per cent, were permanently cured; in 29, *i.e.*, 33.5 per cent, recurrence had taken place; and 23, *i.e.*, 26.4 per cent, had died from tuberculosis since the operation. Blos calculated, from eleven different statistics comprising 745 cases, that following operation there were 54 per cent of permanent cures, 28 per cent of recurrences, and 18 per cent of deaths. The influence of excision of glands on existing tuberculosis of the lungs is of special interest. Jordan's experience is as follows: Of 20 consumptives, included in 140 cases, 16 were found cured at a later examination. Of these 16 cases, 11 were at the same time free from glandular recurrence; consequently, removal of the glandular focus was followed by disappearance of the pulmonary lesion in 80 per cent of the cases. Lung complications developed in 13 other cases some time after operation, so that on subsequent examination tuberculosis of the lungs was found present in 17 of the 140 cases. Of these 17, 11 had fresh glands, whereas 6 were free from glandular involvement."

Mitchell traced 58 out of the 170 cases operated upon in the Johns Hopkins Hospital. He noted their conditions from one to thirteen years after operation, and found 45, or 77.6 per cent, free from local or other recurrence.

The writer has followed his cases with much care, and, although their numbers are not so great as those already stated, he will give them as reported in 1905. The more recent observations have been more favorable, but the reports are not yet suitable for tabulation.

STATISTICS OF AUTHOR'S OPERATIVE CASES.

(Stated in Percentages.)

Observed over six years, 19 cases.   Per cent.
    Apparently cured..   79.
    Filbert-sized nodes, diagnosis doubtful....................................   5.2
    Neck apparently well, but recent operations for recurrence...................   5.2
    Neck well, but tuberculous coxitis...   5.2
    Spot of lupus...   5.2

Observed over three years, 43 cases.
    Apparently cured..   76.7
    Filbert-sized nodes, diagnosis doubtful....................................   7.
    Neck apparently well, but recent operation for recurrences ....   7.
    Recurrent nodes..   2.3
    Neck well, tuberculous coxitis...   2.3
    Lupus...   2.3
    Phthisis...   2.3

Observed over one year, 82 cases.
    Apparently cured..   74.4
    Filbert-sized nodules, diagnosis doubtful..................................   5.

Per cent.
Apparently well now, but have had recent operation for recurrences............ 7.2
Recurrent nodes... 5.
Neck well, tuberculous coxitis.. 1.2
Lupus... 3.6
Phthisis.. 1.2
Tuberculosis of cranium.. 1.2
Died from tuberculosis of spine... 1.2

If we compare the adults in this group with the children, we have the following percentages:

Over 20 years of age, 14 cases.
Apparently cured... 57.2
Filbert-sized nodes, diagnosis doubtful.................................... 7.1
Recurrent nodes.. 21.3
Phthisis... 7.1
Tuberculosis of cranium.. 7.1

Under 20 years of age, 68 cases.
Apparently cured... 77.9
Filbert-sized nodes, diagnosis doubtful.................................... 4.4
Apparently well now, but have had recent operations........................ 8.8
Recurrent nodes.. 1.5
Neck well, tuberculous coxitis.. 1.5
Lupus... 1.5
Died from tuberculosis of spine... 1.5

It is probable that some of the patients who are classed in these tables as "apparently cured" will, at a later time, show further tuberculous inflammation, and that some of those who now have evidences of tuberculosis will eventually be cured, but the tables represent the condition of the patients so far as it could be learned.

Syphilitic Inflammations of the Cervical Lymph Nodes.—Moderate enlargement of the cervical lymph nodes is one of the regular symptoms of syphilis, and does not call for surgical treatment. Occasionally, however, these nodes are so much enlarged as to make the diagnosis from tuberculosis very difficult, and such nodes have many times been removed on the supposition that they were tuberculous. The accompanying photograph (Fig. 178) shows a case in which there was more than the usual enlargement from tertiary syphilis. In this case the depressed nose indicated the real source of the inflammation, but occasionally there is a marked enlargement of the nodes without the ordinary symptoms of syphilis. The surgical interest is principally one of diagnosis, for usually the enlargement will disappear when antisyphilitic treatment is given. Occasionally, however, as in the patient whose picture is given, it is better to take out the most prominent of the nodes and then administer iodide of potassium and mercury. The nodes do not show as marked a tendency to form abscesses as the tuberculous ones do, although abscesses occasionally occur and are followed by characteristic ulcers.

In the case here depicted the nodes were uniformly soft and friable, and on microscopical examination showed no distinct structure.

Neoplasms, Primary and Secondary.—Lympho-sarcomata are the most common primary growths of the lymphatics, and the neck is usually the locality first affected. The term lympho-sarcoam is somewhat indefinite, since several names have been applied to conditions which cannot be definitely separated. Hodgkin's disease, pseudo-leukæmia, anæmia lymphatica, malignant lymphoma, and lympho-sarcoma are some of these names, and the conditions which they represent are either primarily the same or are so similar that it has not been found possible to draw distinct boundary lines between them. We do not know the cause of the disease, but it is characterized by

FIG. 178.—Syphilitic Enlargement of the Cervical Lymph Nodes. (Photograph of patient in St. Mary's Hospital for Children, New York.)

an enlargement of the lymph nodes, which begins in the neck and extends to the other parts of the body. In the ordinary form the inflammation is confined to the lymph nodes themselves, and does not extend to the surrounding tissue.

Histologically, such nodes look as though they were enlarged by simple hyperplasia. In those nodes which are soft the enlargement is mostly in the cellular parts, while in the harder forms it is chiefly in the connective-tissue portions of the nodes. Epithelioid cells, isolated giant cells, and "eosinophilic granules" are found, and have been studied with great care, especially by Goldmann, but nothing positively diagnostic has yet been found. On section the nodes appear whitish, nearly smooth, and of uniform consistency.

The course of the disease is fairly uniform, differing principally in its rapidity in different cases. It usually attacks individuals between 15 and 35 years of age; is seen in children occasionally, but very infrequently in those of advanced years. The enlargement, which usually begins in the neck, progresses without unpleasant symptoms until the mechanical pressure exerted by the en-

larged nodes annoys the patient. The side of the neck from the jaw to the clavicle is filled with a mass of nodes. As this growth progresses, enlarged nodes are noticed in other parts of the body—on the other side of the neck, in the axillæ, in the mesentery, in the groin, etc.; and patients suffer from the mechanical pressure which they exert, as on the œsophagus, trachea, bronchi, and intestines, and from a loss of strength, which appears with the development of cachexia and progresses to a fatal issue. During this time the blood is unchanged as regards the ratio of white to red corpuscles, but shows marked anæmia.

A fever which frequently develops toward the end of the disease is believed to be due to secondary infection.

Treatment.—Treatment offers little for this malady, which almost always (perhaps always) progresses to a fatal issue. The thorough removal of the nodes in the neck on their first appearance is to be advocated in the hope that the disease may be local. When, however, it has extended to widely disseminated nodes, surgery has little to offer, unless it be to diminish the symptoms due to the pressure of those nodes which can be removed. Jordan states that a case of permanent cure after operation has yet to be reported. One may, however, remember that the healing of the wound after the operation takes place with remarkable promptness, and that freedom from adhesions makes the removal of the nodes easy, and hence that the relief from pressure afforded by operation is sometimes to be advocated.

Arsenic has been much used in the treatment of the condition, and beneficial results have been reported by several observers. Billroth, Czerny, Ziemssen, Katzenstein, and others have found that in certain exceptional cases it has almost a specific effect. It may be given in the form of Fowler's solution, from five to twenty or more drops three times a day, the dose being intermitted from time to time as toxic symptoms appear; or various arsenical salts may be used. The constitutional effect may be obtained by the hypodermatic use of Fowler's solution or a one-per-cent solution of sodium arsenate, or the local effect by injecting directly into the enlarged nodes. The administration of the toxins of streptococcus and of Bacillus prodigiosus according to the Coley method has been followed by good results in certain instances, and their use is to be advocated when an operation is not practicable or arsenic cannot be used with benefit. The use of the x-ray has also been of some apparent benefit in certain cases.

The involvement of the cervical lymphatics by cancer is of a secondary nature, the primary growth usually being on the lip, tongue, or fauces, or on the skin of the face or scalp; occasionally the infection spreads upward from the axilla. When we remember that the last United States census report indicates that nine per cent of all the fatal cancers are primarily located above the clavicle, we appreciate the importance of the subject.

Crile has recently had records examined from several hundreds of cases with cancer about the head and neck, and has found that almost without exception the disease extends no farther than the neck. The barrier formed by the abundant cervical lymphatics prevents the wider extension of the disease. It is manifestly wise to attempt to arrest it here by early removal of the infected nodes, yet this is often neglected. Lip cancer is the one in which the lymphatics are most often neglected. Many cases are operated upon in their early stages without removing the lymph nodes into which the affected part drains. A wedge-shaped portion of the lip which includes the cancer is removed, and no incision is made under the jaw, nor are the submental or submaxillary lymph nodes removed. This practice is to be condemned. In every case of cancer of the lower lip the region under the jaw should be explored and the infected lymph nodes should be removed. Those which lie between the submaxillary salivary gland and the body of the jaw should regularly be removed; and so, also, should the submental group which lies between the anterior bellies of the digastric muscles. The incision should be started back of the symphysis and carried backward two or two and a half inches, a finger's breadth from the border of the jaw. The dissection should then be carried through the platysma and the deep fascia after they have been lifted up, and access can thus be gained to the lymph nodes previously mentioned.

FIG. 179.—Lines for Incision Required in Removing Large Epitheliomata of the Lip. By means of this incision access will be afforded to the submental and submaxillary lymph nodes, and, if necessary, to the nodes of the deep cervical chain. (*Medical Record*, New York, February 20th, 1897.)

The results following the removal of small lip cancers when these nodes are removed are far better than those which come from removal of the cancer without the nodes. When the lip cancer is large the incision may well be made on the lines which are indicated in the accompanying diagram (Fig. 179) and the lymphatic nodes of the neck should be thoroughly cleared out at the time of the primary operation. Fig. 180 shows the appearance of a patient who was operated upon by this method and who was living and well six years after the operation. In cancer of the gums and of the tongue the same principles of treatment apply; the submaxillary nodes should always be removed in these cases. When the growth is in the back part of the tongue, in the tonsils, in the parotid, or in some part of the face or scalp, the deeper lymphatics are likely to be infected and should be removed. The technique of removing the deep cervical chain of lymph nodes infected by cancer is the same as that recommended for removing those infected by tuberculosis, excepting that in the former case the removal should be of a more radical character.

They should be dissected upward from the base of the neck and removed most thoroughly.

The cervical lymphatics are also involved in cancer which spreads from below. This is particularly true in cancer of the breast, and the removal of the cervical lymph nodes, in cases of this nature, is recommended as a routine procedure by some surgeons, particularly by Halsted, of Baltimore. The incision is carried upward from below the clavicle, a flap is laid backward, and the nodes at the base of the neck are carefully dissected out. This procedure has not generally been adopted as routine treatment, but it surely should be done in many instances, and those who advise it in every instance have on their side
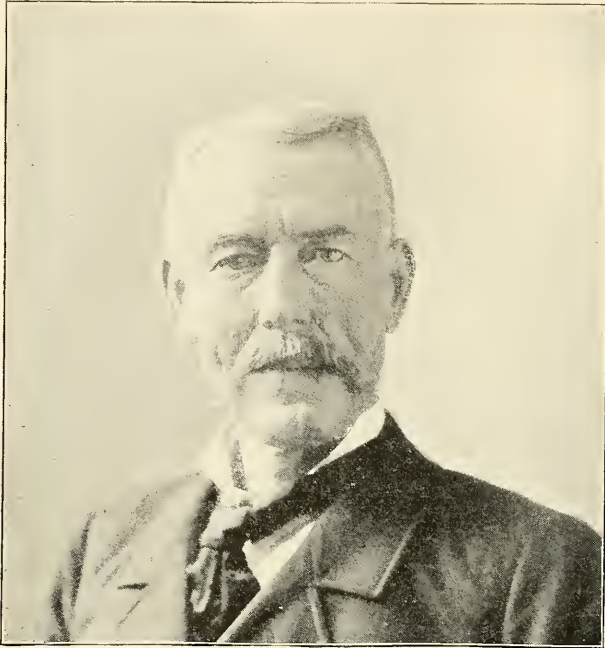
Fig. 180.—Appearance of Patient from Whom the Lip and the Infected Lymph Nodes Were Removed through Incisions shown in Fig. 179. Patient well six years after the operation. (Photograph of patient in the General Memorial Hospital, New York. *Medical Record*, New York, February 20th, 1897.)

the argument of a thorough and careful effort to eradicate the disease in one of the lines of its extension.

Weir (*N. Y. Med. Jour.*, March 3d, 1906) has found that an examination made under the clavicle during the operation gives a good indication of the condition of the cervical lymphatics, and that the lower ones can even be removed by this route.

Traumatisms of the Lymphatics.—The most important traumatism of the lymphatics of the neck is the cutting of the large branches during surgical operations. In very rare instances a bullet or a stab wound may also injure them. After section of the large trunks (the thoracic duct excepted) the flow of lymph

may be sufficient to be disturbing for a few days, but it finally ceases without any ill effects if drainage is provided through the skin.

Section of the Thoracic Duct.—Section of the thoracic duct itself occasionally takes place during an operation at the base of the neck on the left side. Experiments on animals indicate that this is a fatal condition if unrelieved, and that ligation of the duct may also be fatal. In man, however, the injury is usually not followed by serious results if the lymph flow is controlled by pressure, by ligature, or by suture. It has already occurred so many times that an extensive literature on the subject has accumulated. Von Graff (*Zeits. f. Chir.*, 1905, p. 864), in reporting a case, reviews 27 cases from literature, with 2 fatalities. Vantrin (*Zeit. f. Chir.*, 1906, p. 27), in referring to 3 of his own cases without fatality, also refers to another case which resulted fatally. Cushing (*Annals of Surgery*, June, 1898, p. 719) records or reviews 9 cases and brings the subject concisely up to that time.

The main interest really hinges about the anatomical relations of the duct, which frequently arches so high above the clavicle that it may easily be injured. Dieterich, Porter, and Cushing have seen it arching 5.5 centimetres, or thereabouts, above the sternum; and near its opening into the left innominate vein it receives the left jugular lymphatic trunk. It very frequently divides, the branches reuniting or empting into different veins, one of them often on the right side. It may also have branches that communicate with intercostal veins. Hence it is altogether likely that some of its branches have been cut, and not the entire duct, in many of the reported cases. The ligation of the cut vessel is the treatment usually advocated (Lecene, Vantrin, Bucknell, Halsted, Schönborn, Brohl). Cushing suggests that it be sutured, and many surgeons have successfully used packing. The chylorrhœa which follows its section is excessive, and, if unrelieved, leads to great thirst, weakness, and extreme emaciation.

The lymphangiomata, lymph varices, etc., which occur in this locality are considered in the separate section which is devoted to that subject at the end of the article.

II. SURGICAL DISEASES OF THE LYMPHATICS OF THE AXILLA AND UPPER EXTREMITY.

The anatomy of the lymphatics of the anterior and lateral walls of the trunk is well shown in the accompanying plate (Plate XVIII) which has been copied from Sappey's Atlas.

Lymphangitis.—Inflammation of the lymph channels themselves is more often seen in the arm than in any other part of the body. Infection in the finger or hand is frequently followed by a red line which runs up the forearm or

EXPLANATION OF PLATE XVIII.

1, 1, The two lowest of the femoral lymph nodes. It is in these nodes that the larger lymphatic vessels of the foot, leg, and larger part of the thigh terminate.

2, 2, Those inferior and internal nodes in which the lymphatic vessels of the upper and posterior part of the thigh terminate.

3, The highest femoral node, which receives the lymphatic vessels—those belonging to the corresponding half of the body—from the inner side of the buttocks, the anus, the perineum, and the scrotum.

4, Superficial and internal inguinal node, in which terminate all the lymphatic trunks that come from the penis.

5, Node destined for the reception of the lymphatic trunks that come from the posterior, superior, and external aspects of the thigh.

6, 6, Nodes in which terminate the lymphatic vessels of the subumbilical part of the abdomen.

7, Node which receives the lymphatics belonging to the upper and external two-thirds of the buttock of the corresponding side, and also those which come from the lumbar region.

8, 8, Lymphatic vessels of the scrotum.

10, 10, Superficial lymphatic vessels coursing over the back and sides of the penis on their way to the superficial and internal inguinal node.

11, Lymphatic trunk curving around the glans penis. As a rule, that of the right side joines with its fellow of the left in the median line; but in the present instance the two trunks remain independent, only one very small branch passing over from one trunk to the other. Quite often, in the place of a single trunk on each side of the glans, there are two or even three, which, in their semicircular course, communicate, the one with the other, by means of anastomosing branches.

12, Prolongation of the lymphatic trunk which curves around the left half of the glans.

13, Similar prolongation of the lymphatic trunk on the right side of the glans.

14, 14, Very small branches which are given off by the median lymphatic trunk of the subumbilical part of the abdomen. This trunk is no larger than any of the trunks found in other portions of the abdominal walls. The only feature that distinguishes it in some measure from the other trunks in the abdominal region is the circumstance that it furnishes a channel of communication between the lymphatic vessels of the right side and those of the left.

15, 15, Lymphatic trunks which originate at various points throughout the entire subumbilical region and ultimately terminate in the nodes occupying the uppermost part of the axillary space.

16, 16, 16, Lymphatic trunks which originate in the integument of the lumbar region and of the upper and external portions of the buttocks.

17, 17, Lymphatic trunk into which the vessels of the supra-umbilical and subumbilical portions of the anterior abdominal wall pour their contents.

18, 18, Median lymphatic trunk of the supra-umbilical portion of the abdomen and of the anterior thoracic wall. This trunk, like all those which are situated in the median line, serves as a medium of communication between the lymphatics of the right half of the thorax and those of the left half.

19, 19, 19, 19, 19, 19, Lymphatic trunks which originate in the integument of the anterior wall of the thorax and of the abdomen.

20, 20, 20, 20, Lymphatic trunks coming from the lateral portions of both the thorax and the abdomen.

21, 21, 21, Lymphatic trunks coming from the posterior wall of the thorax.

22, 22, Lymphatic trunks coming from the skin of the breast.

23, 23, 23, Lymphatic trunks which have originated in the posterior portion of the shoulder.

24, 24, Terminal extremity of the lymphatic vessels belonging to one of the upper extremities, at the spot where they cross the aponeurosis of the axillary space on their way to the lymph nodes in this region.

25, Large lymphatic trunk which has its origin in the supra-epitrochlear lymph node and lies at a greater depth than any of the lymphatic vessels previously mentioned.

26, Lymphatic trunk which has detached itself from the principal group and is passing on toward the front part of the shoulder, in the interval between the deltoid and the pectoralis major muscles. This trunk, after passing through another node which lies at a lower level (and occasionally is lacking altogether), terminates in a node that is situated below the clavicle.

27, 27, Section of the skin showing the nodes in which the lymphatic vessels previously mentioned terminate.

28, 28, Axillary nodes, of which only those which occupy the lowest position are visible in the picture.

29, 29, Lymphatic vessels of the posterior and lateral portions of the neck. Having reached the level of the sterno-cleido-mastoid muscle, they dip down and disappear from view, on their way to join the inferior cervical nodes.
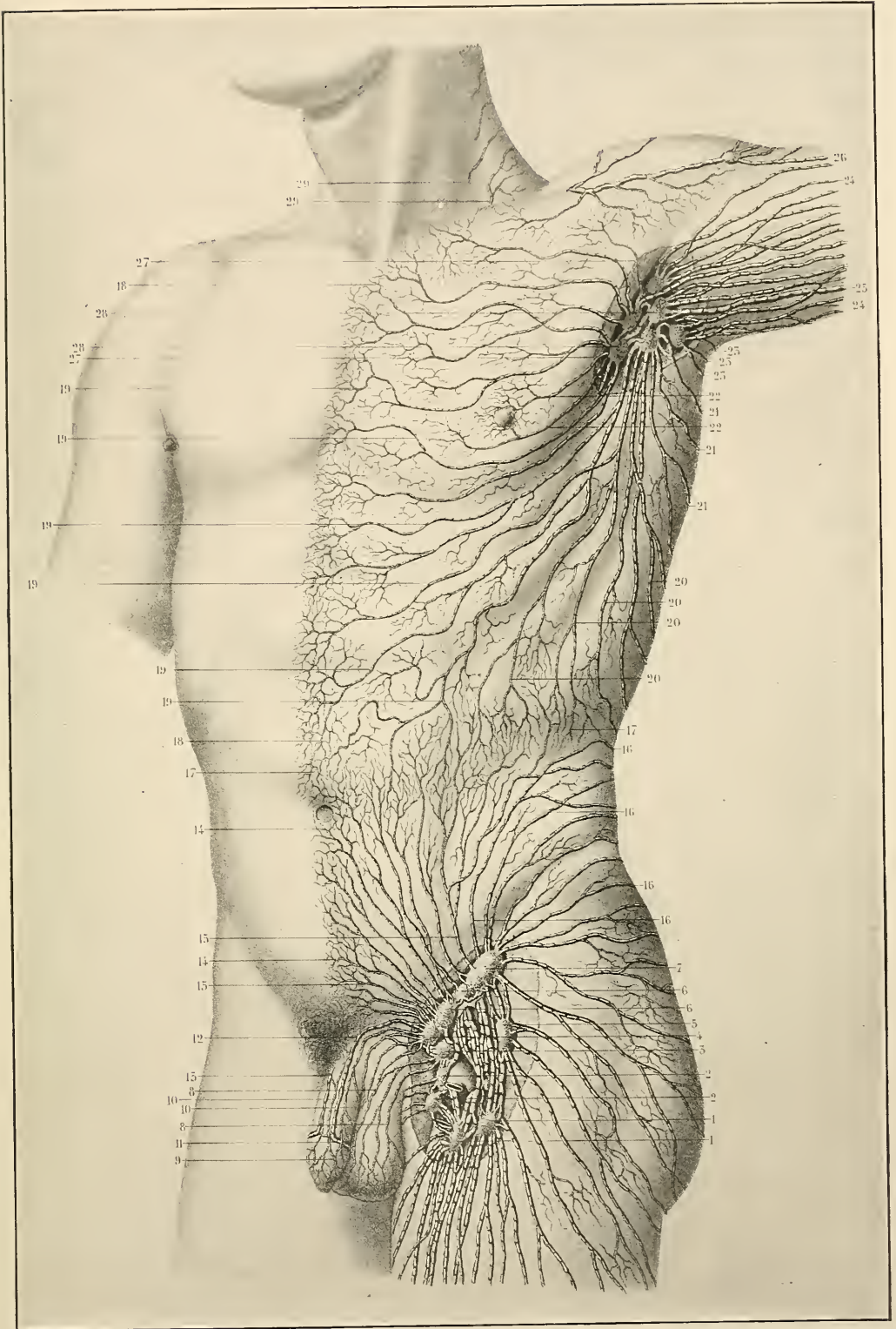
SUPERFICIAL LYMPHATICS OF ONE SIDE OF THE TRUNK OF THE HUMAN BODY.

(From Ph. C. Sappey: *Description et Iconographie des Vaisseaux
Lymphatiques chez L'Homme, etc.*, Paris, 1885.)

even up the upper arm, showing the course of the lymphatics which have become inflamed. This infection may extend so as to involve the lymph nodes of the epitrochlea and axilla, and thence extend even farther; and, if it can be stopped before it has reached that involvement, the result is fortunate. It is particularly fortunate that these lymph channels are so near the surface that these tell-tale marks of inflammation so quickly come to the notice of the surgeon.

The method of treatment is first of all to relieve the primary infection; and the most important way of doing this is to provide an exit for the pus or serum. An incision or a wet dressing, or both, will usually accomplish this. It is to be remembered that the cuts and hang-nails about the fingers, which so often serve as the starting points of lymphatic inflammation above, can almost always be successfully treated by the wearing of rubber finger-cots under which there is a little gauze moistened with a mild antiseptic lotion. If the serum exudes freely into the wet gauze the infection is not apt to be carried into the lymphatics and no serious harm is likely to follow. When the lymph nodes themselves are infected they should sometimes be dissected out. The rôle of the lymph nodes in the severe grades of infection of the arm is not so important as is that of the cervical nodes in severe infections of the neck. They are less numerous than the cervical nodes, and they do not so often prevent the further spread of the infection.

The severe infections are usually due to streptococci, and the inflammation caused by these organisms spreads in the subcutaneous tissue very much as erysipelas spreads in the skin, not following the ordinary paths of the lymph channels nor affecting the lymph nodes themselves more than it does the other tissues. The cases in which the infection is located principally in the lymph nodes are usually of a milder nature, and one frequently sees abscesses in the axilla (see Fig. 181) which are of a mild nature and which do not cause severe constitutional symptoms. The cases in which a severe form of infection is particularly located in the lymph nodes are not common, but when they are encountered they should be treated by removal of the affected nodes.

A word should be said about the use of wet dressings in the treatment of infections of the arm and hand. Without doubt they have a considerable influence in controlling the inflammation, and the red streaks which follow the lymphatics usually disappear under their application; but a so-called wet dressing, as it is applied in a large proportion of cases, is wet only for a short time, as one must have observed on seeing it removed. To secure a continual wet dressing one should either have recourse to the immersion of the member for a certain length of time every three or four hours during the day in a tub containing the proper solution, or should enclose the wet gauze, which should be only moderate in amount, in rubber tissue or oiled silk, thus retaining the moisture. Otherwise the moisture goes to the surface of the dressing, and the skin remains dry.

Tuberculous Disease of the Axillary Lymph Nodes.—The axillary lymph nodes are less frequently the seat of tuberculosis than are the cervical nodes. According to the collective statistics of Balman, Wohlgemuth, Poisson, and Von Noorden, and those obtained at St. Mary's Hospital for Children in New York, the ratio is about 1 case of the former to 14 of the latter. The infection usually comes downward from the neck, but occasionally is received from the hand or arm. The nodes are usually felt as movable nodules in the soft tissue of the axilla, and they frequently reach the size of
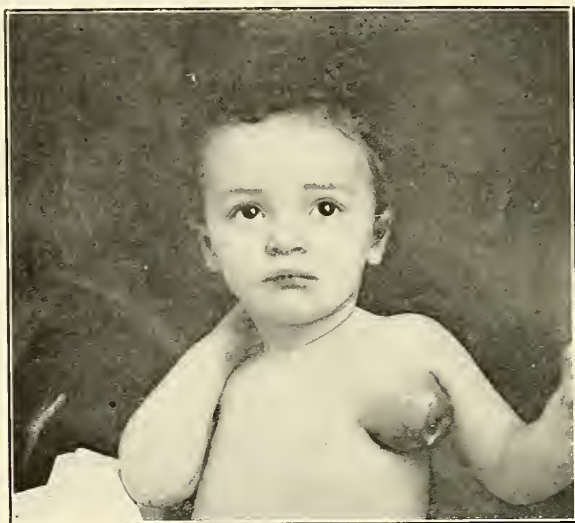
Fig. 181.—Axillary Abscess, Secondary to Infection of the Hand. Very mild constitutional symptoms. (Photograph of a patient in St. Mary's Hospital for Children, New York.)

English walnuts. They show the ordinary lesions of tuberculosis, but do not often lead to the formation of abscesses and sinuses.

They should be removed by operation through an incision along the edge of the pectoralis major muscle. The removal is usually easy, since firm adhesions are rare. The removal of any part of the pectoralis muscle is unnecessary. Recurrences are rare.

Cancerous Disease of the Axillary Lymphatics.—Cancerous disease of the axillary lymphatics is very important. The spread of breast cancer takes place largely by way of the axilla, although not entirely so. The rule was laid down, many years ago, that the axilla should be cleared of its lymphatics in every case of breast cancer, and the extent of the operation has increased until a large part of the pectoralis major and minor muscles is usually removed, partly because their fascia is involved, but partly also because the removal gives better access to the lymphatics of the axilla.

It is not necessary in this place to discuss the removal of the muscles, since

good access to the lymphatics can be obtained by removal of about half of the pectoralis major and by drawing the pectoralis minor first down and then up; but it is important to consider the extent of removal of the lymphatics and tissues in which they lie in the axilla itself. It surely is generally believed that the lymphatics should be removed from the axilla, from the clavicle down, in every case of breast cancer in which there is not some counter-indication, such as debility of the patient, or such general involvement of the tissues that only an incomplete palliative operation is desirable. Surgeons differ in their conceptions of what thorough removal of the lymphatics means, but most of them are content with rolling the fat and contained lymphatics downward from the clavicle, and removing them while still attached to the breast; cutting most of the branches of the axillary vein; exposing the long thoracic and subscapular nerves; and clearing the posterior and lateral muscular walls of the axilla. After this procedure has been carried out in the manner described, there is seldom an axillary recurrence. There are, however, usually some pain and some swelling of the arm. The former is apparently due to nerve injuries, and is usually transitory; the latter seems to be due to the removal of the lymphatics and the consequent obstruction to the return flow of lymph from the arm. It frequently lasts for many months, but usually at last it subsides under the use of massage. Patients should be told, before operation, of the possibility of this swelling.

III. SURGICAL DISEASES OF THE LYMPHATICS OF THE THORAX AND ABDOMEN.

The *bronchial lymph nodes* are of great importance, but their importance is usually not surgical, since they cannot be reached by ordinary surgical procedures. They are of interest to the surgeon, however, from a standpoint of diagnosis. The writer has known of the occurrence of one sudden death from the rupture of greatly enlarged bronchial lymph nodes and the emptying of the pus into the bronchi, the condition being clearly marked at autopsy. The treatment of enlarged lymph nodes in the neck and abdominal region would be somewhat modified if it could be known at the time that similar enlarged nodes were present in the thoracic cavity alongside the bronchi. Northrup has shown how common the enlargement of the bronchial lymph nodes is in children, and Holt gives a picture in which the condition of enlargement of these lymph nodes is most strikingly depicted.

The mesenteric lymph nodes are frequently the site of both simple and tuberculous inflammations. In operations about the appendix they are sometimes seen enlarged by simple inflammation to the size of filberts or small hickory nuts, and it is difficult to determine whether they are tuberculous or not. In

this condition they may be felt through the abdominal wall, and their presence may be wrongly interpreted, since they suggest encapsulated appendicular abscess. It is a fact, however, that nodes of considerable size disappear without removal.

Tuberculosis of the mesenteric lymph nodes is much rarer than tuberculosis of the bronchial or cervical lymph nodes, but still it occasionally exists. Large masses of such nodes can be removed from the peritoneal cavity, and good local healing result. Clinically, however, this condition is usually associated with tuberculous peritonitis, or with tuberculosis of the intestine, or with very extensive tuberculous inflammations of the lymph nodes in other parts of the body, and hence the result of their removal is not encouraging.

Cancerous Disease of the Abdominal Lymph Nodes.—Cancerous disease of the lymph nodes of the abdomen, secondary to cancer of the viscera, is very common and has much surgical importance. In stomach operations the nodes about the lesser curvature and those about the pyloric end of the greater curvature are the ones most commonly involved. Since gastric cancers are, as a rule, situated at the pyloric end of the stomach, the removal of these nodes usually checks the spread of the disease by way of the lymphatics.

The lymphatic vessels from the gall bladder run with the hepatic artery to the hepatic lymph nodes in the gastro-hepatic omentum; those from the intestine are found in the corresponding part of the mesentery or mesocolon; those from the rectum run, for the most part, backward into the mesorectum and thence into the sacral and lumbar nodes, but those in the lower part of this organ become continuous with the cutaneous lymphatics about the anus. Hence, in disease of the lower part of the rectum, the inguinal nodes become affected. The lymphatics from the uterus, Fallopian tubes, ovaries, and upper part of the vagina follow the uterine and ovarian arteries into the broad ligament and thence into the lumbar and internal iliac lymph nodes; those from the lower end of the vagina go to the superficial femoral nodes.

All of these routes are to be cleared, so far as possible, in operations on the organs from which they lead.

IV. SURGICAL DISEASES OF THE LYMPHATICS OF THE GROIN AND LOWER EXTREMITY.

Simple and Venereal Infection.—The venereal bubo is the most common surgical affection of the lymphatics in the groin. It usually comes from a chancroid, but the infection may arise from a balanitis or other form of genital inflammation. The infection is usually of a subacute type.

Those enlarged nodes which are not due to chancroid frequently subside under simple treatment or form only superficial abscesses; those which are due

to chancroid run a characteristic course. A small hard swelling first appears in the inguinal region, and this swelling slowly increases, softens, and finally breaks down into a collection of pus beneath the skin, which, in the mean time, becomes red and eventually assumes a bluish-red hue. The entire process is accompanied by much pain.

The pus escapes either through an incision or through an opening caused by the spontaneous rupture of the skin. It is thinner and more brown than ordinary pus, and the walls of the abscess cavity are brownish and have a sloughy, unhealthy appearance. This process extends from one node to another, and, if unrelieved by treatment, usually continues through a period of many weeks.

Treatment.—Many forms of treatment have been advocated for this condition. In the early stages simple protective dressings or slightly astringent moist dressings, and rest in bed, are advised; and some surgeons have advocated the extirpation, even at this early stage, of the enlarged nodes, in the hope of checking the infection. Both of these measures, however, are apt to be disappointing, since the former usually fails to produce resolution, and the latter is apt to be followed by inflammation in those nodes which were not removed. The following plan of treatment is probably the most satisfactory one when it proves successful; and it succeeds in a sufficiently large number of cases to justify its being tried: During the early stages a simple protective cotton dressing is applied, or the part may be left without any dressing at all. When the first softening appears, a small incision is made into the softened nodes under cocaine anæsthesia, and the pus and softened tissue of the node are squeezed out. The abscess cavity is then thoroughly cleaned with peroxide of hydrogen, irrigated with 1:5,000 solution of bichloride of mercury, and then filled with a ten-per-cent iodoform ointment which is warmed and injected through an ordinary glass syringe. A cold compress usually congeals the ointment sufficiently to make it remain in place; or collodion may be used for the latter purpose. Occasionally this process does not have to be repeated. It is especially adapted to those cases in which there is a single abscess; but in those cases in which, at the same time, there are numerous nodes, each breaking down by itself, it is not so successful. In such instances the removal of the mass of nodes by dissection is the most satisfactory procedure, and is usually followed by reasonably prompt healing. In dissecting the nodes one must bear in mind the possibility of producing œdema of the leg. This œdema of the leg, and also of the genitals, may follow complete removal of the lymph nodes of the groin. It is, however, usually temporary, but the danger of such an occurrence and the inconvenience which it causes are sufficient to make one cautious about making as thorough a dissection of the inguinal lymphatics as might otherwise be made.

A simple infection of the lymphatics of the groin also frequently follows

wounds or inflammations of the foot or leg. The lymph vessels of the leg show streaks of inflammation just as those in the arms do, when there is infection in the areas which they drain, and the femoral and inguinal lymphatics are as likely to become infected and form abscesses as are those of the axilla, and they may be dissected away in a similar manner.

Tuberculosis of the Lymphatics of the Groin.—Tuberculosis of the lymphatics of the groin is perhaps more common than is generally appreciated, and, strangely enough, not infrequently follows wounds of the foot, although one would hardly suppose that tubercle bacilli could find their way into these wounds. In 1903 the writer reported, before the New York Surgical Society,* 9 cases apparently infected from the feet, and since then 4 other similar cases have been treated in St. Mary's Hospital for Children. The progress of the disease in one of these patients, who had a virulent form of tuberculous infection, is shown in the following history:

J. K., a well-nourished, otherwise healthy boy of six years, was admitted to the hospital on September 27th, 1898, having cut his foot about a month previously, and having a bunch of enlarged lymph nodes just below Poupart's ligament on the same side. The wound in the foot had healed. The boy had a temperature of 102° F.; the nodes were acutely inflamed, and were removed on the following day. They were found to be about the size of large hickory nuts, of uniform soft consistence, without visible necrotic or caseous spots. They were considered to be simple hyperplastic lymph nodes infected from the wound in the foot, and the incision was expected to heal promptly. Such healing, however, did not follow. Two weeks after the first operation there was a marked enlargement of the inguinal nodes, and the boy had a temperature of 104° F. These nodes were therefore removed through an incision above Poupart's ligament. They presented the same gross appearance as the others: in size they were as large as large hickory nuts; on section they proved to be rather soft and of a uniform pinkish color, with no visible caseous or necrotic spots; in brief, they presented the typical appearance of nodes that are in a state of simple hyperplasia. On microscopical examination, however, they were found to be tuberculous.

For the next seven weeks there was a slight purulent discharge, the temperature ranging from 99.5° to about 100.5° F.; other enlarged nodes could then be felt when deep pressure was made into the pelvis over Poupart's ligament; and it was therefore decided, on December 2d, to make another operation.

An incision was made above Poupart's ligament, from the anterior superior iliac spine to the pubic crest; the peritoneum was retracted upward, and several nodes were dissected from within the pelvis along the iliac vessels.

On May 19th, the discharge still continuing, a little tuberculous tissue and a few more nodes were removed through a similar incision. At about this time the patient also showed evidences of spinal tuberculosis in the middle dorsal region, and for this he was treated with a spinal brace. He was under observation until October 7th, 1899, spending the summer at the summer branch of the hospital at Norwalk, Connecticut. At that time there was still a very slight discharge from the inguinal wound, but his general condition was good; his spine was doing well. He was seen

*Annals of Surgery, May, 1903.

again six months later; the sinus was then healed, but the spinal caries was progressing. Soon after that he contracted diphtheria, from which he died.

The infection in this case was most virulent. It progressed steadily within eight months from the wound in the foot to the dorsal spine, although four separate attempts were made to check it in its course through the lymphatics, all palpable nodes being removed each time. The infection of a bone was contrary to the general law in lymphatic infection and may be considered an exception.

Instead of narrating the details of the other histories in turn, I will group those subjects which seem of the greatest interest.

In these nine cases the character of the wounds in the skin was as follows:

Case I.—Sluggish ulcer over tendo Achillis, one-half inch in diameter. Excised and found to contain tubercle tissue.

Case II.—Wound in sole of foot two months previously, which became infected, and subsided very slowly under treatment. Entirely healed when patient came to hospital.

Case III.—Slight wound in sole of foot two months previously. Child goes about barefoot; mother had had cough; she dressed wound, which healed in about four weeks. A similar second wound formed three and one-half weeks before admission to hospital.

Case IV.—Five months ago the patient stepped on a rake and cut his foot. The wound healed under treatment, but opened again two months ago. Since then it has alternately healed and broken open. (Now healed.)

Case V.—No statement as to wound in foot.

Case VI.—No statement as to wound in foot.

Case VII.—Had a slowly healing sore on foot about a month ago.

Case VIII.—When patient was admitted there was a sluggish ulcer on inner surface of ankle, one-half inch in diameter. Its duration was not known.

Case IX.—Cut foot in a swamp eight months previously. The wound had alternately healed and opened during that time. When patient was admitted to hospital it looked like a spot of lupus.

Thus, in all the cases but two there are distinct histories of sluggish wounds in the foot.

In one instance the ulcer was excised and found to be tuberculous.

All of these children were accustomed to go barefooted and they all lived in tenement houses and apparently received their infection from the direct ingress of tubercle bacilli.

The course of this disease is very slow, as is indicated in the history given, and may lead to a general infection. The duration of the primary sore in the foot varies from less than a month to about eight months. The femoral nodes in the region of Scarpa's triangle were regularly the first ones to become noticeably enlarged, although in one instance the popliteal nodes were enlarged at

about the same time. The infection of the inguinal nodes above Poupart's ligament followed the enlargement of the femoral nodes, and the inflammation spread upward within the pelvis along the external iliac vessels. The periods of time during which these patients were under observation were, respectively,

Fig. 182.—Œdema of the Leg and Contracture following Excision of Diseased Inguinal, Iliac, and Popliteal Lymph Nodes. (Photograph of a patient in St. Mary's Hospital for Children, New York.)

54, 23, 61, 244, 88, 119, 365, 124, and 410 days, and the long periods of illness followed in spite of the radical operations which were done. The later cases, however, in which a radical operation was done at an early time, did much better than the earlier ones, in which a less radical procedure was used at the start.

Treatment.—The thorough removal of the lymph nodes is the method of treatment which should be used. The femoral nodes can be removed through a vertical incision. The inguinal nodes may then be removed through a transverse incision which joins the vertical one and which is made just over Poupart's ligament. Afterward the iliac nodes should be attacked, the aponeurosis of the external oblique muscle being divided above Poupart's ligament, and the lower edges of the internal oblique and transversalis muscles and the transversalis fascia being drawn upward, as in the operation for ligation of the external iliac artery. If the incision is carried from the symphysis to the anterior superior spine, and good retraction is obtained, access will usually be gained to the iliac fossa, so that the vessels can be explored as far as the bifurcation of the common iliac. If access is not gained through this incision, its outer end may still be carried over the iliac crest, thus permitting an exposure of the pelvic and retroperitoneal nodes as far as the middle of the common iliac artery, or even to the bifurcation of the aorta. The writer has not found it necessary to make so long an incision in any of his cases. In one case a swelling of the leg followed this removal of the nodes, and it has now lasted for two years. (See Fig. 182.) This is clearly a very serious deformity, and one should, if possible, avoid a dissection which is likely to cause it.

Popliteal nodes are seldom so enlarged as to be important, but they occa-

sionally break down both in simple and in tuberculous infections. They seem about as important as the epitrochlear nodes. Their presence is to be borne in mind and an examination should be made for the purpose of ascertaining whether they are swollen, but they seldom are of much surgical importance, infection in each instance usually passing to the group of nodes above.

V. LYMPH-ANGIOMA, LYMPH VARICES, LYMPH-ANGIECTASIS, AND LYMPH-ADENOCELE.

The names lymph-angioma, lymph varices, lymph-angiectasis, and lymph-adenocele are given to a group of lymphatic affections which are found in various parts of the body, but which may be mentioned here in a separate division. There is no distinct line of demarcation between the conditions which are designated by the first three of these names. The fourth, which is an affection of the lymph nodes as distinguished from the lymph vessels, is most often found in the groin in connection with filaria. In it the pressure of the lymph may obliterate the parenchyma of the node and leave widely dilated spaces with an irregular connective-tissue framework.

The lymph-angiomata, too, consist of dilated lymph channels with a framework of more or less connective tissue between them. The channels themselves may preserve approximately the general shape of the original lymph vessels, or they may be dilated so as to be distinctly cavernous or even cystic. Their origin is probably in part in newly formed lymph channels, in part in pre-existing ones. A definite distinction between tumors formed from previously existing lymph channels and those which have developed from newly formed ones is not possible at present. These tumors are usually congenital, but sometimes they are acquired; occasionally they grow rapidly. They occur in the skin as soft, slightly elevated tumors, and they may occur in the tongue, forming the condition termed macroglossia. The lymph channels are usually filled with a translucent milky fluid, probably identical with the normal lymph. When they rupture there is sometimes serious lymphorrhœa. They are benign tumors, but may cause very serious deformity, and by their mechanical pressure may be very disturbing.

The accompanying photograph (Fig. 183) shows the appearance of a boy of six years, who was treated in St. Mary's Hospital and who was shown to the New York Surgical Society, November, 1901. The swelling, which was of firm texture, so that pressure from the fingers did not appreciably diminish its size, had been present since birth, but had been of small size until recently. It had been increasing moderately for three years, and during the last month had grown very rapidly. It seemed to involve all the tissues of the cheek, and there was no distinct line of demarcation between it and the surrounding tissue. A piece

excised for microscopical examination showed it to be composed very largely of lymphatic vessels, with a connective-tissue framework and the ordinary structures of the cheek in a somewhat œdematous state.

The term lymph varices is applied more commonly to superficial dilatations of lymph vessels. (See Fig. 184.)

The term lymph-angiectases is applied to collections of dilated lymph vessels which have become engorged from obstruction to the flow of lymph. This obstruction may be due to mechanical pressure on the lymph channels, to their occlusion from injury, to the presence of inflammation in their walls, particularly in the intima, or to foreign substances lodged within their lumens. Among the causes of mechanical pressure we may mention cicatricial contractures,

Fig. 183.—Lymph-angioma of the Face, in a Boy Six Years of Age. (Photograph of a patient in St. Mary's Hospital for Children, New York.)

tumors, and ascites. The most frequent cause of occlusion due to an injury is an incised wound, either one of accidental occurrence or one produced in the course of a surgical operation. It sometimes happens that the lymphatics are so thoroughly dissected from the groin or from the axilla, and, according to some observers, from the upper part of the neck, that œdema (due to the engorgement of the lymph channels) follows. After repeated attacks of erysipelas or lymphangitis, thrombosis may lead to the occlusion of the lymph channels through endothelial enlargement. Metastases from carcinoma may block the lumens, and so also may tuberculosis. The most common cause of

the plugging of the lymphatics is, however, the presence of the *Filaria sanguinis hominis*.* This parasite, a nematode worm, lives in the lymphatics and blood-vessels of man. The adults live in the larger lymphatics, especially those of the abdomen, scrotum, and groin, and in the thoracic duct. The female gives off enormous numbers of ova, which develop into small motile embryos and circulate in the blood. These embryos are called Filariæ nocturnæ(?). They may be found in the blood that is drawn at night from affected patients. They begin to appear at about eight o'clock, and are found in the greatest numbers at about midnight. During the day they are in the abdominal and thoracic vessels. They are actively motile, their length is about four-tenths of a millimetre, and their diameter about that of a red blood corpuscle. Hence they are able to enter the finest capillaries. It is supposed that they go into the superficial capillaries at night because these minute vessels are at that time more relaxed. The time of their appearance can be reversed by having the patient rest in the day and be up and about during the night. They will then be found in the blood in the day-time, but will be absent at night. Their num-

Fig. 184.—Lymph Varix of the Thigh, from a Specimen in the Musée Nicaise. (Fischer.)

ber is sometimes very great. Manson† estimates that in one case at least fifty million of these parasites must have been present in the body.

Certain forms of mosquito act as intermediary hosts, the embryo being drawn from the infected person into the stomach of the mosquito. Development into the adult worm takes place in the mosquito's body in from sixteen to twenty days. The parasite may in turn be transferred into the circulation of the person whom the mosquito bites. It is also believed by some observers that the infection may be obtained from water in which the mosquitoes have perished.

The filaria is not often found in the United States, excepting in individuals who have brought it from the tropics. The possibility of its existence, however, is to be borne in mind by the physician, particularly in the South. It exists very generally in the tropics. Egypt, Brazil, and the South Sea islands are most often mentioned as the infected districts. In some of the Pacific islands nearly half the population show evidences of infection, and Ashford‡ reports

* Wood: "Chemical and Microscopical Diagnosis," Appleton, New York, 1905.
† Manson, in Journal of Tropical Medicine, May, 1900, p. 254.
‡ Ashford, in N. Y. Med. Record, 1903, p. 724.

that twelve per cent of a battalion of native soldiers in Porto Rico had filariæ circulating in the blood, and he estimates that about the same proportion of the general population has the same condition.

Symptoms.—It is possible for large numbers of the filariæ to circulate in the blood and lymph without creating noticeable symptoms. The fact that a large number of people in the tropics harbor these parasites and still enjoy reasonably good health shows how mild an effect they may have. Nevertheless, they are prone to obstruct important lymphatics, and the result may then be very serious. It is a mechanical problem. The adult filariæ are large enough to plug large lymph vessels and thus obstruct the flow of lymph; the symptoms produced varying with the situation of this obstruction and with the consequent lymph engorgement. The groin, it is stated, is the most common site of lymphatic tumors thus formed. Then follow, in the order of frequency, the scrotum, which is a very common seat of elephantiasis; the leg, and, finally, various parts of the body. Ashford has only seen one lymph varix; it was situated on the temple. He found chyluria present, however, in 20 per cent of his cases, but Henry* found that chyluria occurred only rarely. Lymphadenoceles in the axillary and mesenteric nodes are not rare.

Secondary infections sometimes take place. Those who have this form of lymphatic engorgement are particularly subject to attacks of erysipelas and phlegmon, and, since the local resisting power has been lessened in such patients, the attacks are particularly likely to be serious.

Certain patients have chills, fever, and prostration early in the disease, apparently as a result of the filaria infection and independently of secondary infection.

After military marches, prolonged exertions, and exposures of various sorts, exacerbations in the symptoms are of frequent occurrence.

Elephantiasis should also be referred to in this connection. This condition, like lymph-adenocele, is due primarily, as a rule, to the plugging of the lymphatics with filariæ, but the disease seems to be particularly located in the skin and subcutaneous tissue, where there is a chronic hyperplasia. The term, indeed, is applied to extreme hypertrophy of the skin and subcutaneous tissues, a condition which occasionally occurs without the presence of the filariæ, but the plugging of the cutaneous and subcutaneous lymphatics with these parasites is surely the main cause of the condition. The enlargement of the parts affected may go on so as to make the member (often the leg) a large boggy mass, somewhat resembling a limb of the elephant. Other portions of the body, particularly the genitals, are also in some cases involved. The course of this ailment is very slow; the sufferers usually endure the weight and discomfort of their enlarged members for years.

The filaria infection, according to Mazea-Azema, frequently goes on to spon-

* Henry, in Med. News, May 2d, 1896.

taneous recovery in adult life. It is also said that it often disappears if patients move to a filaria-free district. When the affection does not disappear, the mechanical weight and pressure of the enlarged structures, and the tendency to serious secondary infection, are the main causes of the graver results of the disease.

Diagnosis.—The diagnosis of filaria will depend very largely on finding the embryos in the blood by microscopical examination. This can be done without difficulty during the nocturnal ingress to the capillaries.

The lymph-adenocele in the groin presents the most common difficulties in the way of a diagnosis. The resemblance of the tumor (Fig. 185) to a venereal
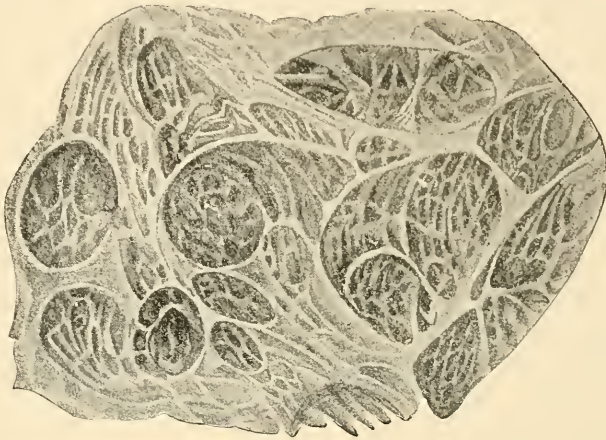
FIG. 185.—Structure of a Lymph-adenocele, Showing Dilated Lymph Spaces. (Nélaton, in Fischer's "Krankheiten der Lymphgefässe, Lymphdrüsen und Blutgefässe.")

bubo, an epiplocele, a cold abscess, a lipoma, a venous erectile tumor, or a deep-lying lymph-angioma is frequently sufficient to puzzle the observer. Ashford found that in many of the cases which he saw among soldiers the condition was believed to be a venereal bubo. The resemblance, however, must diminish with the progress of the two diseases, since the buboes tend to suppurate and the lymph-adenoceles seldom do so. The history and absence of other venereal symptoms should aid in the diagnosis.

Incarcerated epiplocele bears much resemblance to lymph-adenocele. Its nodular structure, however, is less distinct, and there are not the same lymphatic enlargements leading up to it. Its size also frequently increases after continued standing or after coughing, and diminishes when the patient is recumbent. In lymph-adenocele there is often a somewhat similar enlargement on the other side.

Cold abscess is usually connected with carious bone.

Lipomata seldom occur in the groin. If they are found there, their mobility and the white mottled appearance of the skin which their attachments give on pressure or traction, are characteristic.

Venous erectile tumors are usually dark-colored and compressible.

Lymph-angiomata are so often associated with lymph-adenocele that they are not to be definitely distinguished; they are usually less firm in texture.

Treatment.—The ridding of the system from the filariæ is of course the prime indication in those forms of lymph-angioma, lymph-adenocele, and elephantiasis which are due to their presence. I am not acquainted with a specific for accomplishing this. The removal of the patient to a district free from filariæ may result in relief from the parasite. When this is not possible, surgery may give relief to a certain proportion of the sufferers. Those who have circumscribed tumors suitably located are greatly benefited or cured by the removal of these masses. Certain forms of lymph-angioma—for instance, the one shown in Fig. 183—are so diffuse that removal is impracticable. For cases like these the use of the galvano-cautery or actual cautery has been advocated; and so also have the employment of pressure by means of pads and tight bandages, and the application of counter-irritants. For lymph-adenocele which cannot be extirpated Anges recommends the compression of the surrounding tissue and then the injection of five or six drops of a solution composed as follows:

$$\text{℞ Liq. ferri sesquichlor} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 25.0$$
$$\text{Zinci chlorat.} \dots\dots\dots\dots\dots \quad \dots\dots\dots\dots\dots\dots 1.5$$
$$\text{Aquæ destillat.} \dots\dots\dots\dots \quad \dots\dots\dots\dots\dots\dots\dots \ 60.$$
$$\text{M.}$$

The compressing ring is to be removed fifteen minutes after the injection.

Lymph varices sometimes rupture and form fistulæ which can be successfully treated by caustics or by extirpation of the fistula wall. The masses of hypertrophied tissue which are formed in cases of elephantiasis, and even the entire leg or other member, in certain instances, may be removed surgically. The healing after surgical operation on these tissues is often delayed, but may usually be obtained.

PART IX.

SURGICAL DISEASES CAUSED BY INTENSE HEAT AND INTENSE COLD, AND BY THE ELECTRIC CURRENT.

BURNS AND THE EFFECTS OF ELECTRIC CURRENTS AND LIGHTNING.

By BENJAMIN T. TILTON, M.D., New York City.

I. BURNS.

Etiology.—Burns have a very varied etiology. In general, they are caused by the action, upon the body, of the direct flame, radiated heat, heated substances, caustics, acids, etc. The sun's rays may cause slight or severe burns. Scalds are produced by hot fluids or steam. The severity of the local effect upon the tissues depends upon the nearness of the object in question, its actual temperature, the length of time that its action lasts, and the extent of surface involved. Scalds are usually more extensive than burns, as the hot fluid or the steam is quickly diffused over a large surface, and the saturated clothing keeps up the action. Unlike most burns, scalds do not destroy the hairs. Burns, however, are likely to extend to a greater depth than scalds. The different acids produce varying appearances; nitric acid causes yellow stains, sulphuric acid reddish. Carbolic acid is a frequent cause of burns of the lips and mouth in attempts at suicide. Lightning stroke and the electric current produce burns chiefly at the point of contact. The hot-water bottle, which is so frequently used in a careless way in the treatment of unconscious patients in shock or after operations, is a common cause of burns. When not properly protected the heated bottle comes in contact with the patient's body or extremity, and, not causing any pain on account of his unconscious condition, may produce deep burns which confine him to bed much longer than the operation itself. Such burns are not infrequently the cause of a lawsuit for damages, and nurses cannot be warned too often about the danger of their occurrence.

Caustics produce burns when brought in contact with the skin or mucous membrane. Caustic alkalies are not infrequently swallowed by mistake, causing burns of the œsophagus which may be immediately fatal from perforation, or which result later in strictures and their consequences.

Pathology.—The effects produced by the different varieties of burns and scalds are much alike, so that they can be considered together. These effects are conveniently divided into three degrees. In burns of the *first degree* there is a simple hyperæmia of the skin. The superficial vessels are dilated and there is a slight exudation of serum from the small veins and capillaries, causing a mild swelling. The outcome is complete return to the normal condition. The

epidermis frequently comes off later in the form of patches or shreds. Some pigmentation may result, especially in burns caused by the sun's rays.

The *second degree* of burns is that of vesication or bleb formation. In this case the exudation is more marked and the epidermis is lifted from the cutis in the form of blisters or blebs of small or large size. These blebs contain clear, yellowish or blood-stained serum which may become turbid from the admixture of pus corpuscles.

If a bleb is opened soon after its formation, the serum flows out and the reddened rete Malpighii is seen; at other times the fluid will be found to have already coagulated in the form of a thin, jelly-like substance which can be removed only with some difficulty. It is very common for these blebs to break open, and the contact of the clothes, for example, causes the epidermis to become displaced and rolled up. Provided no infection occurs, causing destruction of the underlying cutis, the outcome of this degree of burn is the same as that of the first, viz., a return to the normal conditions without scar formation. The serum escapes from the bleb or dries up within it, and either the epidermis is replaced by new or it falls back and unites with the rete Malpighii. The process of repair is finished in about two weeks and the area shows merely some pigmentation. If infection occurs, the resulting death of tissue may be followed by the production of granulation tissue and a cicatrix, just as happens in burns of the third degree.

Burns produced by acids and caustic alkalies do not cause vesication.

Burns of the *third degree* are those in which there is death of tissue produced by the burn. The more intense or more prolonged heat involves the subepithelial tissues, destroys the blood-vessels as well as the connective tissue by withdrawal of fluid and coagulation of the albumin, and causes coagulation of the blood. The result is local death of tissue, with the formation of an eschar. This may be superficial death, involving only the cutis, or the destruction may extend to a greater depth, the different tissues and even the bone being involved; indeed, in some cases there may be complete carbonization of an extremity. The outcome of all such burns is sloughing, granulation with more or less suppuration, and, finally, scar formation of greater or less extent.

Infection of the burned area increases the amount of suppuration and death of tissue. If the parts are kept perfectly aseptic, the eschar separates with a very small amount of discharge. In case of infection, the original eschar separates more rapidly, but, by reason of the added inflammation, further death of tissue takes place, and there may be spreading cellulitis, lymphangitis, etc. Owing to the difficulty of maintaining complete asepsis, it is the rule for burns of the third degree to suppurate more or less. Later, there is excessive production of granulation tissue, followed by slow cicatrization. These scars are sometimes very unsightly, especially on the face, and have a great tendency to contract, causing marked deformities and interference with function. Ectro-

pion of the lower eyelid, eversion of the lip, stenosis of the passages of the nose or ears, and flexion of the elbow are common results of scars from burns. Burns and scalds within the mouth and throat may result in œdema of the glottis. The inhalation of steam or of ignited gas, drinking hot fluids or carbolic acid, may all produce this result. Complete closure of the glottis may ensue, necessitating tracheotomy or intubation.

Like other cicatrices, those produced by burns may result secondarily in the formation of keloid or epithelioma. Recently there came under my observation a case of extensive epithelioma which developed in the cicatrix of a burn that had occurred fifty years before. The entire cicatrix, which involved the side of the chest, axilla, and shoulder, was converted into an ulcerating epithelioma. The patient was sixty years of age.

Ulceration is not an infrequent occurrence in scars from burns, especially in tuberculous, syphilitic, or badly nourished individuals. It may occur years after the formation of the cicatrix. If the destruction of tissue involves the deeper parts, such as the muscles and bone, the separation of the dead parts proceeds very slowly and may require weeks or months if left to itself. It may be necessary to remove artificially the necrotic tissues before healing can occur.

The pathological changes in more distant parts of the body are chiefly those cf congestion of the different viscera. The intestinal tract, kidneys, lungs, and brain are frequently found to be the seat of congestion after death. In exceptional cases ulceration occurs in the intestine, particularly the duodenum, and it may result in perforation and death. The whole intestinal tract may be the seat of catarrhal inflammation. The kidneys may subsequently become the seat of a nephritis caused by the primary congestion or by the later excretion of poisonous substances during the period of suppuration and repair. Nephritis is not, however, a very common complication. It shows itself by the presence of albumin and casts. Ponfick was the first to find, in the urine and kidneys, yellowish-brown casts which are due to the presence of disintegrated red blood cells.

The explanation of the mode of origin of the duodenal ulcers following burns is still an open question. Some authorities think that they are due to the destruction of the epithelial covering of the mucous membrane from the action of formate of ammonium absorbed from the burnt area. The more probable theory is that there is a primary thrombosis of small vessels in the wall of the intestine from accumulation of disintegrated red corpuscles, and that this thrombosis is followed by necrosis. The necrotic areas subsequently undergo digestion by the intestinal juices, and hence the formation of ulcers.

Symptomatology.—The local symptoms of burns of the first degree are those of the mildest grade of inflammation. These are redness of the skin, slight swelling, increased warmth, and pain. The pain may vary from a moderate sensation of burning to intense agony. Burns of some regions are naturally

more painful than those of other regions. After a few days there is usually desquamation of the epidermis in the form of scales or patches.

The general symptoms depend upon the extent of surface covered by the burn. Burns of the first degree are usually fatal if more than two-thirds of the body surface is involved. Extensive burns usually cause shock of more or less severity. The pulse is weak and rapid, there is mental apathy, the surface of the body is cold, the temperature subnormal. There is often vomiting and there may be great thirst. The urine is scanty and there may be hæmoglobinuria. The cause of the prompt death that sometimes occurs after extensive burns has been attributed to a number of factors besides shock. Some authorities ascribe it to the great destruction of the red corpuscles in the blood. The loss of red corpuscles is thought to have a fatal effect upon respiration and metabolism. This destruction means, on the other hand, setting free of hæmoglobin, disintegration of the white corpuscles, and extensive thrombus formation in the vessels. Others think that the fatal results are due entirely to a toxæmia originating from the site of the burn. The blood and urine of burned individuals have been found to contain toxins. Still others claim that the arrested activity of the skin in burns allows the absorption of poisons into the system. Excessive irritation of the nervous system, owing to the resulting reflex diminution of vascular tone, has been mentioned as a cause of death. Finally, overheating of the blood, with subsequent cardiac paralysis, is a possible etiological factor.

In place of the picture of collapse the patient may, on the contrary, present that of a person very much excited and very restless. He tosses about in bed, crying and complaining of pain. The body temperature is elevated. He finally becomes exhausted, comatose, and dies. As a general rule, the collapse symptoms are the more common.

The local symptoms of burns of the second degree are those of the first degree with the additional symptoms produced by bleb formation. The blisters vary in size and the contents are either clear, bloody, or turbid. The epidermis covering the blisters is often displaced by the rubbing of the clothing and hangs from the extremities or body, leaving the reddened corium exposed. The epidermis may be discolored and the hairs burned off. In the absence of infection the subsequent symptoms are those produced by exfoliation of the raised-up epidermis and growth of fresh epidermis over the exposed corium. If infection occurs there will be a profuse purulent discharge and destruction of more or less of the subjacent tissues. This will be followed by the appearance of granulations and the formation of a cicatrix.

The general symptoms of burns of the second degree are the same as those of extensive burns of the first degree, except that they are more marked and may result from involvement of less surface. When more than half the body is involved, death usually occurs. Shock is almost invariably present in these extensive burns and is one of the most important etiological factors in the fatal

cases. Symptoms of cerebral congestion may develop early. Delirium may be followed by unconsciousness and coma. Among 50 cases of extensive burns collected by Erichsen, 33 died in the first week (27 within the first four days), 8 in the second week, and the remaining 9 within six weeks. The majority, therefore, died as the result of damage to the organism as a whole, and the minority in the stage of reaction.

During the stage of reaction which follows the primary stage, the patient may suffer from symptoms of congestion in various parts of the body. There may be suppression of urine, which is often fatal. The symptoms of cerebral congestion may continue. There is bleeding from the intestines; there may also be diarrhœa and vomiting from congestion or ulceration of the gastro-intestinal tract. Pleurisy and pneumonia may develop.

The local symptoms of burns of the third degree may vary very much. There may be a destruction of the skin only, or an entire part may be charred. The eschar is usually dry, brown, or blackish, and without vitality; it may be white, resembling alabaster. The separation of the dead tissues from the living is accompanied by the signs of suppuration and requires from eight to ten days. There is a discharge of débris and pus from the burnt area, and the surrounding parts may appear red and swollen.

Local wound complications are not infrequent in the early or later stages of burns of the third degree. Examples of such are lymphangitis and erysipelas. Tetanus and septicæmia are the most common general diseases. The healing of the granulating surfaces may occupy a very long period, owing to their large extent and the tendency of the granulations to become exuberant. After healing has occurred the cicatrix shows a marked tendency to contract. This results in decided disfigurement of the face, for example, or in impairment of the functions of a joint from contracture. The scars are usually characteristic. They are irregular, tend to stellate radiation, and frequently show ridges, pockets and bridles.

The general symptoms of burns of the third degree are very much the same as those observed in burns of the second degree. The pain varies in severity. If the outer layers of the skin are alone destroyed, leaving the nerve endings exposed, the pain is much more unbearable than is the case when the whole thickness of the skin is involved. The extent of surface covered determines, as a rule, the amount of shock. An early fatal outcome takes place, as a rule, only when a very large extent of the body is involved. The promptly fatal cases are most likely to be those of burns of the second degree. In the stage of reaction the various visceral complications are possible. Cerebral and renal congestion may result in delirium and suppression of urine. Ulcer of the duodenum, when present, causes vomiting and the escape of blood by way of the rectum, or, if it perforates, peritonitis and death. During the stage of healing of the granulating areas the prolonged suppuration may cause death from exhaustion, or there

may be a fatal erysipelas, septicæmia, or other wound infection. When the ulcer is located in the neighborhood of some cavity, such as the abdomen or cranium, perforation may occur, causing peritonitis or meningitis.

Prognosis.—The prognosis of burns depends in the first place upon the age of the individual; it is distinctly more grave in the very young and the aged. Furthermore, the condition of the general health is an important factor. Delicate women are much more likely to succumb than robust men. Alcoholic individuals offer less resistance and are more liable to visceral complications than the non-alcoholic. The location of the burn also influences the prognosis. Burns of the abdomen and chest have been found to be particularly dangerous.

As has already been stated, the extent of the surface involved is of very great moment in the prognosis. Burns even of the first and second degrees may prove fatal when from one-half to two-thirds of the body surface is involved. Extensive burns of the third degree are likely to prove fatal later from exhaustion or septic absorption.

The question of infection of the burned area is of great importance in the prognosis. Aseptic treatment prevents the local wound complications and limits the amount of septic absorption. Laryngitis, with œdema of the glottis, calls for a dubious prognosis.

Treatment.—The treatment of burns of the first degree may have to be both local and general. Extensive burns require treatment for the shock by the usual remedies, such as stimulants, saline infusion, etc. For the excessive pain, morphine is administered hypodermically, or, in cases of extensive burns, the patient may be anæsthetized. Placing the patient in a warm bath of salt solution or weak sodium bicarbonate solution diminishes the pain and shock in extensive burns. The patient may be kept in such a bath for days or even weeks.

The local treatment of the first degree of burns has as its chief object the protection of the burned surface from the air. In addition, the use of some bland or moist preparation tends to diminish the pain and hyperæmia. Boracic ointment is a favorite remedy. Simple vaseline is also useful. Carron oil (equal parts of linseed oil and lime water) is a popular remedy. Gauze is covered or saturated with the ointment or oil, applied to the part, and held in place by a roller bandage. Wet dressings of boracic acid (four-per-cent) or carbolic acid (one-per-cent) diminish pain and are usually well liked. Dusting powders of boracic acid, dermatol, zinc oxide, etc., may be substituted for the ointments or wet dressings. In case of emergency, household articles, like molasses, flour, starch, may be employed to advantage. For the face, an application of collodion gives a useful and convenient form of protection. The local treatment does not have to be maintained for a long time, as the hyperæmia and pain soon subside.

Burns of the second degree are to be regarded as open wounds, and hence antiseptic precautions are necessary. Furthermore, the air, with its germs, must

be excluded from them. The surface of the blebs or the exposed dermis should
be cleansed and irrigated with some bland, mildly antiseptic solution, such as
four-per-cent boracic acid or simple salt solution (0.6-per-cent). Shreds of epi-
dermis should be cut away with scissors, and foreign materials or impurities re-
moved as completely as possible. In other words, the parts should be rendered
as nearly aseptic as possible and in the best condition for healing to occur.
Avoidance of infection is extremely important, as the latter may result in loss
of substance of the true skin or deeper parts, causing scar formation. The blebs
should be opened at their base by aseptic scissors and the serum allowed to
escape. The covering of the bleb should not be removed, as it may subsequently
become attached to the underlying derma.

The dressings of these burns are much the same as those employed in burns
of the first degree. It is necessary here, however, to bring aseptic substances
in contact with the burned surface. Boracic ointment spread on sterile gauze;
wet dressings of boracic acid, aluminum acetate, or weak carbolic acid; sterile
dressing powders, such as boracic acid, zinc oxide, starch, or bismuth—all these
constitute very efficient methods of treatment. The powders help to dry up
the secretions. Strips of rubber tissue, moistened in some antiseptic solution
(e.g., four-per-cent ichthyol) and applied to the parts, make a convenient form
of dressing. Many surgeons, particularly the French, advocate very warmly the
use of picric acid. It is employed in solution varying in strength from 1 in 100
to 1 in 50. Sterilized gauze is saturated with this solution and applied over
the affected surface. It is claimed to have a marked power of lessening pain
and promoting the proliferation of epithelium. One disadvantage lies in the
the fact that it stains clothing and skin.

Nitzsche first disinfects the burned surface with carbolic acid, after which
it is covered with a thick varnish of linseed oil and litharge mixed with five per
cent of salicylic acid. After the first coat is dry, a second one is applied, and the
whole is covered with a thick layer of wadding and a bandage. Cicatrization
occurs without change of dressings. If suppuration occurs, the wadding is
removed, and dried salicylic acid is dusted over the surface.

If infection and inflammation have already occurred and the surrounding
skin is red and painful, wet dressings are the most efficient form of treatment;
they rapidly cause a subsidence of the local inflammation.

In the subsequent treatment, burns should not be dressed too often, on ac-
count of the associated pain. Shreds of tissue can be removed at these times
with scissors, and the surface cleansed by some non-irritating germicidal solution,
such as boric acid. Stronger antiseptic solutions should be avoided in the
dressings, on account of the danger of poisoning when there is a large surface
for absorption. Gauze soaked in aseptic decinormal salt solution makes an
excellent non-irritating wet dressing.

In the case of extensive burns, the use of the continuous bath is often advis-

able. The sufferings of the patient are thereby greatly mitigated, and the formation of the new covering of epidermis takes place promptly and satisfactorily.

The general treatment consists in the employment of measures for combating the primary shock and subsequent complications. Suppression of urine is treated by diuretics and steam baths or hot packs. Delirium due to brain congestion requires sedatives and an ice cap. Intestinal complications may require special attention.

Burns of the third degree are also to be treated as open wounds, and they require even more attention and stricter asepsis than those of the second degree. The parts should receive a preliminary disinfection, and, during the whole process of separation of the dead tissues and healing of the granulating areas, nothing but sterile material should be brought in contact with the burned area. The gauze dressings may be dry or moist. Powders are often useful in drying up the discharge and preventing decomposition of the dead parts. Wet dressings are particularly useful in case the surrounding tissues are inflamed. They also tend to hasten the formation of a line of demarcation and the separation of the dead tissues from the living. The necrotic parts should be removed when demarcation has occurred. The granulating surfaces are treated by the use of ointments such as boric or ichthyol. When the granulations are exuberant or sluggish, nitrate of silver, in the form of a stick, can be applied. Extensive granulating areas require skin-grafting. In this way the time of healing may be very much shortened and the drain on the patient thus materially lessened.

Contraction of the cicatrix, which is a marked characteristic of the cicatrices following burns, should be prevented as far as possible. Skin-grafting, immobilization of a limb in an extended position by splints, separation of adjoining parts by the dressings, and systematic passive movements may all have to be made use of for this purpose. If the contraction has already occurred, stretching, division and extirpation of the cicatrix, followed by some form of plastic operation, are the measures which must be adopted.

Keloid and malignant degeneration of the cicatrix require excision, as in other cicatrices. A very painful or disfiguring scar may also make excision necessary. Continued ulceration, when caused by tuberculous or syphilitic disease, will require constitutional as well as local treatment.

II. EFFECTS OF ELECTRIC CURRENTS.

Since the very general introduction of electricity into modern civilization, injuries from this source have become very frequent. According to Kratter, the lowest limit of danger to life is five hundred volts. The current sufficient to cause death is usually fixed at fifteen hundred volts. The induction current is much more dangerous than the constant current of the same strength. If death does not occur immediately there is usually sudden loss of conscious-

ness, which may last for a period of time varying from a few minutes to several hours. Dizziness, weakness, headache, and palpitation of the heart may persist for several days. At the point of contact, burns of different degrees occur. In fatal cases death results either at once or within a few minutes. The autopsy shows, besides the burns at the point of entrance of the current, signs of congestion of the thoracic organs, dark-colored blood, and often small hemorrhages which are in part the result of the action of the current. The cause of death is a central paralysis of respiration or of the heart action.

Among the conditions that may result from electric shocks are hemiplegia, paraplegia, blindness, impairment of hearing, taste, or smell, and traumatic neurosis and hysteria. These may be more or less permanent.

The local effects are those of other burns. They may be superficial or deep. They are usually not very painful, nor are they accompanied by fever or other constitutional symptoms. The line of contact between the flesh and the electric wire is black, while the adjacent skin is pale and more or less dry. Owing to trophic disturbances, sloughing and slow repair are said to be more common than in ordinary burns. It is often impossible to determine at once the full extent of the damaged area, as may be done in an ordinary burn. The thermal action of the electric current appears to be most marked beneath the skin, and consequently is not visible to us until later, after sloughing has begun. It has been thought that the cells of the affected tissues produce substances which only gradually cause a destructive action upon the neighboring cells. The extent of the local burn will naturally correspond with the size of the area of contact. Contact with the finger-tip, for example, will result in a small circular burn, while the contact of a broken wire, which more or less encircles the body, will cause a streaked burn over a large area of the body surface. Ecchymoses, often punctate in character, and perforations of the skin are sometimes found without actual burns. Some fatal cases are on record in which no local lesions were found at the point of contact.

The treatment will be considered under Lightning Stroke, in the following section.

III. LIGHTNING STROKE.

Lightning strokes may cause either local changes in the skin, in the form of burns and hemorrhages, or lesions of the entire body. They may produce rupture of the intracranial blood-vessels or of one of the internal organs, like the heart or the liver. The most frequent and important effect produced is paralysis of the nervous system, which sometimes causes death, either immediately or after a severe dyspnœa lasting minutes or hours, or else disappears in the course of days or weeks. Only seldom do single nerves remain permanently paralyzed. Temporary paralyses are most likely to result when the lightning

does not strike the body directly, but first hits some object in the vicinity. There is sometimes temporary or permanent impairment of special senses. Partial paralysis of the extremities may remain·for a long period. Some neurologists claim that a true spinal ataxia may persist, this condition being due to definite anatomical changes in the cord. In the majority of cases, however, recovery takes place, even when the paralysis or paresis has lasted for months. Disturbances in swallowing, and retention of urine, have also been observed. Functional nervous affections, such as hysteria or hystero-epilepsy, may be the outcome in non-fatal cases, or there may be apoplectiform or epileptiform seizures, as well as disorders of the special senses—deafness and blindness. Cases of bulbar paralysis have also been reported.

At the time of the accident the patient may show slight disturbances of consciousness or may pass into a condition of coma lasting many hours. There may be serious lesions in the eye causing temporary or permanent blindness. Subconjunctival and retinal hemorrhages, cataract and iritis, have all been observed. Along ·the course taken by the lightning the skin shows burns of greater or less intensity, also destruction of tissue at the points of entrance and exit. The lines are usually brownish-red and are branched in a characteristic way. They are caused mainly by hyperæmia, as evidenced by a temporary paralysis of the vasomotor nerves, and they disappear promptly if they are not associated with severe burns. According to some authorities the streaks are caused by hemorrhages along the course of a blood-vessel and its branches; hence the branched appearance of the marks. The streaks may run from one end of the body to the other, causing most striking appearances.

The burns in the skin are very much the same as those produced by electrical currents in general. They can be divided into the same three grades as ordinary burns. The skin and subcutaneous tissues are sometimes perforated, and the edge of these openings may be blackened or of a grayish-white color. If the lightning stroke involves the thorax or abdomen, the perforations may go through the pleura or peritoneum. In a few cases punctate spots have been found in the skin over a large part of the body. These occur in groups and consist of circumscribed ecchymoses in the cutis. Acute œdema of the skin over a limited area has been seen to follow lightning strokes as well as electrical accidents. It has been thought to be due to a sudden paralysis of the superficial vessels. A post-mortem examination of the nervous system may show hemorrhages and lacerations in the central nervous system. These are sometimes evident only on microscopic examination.

The *treatment* of lightning stroke and other electric injuries consists, first, in the employment of external warmth, artificial respiration, and stimulants during the stage of shock. Basing their action on the fact that the heart is often found, at autopsy, distended with fluid blood, some authorities (Kratter, Jellinek) advise venesection. Furthermore, they recommend lumbar puncture, owing to the

increased intracranial pressure from intracranial hemorrhage. The artificial respiration should be kept up as long as there are no sure evidences of death having occurred.   Later, galvanism and strychnine may be employed for restoration of function in the paralyzed nerves.   The lightning streaks and ecchymoses usually disappear rapidly and require no special treatment.   The burns are treated on the same principle as ordinary burns of the different degrees.   As the skin lesions are usually very painful, it may be found necessary to administer narcotics.   The separation of the dead tissue often progresses very slowly, and consequently local treatment may be required during a prolonged period.

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CONGELATION, OR FROST-BITE.

By PAUL MONROE PILCHER, M.D., New York City, Borough of Brooklyn.

THE ability of the tissues to resist cold depends upon the amount of heat production in the body, the means used to conserve the heat produced, and upon the degree of cold and the medium through which it acts upon the exposed tissues.

All races do not suffer equally when exposed to the same degrees of cold. For example, the peoples living in the Far North are exhilarated by the cold weather and their tissues become accustomed to exposure, while the Southern races are depressed by the same degrees of cold. Again, different healthy individuals of the same race react differently to the same degrees of cold.

The Esquimaux, while they do not suffer so much from frost-bite, still in the coldest months of the year their bodily functions are affected by the cold. They sleep a great deal, are less energetic, the women cease to menstruate, and in general sexual vigor is at a low ebb.

It is also a strange fact that, during the famous retreat from Moscow, the Italian soldiers suffered far less than did the Swiss and Germans from the cold. It may have been that they were better clothed and fed.

Cases of recovery after exposure to low temperatures have been reported in which the body temperature has diminished to 76°, 80°, and 81° F., while many have perished whose body temperature has not been lowered below 92° F.

In his "Statistics and Studies from the Alcoholic Wards of Bellevue Hospital," Dr. Alexander Lambert gives some very interesting facts in regard to low temperatures of the body in alcoholics: "It is seldom reduced more than $\frac{1}{2}$° or 1° C., though very large quantities of alcohol may cause a fall of 3° to 5° C., or even more, as in one of my patients, whose temperature on admission was 90° F., and remained between 90° F. and 92° F. for fifteen hours, then rose slowly to normal, reaching this point thirty-six hours after admission. The lowest temperature I have seen was in a woman who was found in a hallway comatose from alcohol; the temperature of the air was about 6° above zero. After the patient had been in the hospital for three hours, wrapped in blankets and surrounded with hot-water bottles, her temperature in the rectum was 80° F. The temperature, four hours later, was 83° F. The temperature reached normal twelve hours after admission and continued to rise, until twenty-four hours after it had first been taken it was 104° F. The patient died, thirty-six hours

after admission, with a temperature of 103.8° F. Post-mortem examination showed two small patches of broncho-pneumonia in the left upper and right lower lobes. Such a temperature as this in drunkards exposed to cold is unusual, but by no means unique. Schafer's 'Physiology' quotes records of temperature in drunkards, after such exposure, of 79.5°, 80.6°, 83.1° F., the patients dying; others with temperatures of 75.2°, 76.4°, 82.2°, and 86° F., and the patients recovered after a few days." A case was reported by Dr. James T. Pilcher in which a patient, after exposure to a cold sleety rain which froze as it fell, had a rectal temperature of 68° F. The patient died.

Many striking examples of the effect of cold upon men may be found in the histories of wars. In 1709 a large part of the army of Charles XII was destroyed by cold, 2,000 men being frozen to death during one march. Capt. Edward L. Munson, United States Army ("Reference Handbook of the Medical Sciences"), has collected many interesting facts concerning some of the wars. Seven thousand Swedes, in 1719, perished in the mountains between Sweden and Norway while on their way to the siege of Drontheim. During the Crimean war there were 5,290 cases of frost-bite, with 1,179 deaths, among the French troops; while among the English forces the cases amounted to 2,852, and 463 deaths.

The history of congelation in armies shows that when soldiers are weakened by fatigue, sickness, and privation, and are surrounded in general by unhygienic conditions, the death rate from frost-bite is greatly increased.

On the other hand, when the troops are well fed, clothed, and drilled, they are able to withstand very low degrees of temperature. In the Powder River expedition of 1876, conducted through three winter months, the mercury never above freezing, often down to 40° below zero, in a force of 2,000 men, but 31 cases of frost-bite occurred; while in the 350 Indians who were with the command, no cases were reported.

Cold acts upon the body more slowly and more gradually than does heat, and it generally affects a smaller area, but penetrates more deeply.

Its harmful effects depend upon many conditions: in the first place, upon the medium through which it acts. The clearness of the air, the altitude, and the suddenness of the changes of temperature, vary its effect; and, above all, in the presence of a high wind the action of cold is intensified. A person who is in active motion on a still day can easily withstand a temperature of from 40° to 50° below zero (Fahrenheit), whereas if a high wind were blowing and no protection were afforded, the person would rapidly succumb. Snow, although a frozen medium, may protect against freezing, as has been repeatedly seen.

The constitution of the individual, the temperature, the age, the nutrition, the condition of rest or motion—all these factors vary the effect of cold. Anything which tends to retard the circulation or to hinder muscular action increases the effect of cold. The clothing, when it is so thick that it causes the person

when in motion to perspire, increases the danger of frost-bite, and anything which fits tightly decreases the resistance of the part.

Pathology.—Cold acts upon the surface of the body as an irritant. At first it causes a contraction of the smaller arteries, and a local anæmia results. The blood stream is slowed, the fluid is cooled, and a passive dilatation of the veins takes place. There follows a transudation of serum, and an œdematous extravasation occurs in the tissues. The superficial layers of the epidermis are raised up by the extravasation, and blebs are formed. Unless the cold is very intense and its action is prolonged, the process stops here, and complete recovery is possible. But if its action is prolonged, paralysis of the vasomotor nerves occurs and dilatation of all the vessels takes place. Complete stasis may result. It is possible, even at this stage, that the circulation may be entirely re-established. This vasomotor paralysis may last for hours or even days and may remain in a modified degree for life, as is exemplified by the cases of freezing of the nose in which the red or bluish color persists after the acute inflammation has subsided.

In the most severe cases the blood freezes, the blood corpuscles are destroyed, the hæmoglobin is set free, the circulation cannot be re-established, and gangrene results.

According to Sonnenberg,* if the epidermal blisters burst, a rapid evaporation of the contents and evaporation from the deeper-lying parts may take place. Dry gangrene or mummification results. If, however, the blisters remain and cover the parts, evaporation is hindered and moist gangrene with all of its complex of symptoms occurs. Near the line of demarcation the gangrene is always of the moist type.

As an after-effect of freezing, an endarteritis chronica obliterans may be set up, and this may lead to the entire occlusion of the vessels.

Freezing produces degenerative changes in the muscles and an interstitial inflammation of the nerve trunks.

The pathological lesions may be divided into four grades:

1st Degree.—Superficial erythematous inflammation of the skin, acute and chronic.

2d Degree.—Formation of blisters without destruction of the deeper layers.

3d Degree.—Local destruction of tissue, superficial and deep.

4th Degree.—Gangrene of an entire extremity or a portion of the body.

The areas of freezing are generally unevenly distributed. The ears, toes, and fingers are most frequently affected, the nose less frequently. Many cases of freezing of the penis have been reported.

Symptoms and Course.—When a healthy individual leaves a warm house and goes out into the cold fresh air the skin becomes flushed, the face and nose assume a rosy, healthy appearance, the circulation is stimulated, and there is

* "Deutsche Chirurgie," Lieferung 14.

a feeling of exhilaration. The anæmic, poorly nourished person feels the cold much more quickly. The circulation does not respond to the new stimulus and the face becomes pale and looks shrunken and yellowish and the nose bluish and pointed. As the action of the cold continues, especially in the presence of a strong wind, the face and exposed parts begin to smart and burn, the ears to tingle, and actual pain may be experienced. After a while the skin becomes anæsthetic and the pain or burning sensations disappear. It is owing to this anæsthesia of the skin that persons are often unaware of the gradual freezing process which is taking place. If the person should suddenly enter a warm room, the burning and smarting return, and the skin becomes flushed, provided the freezing process has not developed too far. The face and hands become bluish-red, and are moderately swollen. A superficial erythematous inflammation is present. This generally passes off without any harmful consequences. If the action of the cold is long-continued, or if the same parts are repeatedly the seat of such an inflammation, the lesion may be more persistent and troublesome. In this way the condition known as *chilblains* or *pernio* is produced. It is seen most frequently on the toes, fingers, hands, face, nose, and ears. The affected areas may present the appearance of circumscribed, raised patches of a more livid color than the surrounding parts, or the skin may be evenly swollen and dark-bluish or purplish-red in color. The inflammation may be so severe that vesication and ulceration result. The affected parts itch intensely and there is a sensation of burning. This may increase or remain unchanged when the part is warmed. After the acuteness of the inflammation has subsided, the swelling and redness may remain, and may even become intensified when the part is again exposed to the cold. In other cases there is an increased vascularity which gives to the part a livid, bluish color. This may remain for weeks, months, or even years. When the toes or feet are affected, the skin is apt to be irritated by the clothing, and blisters, pustules, and chronic ulcerations may result. All the subjective symptoms are increased by new exposures to cold. The burning and itching become unbearable, and the sufferer tries to relieve himself by rubbing and scratching, which only increase the distress, until finally the skin is torn and the pain gives some relief. In the milder cases the lesion gradually disappears, but in the more severe cases the affected areas are troublesome for years.

This form of erythema, which is also termed *congelatio*, occurs most frequently in persons having a feeble circulation or a strumous diathesis. From a diagnostic standpoint it is to be noted that the redness disappears on pressure, and that the erythematous areas are cool to the touch, while subjectively hot.

Lesions of the *second degree* are frequently seen involving the ear. The symptoms of freezing of the first degree are present, but they are all more intense. If the parts are poorly supplied with blood, they are colorless and hard and cold to the touch. As soon as the cold is removed, especially if the

part has been too rapidly thawed, it begins to swell. The skin assumes a deep red or even a deep violet color. If the part involved has a loose texture, the œdema will increase to a marked degree, even within a few hours. Vesicles, usually of large size, will form on the surface. The blebs generally contain a clear colorless or slightly turbid fluid. The skin surrounding them is more or less red. When the vesicles are evacuated, a yellow crust forms over them and they heal without leaving a scar. The inflammation and œdema persist for a few days, and then, as a rule, the tissue returns to its normal state again. Or chilblains may follow, especially when the toes and fingers are affected. Generally, when a tissue has been subjected to freezing of the second degree, it is, from that time forward, more susceptible to changes of temperature and to various other external irritants.

Lesions of the *third degree* are characterized by a local destruction of tissue. When the cold is removed, the affected area does not react, as occurs in freezing of the first and second degrees, but remains cold and blue. On the surface there may develop flat blisters which contain dark fluid and quickly dry up, forming scabs. As a rule, according to Sonnenberg, the surface is covered with thick, darkly stained crusts, which are strongly adherent. Or the epidermis may look smooth and of a dirty grayish-brown color. When the necrotic tissue comes away it leaves a superficial, unhealthy ulcer, which bleeds easily and may be either very sensitive or almost anæsthetic. The ulcer generally heals in a short time, leaving a light scar.

If the process has extended into the deeper structures, the necrotic tissue separates more slowly. The healthy tissue surrounding the frozen part often shows a diffuse, wide-spread redness, which is in distinct contrast with the cold, bluish, anæsthetic skin of the area of congelation. The vessels which supply the tissue immediately adjacent to the necrotic area may undergo chronic degenerative changes, and on this account the healing may be long delayed.

Cases of freezing of the *fourth degree*, in which there results gangrene of an entire extremity or other portion of the body, are encountered, as a rule, only in persons who have been overcome by the cold and have remained motionless and unconscious for a more or less protracted period. The individual who is thus overcome by the cold first experiences a feeling of lassitude and muscular weakness. Walking or muscular effort of any kind increases the lassitude. There is an increasing desire to rest, which, when yielded to, only makes further effort harder. The senses become numbed; sight and hearing are less acute; the gait is uncertain and like that of a drunken man; the skin is pale and blue; and, finally, the sufferer cannot go on, the desire to sleep overcomes him, and he lies down. If the cold is not of too severe a degree, life may persist for a long time. The respiration and pulse gradually diminish in frequency. If the heart still beats when the patient is rescued, resuscitation is possible, provided the warming process takes place gradually.

Larrey describes the phenomena which precede the death of the soldier from cold while on the march, as follows: "The dangerous condition is shown in the pallor of the face, by a kind of idiocy, by feebleness of vision or, perhaps, total loss of that sense; and in that state they march for a greater or less length of time, conducted by their friends. The muscular action is weak, and the individual totters on his legs like a drunken man. This weakness is progressive, and is a certain sign of the gradual loss of vital power."

The convalescence is often prolonged, and is marked by unconsciousness, sometimes by delirium, by distressing headache, and by lingering weakness. Death may occur even after consciousness has been regained.

It is in such cases that freezing of the fourth degree is seen. The dead part is blue, cold, and insensible; vesicles of varying size appear on the surface; the underlying parts are dry and red; the adjacent living tissue is red and markedly œdematous. Fever may be present, but is often entirely absent. Gradually, within from one to four weeks, a line of demarcation forms at the junction of the healthy and diseased parts. The distal part turns a blue-black in color and as a rule is dry and parchment-like. Near the line of demarcation the color is more grayish and the tissue is softer and more moist. Spontaneous separation of the part may take place. In some cases the diseased part may degenerate into a state of moist gangrene, accompanied by suppuration and involvement of the contiguous tissue. Such cases are accompanied by marked constitutional symptoms.

The course of events and the results of surgical interference are well illustrated in the following case which recently came under the writer's observation:

The patient, an adult male, 53 years of age, was caught in a snow storm and was overcome by the cold. After an exposure of about seven hours he was found unconscious. He remained in this state for three days. When he was found his hands and feet were cold and blue-black in color. After long and repeated rubbing with snow they began in part to regain their normal color, but the distal portions remained a dull bluish-red. Slowly, portions of the right hand cleared up. All the affected parts were swollen and œdematous. After the patient had regained consciousness he suffered severe pain in the hands and feet, and this continued until the day of his admission to the Hospital, sixteen days after the exposure.

Right hand.—At that time the right hand showed an area—measuring about two by three inches—of superficial dry gangrene, which stretched across the carpophalangeal joint on the dorsum of the hand; and there were also areas of dry gangrene involving the tips of the fingers and thumb. The entire distal phalanx of the middle finger was gangrenous. Motion of the fingers was almost entirely restricted.

Left hand.—Index, ring, and little fingers, and the last phalanx of both the middle finger and the thumb were in a state of dry gangrene. The hand was swollen and of doubtful color.

Right foot.—All the toes and the entire foot, as far up as to the level of the tips of the malleolar processes, were black, cold, and insensible.

Left foot.—In a similar condition; a more definite line of demarcation encircled the ankle joint.

The general condition of the patient was fair. Temperature 101° F.; pulse 112; respirations 28; condition of lungs, negative; slight systolic murmur over the pulmonic area. Urine: acid; specific gravity 1015; faint trace of albumin; and a few hyaline and granular casts.

Three days after admission both feet were amputated, the bones being sawed

FIG. 186.—Ultimate Result in a Case of Frost-Bite. Photograph of case referred to in text, showing stumps of legs, loss of left hand, and condition of right hand. It demonstrates clearly the uneven destruction of issue; also the value of waiting for spontaneous separation where possible.

through at the middle point of the leg. Long anterior flaps. Little hemorrhage. Free drainage provided for.

Two days after the operation the anterior flaps of both stumps showed areas of superficial gangrene. The stump of the right leg finally healed, but it was found necessary to do an amputation of the left leg at the knee-joint before healing took place.

On the thirty-fourth day after the exposure an amputation of the left hand was done at the carpo-metacarpal articulation. The thumb was amputated at the metacarpo-phalangeal joint. The last phalanx of the middle finger of the right

hand was amputated. The other gangrenous areas of the right hand separated spontaneously and healing then took place.

The case illustrates very well the conditions generally met with in freezing of the fourth degree. The features to which special attention should be called are these: The gradual restoration to functional activity of parts which have been severely frost-bitten, when not too rapidly thawed; the severe pain in the affected parts: the non-septic character of the gangrene; the unsymmetrical involvement; the dangers of operating upon the tissues too close to the gangrenous parts; and especially the value of delaying operation as long as possible before amputating a part, for, in the above case, it seemed as if the patient must lose at least the distal portions of the fingers of his right hand, whereas by waiting it was found possible to save them.

Prognosis.—The prognosis of frost-bite varies with the degree of the lesion. Freezing of the first, second, and third degrees is not dangerous to life, healing taking place without scar in the first two degrees; the lesions of the third degree are entirely local. The prognosis in cases of frost-bite of the fourth degree is generally bad, the result being either a great loss of tissue or the death of the patient. Tissues thus affected are especially susceptible to sepsis, and healing is long delayed.

Treatment.—The experience of centuries has taught us that the most important principle in the treatment of frost-bite is to avoid thawing out the affected area too quickly. When a frozen part is too rapidly warmed the results are likely to be a sudden paralysis of the muscular walls of the vessels and a destruction of the individual tissue-cells, and gangrene follows. Subjectively, the burning, pricking, and pain are increased.

In the milder grades of congelation the affected areas should first be rubbed with snow or some other cold solid medium, then with cold water. At first, the water with which the cloths are saturated should be cold, but very gradually it should be made warmer and warmer until the tissues have been thoroughly thawed out. It is also a matter of importance not to bring the patient from the cold outdoor atmosphere into a well-warmed room. The change should be effected gradually. The affected parts should be carefully protected against high degrees of heat. To allay the inflammation which results, cooling lotions may be applied. All external irritation must be removed.

In the treatment of chilblains, prophylactic measures are of great value. It is important to protect the parts predisposed to chilblains by warm wraps (woollen socks for the feet and gloves for the hands), and the feet should be clad in roomy, well-fitting shoes. The hands and feet should not be put suddenly into hot water, nor warmed before the fire; and, in general, sudden changes of temperature should be avoided. In the acute cases the patient should remain quiet in bed, the parts should be rubbed with snow and cold water, and cold compresses should be applied. After the acuteness of the inflammation has

subsided, the affected areas are to be protected from the cold, and stimulating balsams and ointments should be used. Balsam of copaiba may be applied at night and left on until morning, care being taken to protect the clothing from being soiled. Tincture of iodine is especially valuable and should be applied at night; or an ointment containing equal parts of resorcin, ichthyol, and tannic acid may be employed to advantage. To allay itching and burning, Monroe recommends compresses moistened with acetate-of-zinc solution (one drachm in a pint of water). Lead-and-opium wash may also be used. When blisters form they should be opened under aseptic conditions, and an ointment of boric acid and vaseline, equal parts, should be applied. Chronic ulcers are best treated by touching them with a stick of silver nitrate, or by painting them with tincture of iodine and afterward protecting them by an application of red iodide of bismuth powder.

Internally, tincture of belladonna may be given to allay the itching and burning. Potassium iodide in gradually increasing doses may sometimes be employed to advantage. Anything which tends to increase the general physical well-being of the patient should be encouraged.

In the prevention of freezing, an abundance of nutritious and fatty food and a sufficiency of proper clothing are of greatest importance. The feet should be encased in loose, water-tight, and comfortable footwear. To protect the hands, heavy gloves or mittens are essential. In the Japanese army, a mitten is used with a single division into which the trigger finger can be slipped when desired.

When on the march, troops should be supplied with hot food or drink, the ranks kept well closed up, and straggling prevented. In general, if the army is well fed, well clothed, and free from sickness, it can undertake a winter campaign with perfect safety, provided the distances to be covered are not too long.

In treating persons who have been overcome by the cold, Sonnenberg recommends that they be brought into an unheated room and placed in a cold bed. The body should be rubbed with cold wet towels. Then the patient should be put into a full cold bath of the same temperature as the room. The temperature of the bath should be gradually increased until, in the course of two or three hours, it shall have reached about 80° F. Painful portions of the body should be bathed with cold water and enveloped in cold wet cloths. The patient should be freely stimulated at first by subcutaneous injections of brandy or whiskey combined with hot rectal enemata containing either whiskey or coffee. Later, large doses of whiskey or brandy may be given by mouth, if the patient's condition will permit.

In the very serious cases, if there are any signs of life when the patient is found, artificial respiration should be carried out and oxygen administered. Everything possible should be tried in order to re-establish the circulation in the frozen members. Bergmann recommends that the extremities be carefully

protected and then *suspended in a vertical position* with the knees and elbows slightly flexed, in order to facilitate the return flow of the venous blood and thus to diminish the œdema and lessen the extent of gangrene. This method of treatment has been tried in a number of cases, and the results have been most satisfactory. It therefore should be included in the routine treatment of these cases.

The German writers recommend that the limbs should first be kept enveloped in moist compresses and later in antiseptic compresses. The writer would recommend, as a modification of this method, the avoidance of all moisture after the first forty-eight or seventy-two hours, because the presence of moisture fosters the development of moist gangrene, which greatly adds to the danger of the situation in these cases. It is better, after the first forty-eight hours, to dust the affected part with boracic-acid powder and then to encase it in a thin layer of wool, care being exercised to ward off all sources of irritation and to avoid high temperatures.

As a rule, if the case has been properly treated there will result only a dry gangrene, from which there is very little absorption, and therefore it will be possible to wait for a line of demarcation to form. This is especially true of frozen fingers and toes, and they may therefore be allowed to separate spontaneously. If the condition of the patient will permit, an expectant line of treatment may be instituted in the cases in which larger areas are involved. But when moist gangrene develops, as often happens, an immediate operation is indicated. In all cases, whenever such a course is possible, it is well to wait for the line of demarcation to form, for then the amputation may be done fairly close to this line. When it is necessary to operate before the line of demarcation has formed, the amputation should be done at some distance from the gangrenous area, for in such cases, as was seen in that cited above, there is danger that gangrene will develop in the stump.

It is important to remember, as I have already stated above, that if the frozen limb is kept moist and hot, moist gangrene is sure to follow.

PART X.

SIMPLE AND COMPLICATED WOUNDS, INCLUDING GUNSHOT WOUNDS.

WOUNDS OF SOFT PARTS BY CUTTING AND PIERCING INSTRUMENTS.

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WOUNDS made by cutting and piercing instruments may be arranged in three groups, as follows:

(1) Incised wounds;

(2) Punctured wounds;

(3) Wounds which, while they may have the physical characteristics of incised or punctured wounds, require separate consideration on account of the special character of the mechanism of their production or because of their liability to infection.

To this class belong the stab wounds, sword and bayonet wounds, dissection wounds, and post-mortem wounds.

I. INCISED WOUNDS.

An open wound having well-marked, cleanly cut edges is called an *incised* wound. The vulnerating instrument must be either sharp-edged or, if blunt, must move with a relatively high velocity to produce a traumatism having these characteristics.

In the typical wound of this class, made by a keen-edged instrument, a minimum amount of tissue is actually destroyed by the impact of the vulnerating body, and bruising and laceration of the lips of the wound are absent.

Classification.—Incised wounds may be classified:

(1) According to the region of the body involved; as wounds of the head, neck, chest, abdomen, etc.

(2) As simple or complicated wounds.

A simple wound is one which involves only the skin or mucous membrane, fascia, muscles, small vessels, and nerves; while in a complicated wound important structures are injured, a joint or other cavity being opened, important tendons, vessels, or nerves divided, etc.

(3) As aseptic or septic wounds.

An aseptic or non-infected wound is one into which no septic material has

been introduced in sufficient quantity to interfere appreciably with the normal process of repair, or one from which, although septic matter has been introduced, it has subsequently been removed or rendered inert. A septic or infected wound, on the contrary, is one into which, as a result of the conditions under which it was received or from other causes, infectious material has gained entrance in quantity in excess of that which the tissues are able to neutralize or destroy and has been allowed to remain. If this definition is accepted the terms aseptic and septic have a relative meaning only, for it is possible that in every operation wound a number of pathogenic bacteria find lodgment, however perfect the technique of the operation and however careful the operator and his assistants may be. In most cases, fortunately, the resisting power of the tissues is sufficiently great to withstand these; the bacteria do not multiply, but are destroyed and the wound remains aseptic. From a practical standpoint the classification of wounds as septic or aseptic is very important, for upon it depends in a great measure the method of treatment to be employed.

Incised wounds are further classified as *penetrating* when the vulnerating instrument enters one of the body cavities, or as *perforating* when it passes entirely through a part of the body.

Symptoms.

Pain may be said to be a constant initial symptom of all incised wounds, though it may vary much in character and degree. The pain which immediately follows the reception of the injury is usually of a smarting or burning character and is due to the irritation caused by the division of the sensitive nerve filaments and the exposure of their cut ends to the air. The degree of pain is very variable and depends upon the sensitiveness of the part wounded, upon the degree of mental excitement or muscular exertion the individual is undergoing at the time, and upon the velocity and sharpness of the instrument inflicting the wound. Wounds involving sensitive parts of the body cause more severe primary pain than those of comparatively insensitive parts: thus, a wound of the palmar surface of the hand is more painful than a wound of the buttock or outer surface of the thigh. Idiosyncrasy has a marked influence, some individuals being much more susceptible to painful sensations than others. The degree of pain also depends on the condition of the wounded part as to irritation or hyperæsthesia at the time of the injury, a wound in the vicinity of an acute inflammatory process being usually more painful. Excitement and muscular exertion modify the painful sensations to a marked degree. A wound, particularly an incised wound by a sharp instrument, may produce no pain at all, the individual not being conscious of having received a wound. The pain which comes on later, after incised wounds, is of a different character from the primary pain and is usually milder in degree than that following any

other class of wounds. This pain is due to the pressure on the sensitive nerve filaments, the result of the increased tension of the parts which is present in the early stages of the process of repair. Among the factors contributing to this state of tension may be mentioned the increased flow of blood to the part, the diapedesis of the leucocytes, and the proliferation of the fixed tissue-cells, together with the exudation of plasma. If no inflammatory condition supervenes as a result of infection, and if the wounded part is placed at rest and properly protected, this secondary pain, which has never been severe, gradually subsides and in a few days entirely disappears.

Hemorrhage.—There is always immediate hemorrhage following the reception of an incised wound. Hemorrhage is more marked in wounds of this class than in any others, partly because of the clean division of the vessels and also because of the absence of laceration and contusion of the walls of the wound, which conditions, present in other wounds, favor the deposition of fibrin and encourage the formation of clots. The severity of the hemorrhage will depend upon the size and shape of the wound and upon the number and character of the vessels involved. In slight wounds, or in those situated in parts not very vascular, hemorrhage may be insignificant and transient, being arrested in a few minutes on exposure to the air or after application of slight pressure. Such cases as these are of common occurrence and usually of no importance. When larger vessels are cut or where the capillary network is richer, the bleeding is more profuse and of greater significance.

Hemorrhage from *capillaries* is intermediate in color between that from arteries and that from veins, and oozes up from the whole surface of the wound and is immediately arrested, at least temporarily, by pressure. In hemorrhage from *veins* the blood is dark in color and flows in a steady stream welling up out of the wound without intermittence except in certain wounds of the neck or chest, in which the flow may take on a rhythmic character due to the respiratory movements.

Venous hemorrhage is rarely excessive unless a large trunk is wounded. It is greater if there is an impediment to the free return of blood to the heart as in some wounds about the head and neck with obstructed respiration, or when a constrictor is placed on a limb in such a way that it obstructs the venous return without completely stopping the arterial flow. Wounds involving the large veins about the neck are especially dangerous on account of the hemorrhage and also because of the liability of air entering the circulation through the wound in the vein.

In *arterial* hemorrhage the blood is scarlet in color, and if the vessel is exposed by separating the edges of the wound it will be seen to issue in jets from the proximal end, with exacerbations of velocity and force synchronous with the systole of the heart. Where the hemorrhage comes from a small artery deeply situated in a narrow wound or where the flow from the wound is obstructed, this

remitting character is not so marked and may be entirely absent, the blood welling from the wound as in venous hemorrhage. Bleeding from a partially divided artery is more persistent than from one which has been completely divided.

The constitutional effects produced by hemorrhage depend upon the amount and rapidity of the hemorrhage. A sudden loss of blood produces more profound symptoms than if the loss is gradual. The symptoms are: Rapid and feeble pulse; pallor of the skin and mucous membranes; sighing and irregular respiration with dyspnœa, and restlessness; a clammy condition of the skin; nausea; and disturbances of the special senses, particularly sight and hearing.

If the hemorrhage is profuse there are, finally, syncope, collapse, unconsciousness, and convulsions. In the very young and the aged the severity of the symptoms is greater, relatively, than in healthy adults. After severe hemorrhage there is frequently noticed a slight febrile condition, due to general nervous irritation following the loss of blood and to the absorption of fibrin ferment. At this time the pulse is accelerated and compressible and all the vital functions are in a state of depression.

Retraction of the Lips of the Wound.—This occurs in all incised wounds and is due to the elasticity and retractility of the skin and underlying tissues. The degree of retraction varies in the different parts of the body, the retraction of the edges of the skin being greatest in wounds of those parts where it is loosely connected with the structures beneath. Thus, in the palm of the hand the retraction may be slight, while on the inner surface of the thigh or on the abdomen it may be considerable. The amount of separation also depends on the direction of the cut. If the wound is parallel with the elastic fibres of the skin it will be less than if the section is across those fibres. The retraction is greater in a long wound than in a short one; it is also greater in a deep wound than in a superficial wound of the same length. In a wound involving muscular tissue the retraction is greater if the muscle is divided transversely than if it is separated in the direction of the fibres, and is greater if the muscle is completely divided than if only partially divided. It is greater also when long muscles with attachments only at the extremities are divided transversely than in short muscles or muscles attached to bone throughout their length. These facts are all taken into consideration by the surgeon when planning his incisions for operations. He so makes his incision through the skin that, having due regard to other structures, he will have less retraction of his wound edges and consequently less tension on closure than if he should make it otherwise. When muscular tissue has to be divided, he makes the separation, when this is practicable, in the direction of the fibres rather than across them.

Loss or Impairment of Function.—This symptom is present, to a greater or less extent in all wounds, but varies greatly and is dependent on several factors. It may be due to pain or to the natural depressant effect which injury has on the general system (known as shock), and which is general in character and not

confined to the part wounded; or the impairment of function may be limited to the parts directly affected by the wound, and in such cases will vary in accordance with the function and importance of those parts. Anæsthesia, paræsthesia, and paralysis will be present if important nerves are divided; if tendons or muscles are severed, motion is interfered with; if the chest or abdomen is involved, respiration may be affected; and so on.

The duration of this disturbance of function will depend upon the cause. If it be due to a temporary condition such as shock, it will cease when the shock has been recovered from, but if due to the disabling of particular structures its duration will depend upon the length of time required for the healing process, upon the methods of treatment employed to assure prompt and accurate union of divided tendons, nerves, and muscles, and also upon the fact whether an infective process has been established or not.

Shock.—One of the most constant and also one of the gravest constitutional symptoms of severe wounds is that condition known as *shock*. Shock is a state of depression of the vital functions in which the cardio-vascular system is especially affected; as a rule, it quickly follows the reception of the wound and may vary in degree from a mere momentary depression of the vital forces, manifested by slight mental dulness or confusion, to the most profound depression followed by death. Goltz has demonstrated that the essential factor in the production of shock is a weakening or paralysis of the vasomotor areas of the medulla. This paralysis is reflex in character and results from the irritation of the sensory nerves involved in a wound or injury, and the degree of weakening of the centres corresponds to the intensity and duration of the peripheral irritation. As a result of the vasomotor paralysis and the weakened heart action, the veins, especially those of the abdomen and the right side of the heart, become distended, while the quantity of blood in the arteries is diminished. Under these circumstances the lungs and brain fail to receive a sufficient amount of blood, syncope ensues, and, if the condition continues, death shortly follows. In some individuals shock is more marked than in others after injuries of equal severity. Women, as a rule, suffer less from shock than men, and the young less than the old. Mental conditions and impressions also have a great influence on the degree of shock; depressed mental conditions, fear, and apprehension aggravate shock, while cheerfulness and hope diminish it.

As the subject of shock is very fully treated in the preceding volume (p. 463) it is unnecessary that I should pursue it any further in the present article.

The Healing Process in Incised Wounds.—The method by which repair of incised wounds is effected differs in no essential respect from that of other classes of wounds, but, owing to the small amount of tissue devitalized and the comparative ease with which these wounds may be rendered aseptic, and on account of the facility with which accurate coaptation of the edges may be

made, the repair of incised wounds is more rapid and complete than that of wounds of any other class.

The different steps of the healing process—steps which are known by such designations as "healing by first intention" or "primary union"; "healing by second intention," "healing by granulation" or "secondary union"; "union by aseptic blood clot"; and "healing under a scab"—are described in detail in Volume I, and it will therefore be unnecessary to repeat the description here.

Febrile Manifestations Occurring during the Healing Process.—After the reception of an incised wound, whether made in the course of an operation or otherwise, practically no constitutional effects are manifested during the process of healing, unless the wound was of a very serious nature or unless infection has taken place. Where the healing takes place by first intention or by blood clot, the condition remains good, there is only slight disturbance of temperature, and the patient feels comparatively well. If the character of the wound is severe and considerable hemorrhage occurs, the injury may be followed, during the first few hours after reaction has set in, by a slight elevation of temperature accompanied by increased frequency of pulse, slight thirst, and dry skin. This condition is called *aseptic fever* and manifests itself during the period immediately following the shock from the wound. The temperature seldom rises above 101° F. and is ephemeral in character, lasting only a very few hours or a day or two. If the dressing is removed the wound will be found in good condition, with very slight or no redness about the edges, and with no evidence of infection. This form of fever is more likely to occur if there has been much oozing of blood after the dressings have been applied, or if there has been much manipulation of the tissues during the operation or in cleansing an accidental wound. It is now generally ascribed to the absorption of the products of the disintegration of effused blood and tissue detritus, particularly fibrin ferment and other pyrogenous substances from the wound.

Traumatic or Septic Fever.—If the wound is not aseptic a more serious disturbance of the system takes place and there are evidences of an inflammatory reaction in the wound. The fever is due to the absorption of the products of putrefactive and fermentative bacteria, and must be distinguished from that due to suppuration. In large wounds containing blood clot and serum, where bacteria have gained entrance and found suitable soil for multiplication, chemical products—ptomaïns—are developed, and these, being rapidly absorbed, produce symptoms of septic intoxication. The bacteria themselves do not invade the tissues, there is no septicæmia, but all the constitutional disturbance is due to sapræmia, the amount of disturbance depending entirely upon the dose of the poison.

The subjects of septicæmia and pyæmia have also been fully discussed in Volume I (pp. 415 *et seq.*), and I may therefore pass on to the consideration of other matters connected with the subject assigned to my care.

Prognosis of Incised Wounds.—The prognosis of incised wounds depends upon many factors aside from the gravity of the wound itself. Among the conditions to be considered are the following: the surroundings under which the wound is received and treated; the food; the domicile; the means of obtaining cleanliness, etc. Those who lead an outdoor vigorous life usually recover more quickly than those living under the reverse conditions. The mental state of the individual is of importance in considering the prognosis; those of a hopeful sanguine temperament being more likely to recover from severe injuries than those of a brooding and melancholy disposition.

Wounds heal with greater rapidity in the young than in the old or middle-aged. This is because the recuperative and reparative forces are more vigorous in the young and also because there is less probability of existing organic disease. As age progresses the reparative powers diminish until in the very old a wound, which in the young would be comparatively trivial, may be very dangerous. This rule, however, is by no means universal, for many old people make an excellent and rapid recovery from serious operations and wounds.

The presence of certain diseases renders the prognosis especially grave. Among these may be mentioned: erysipelas, tuberculosis, and diabetes mellitus, the presence of any one of which diseases warrants a grave or dubious prognosis. Tuberculosis is likely to retard the reparative process greatly on account of the exhausting nature of the disease, and in a diabetic patient the wound is likely to become gangrenous, or, if important vessels have been divided, gangrene may attack distant parts supplied by these vessels. On the other hand, a wound received by a person in the advanced stages of tuberculosis or diabetes is apt to react unfavorably on these affections, aggravating them, though the wound itself may heal without difficulty. The same may be said in regard to those diseased conditions in which there are advanced organic changes in the liver, kidneys, or heart.

The final result of incised wounds as regards restoration of function of the parts involved depends in a great measure upon the location of the wound, its severity, and the treatment employed. If tendons, muscles, or nerves have been divided the prognosis as to function will depend upon the facts whether these structures have been properly united, whether infection has taken place, and whether the wounded part has been kept at rest. Adhesions are apt to take place in extensive wounds and may interfere with the function of the parts. This is more likely to occur in wounds in which several layers of muscles or several contiguous tendons have been divided. In such cases, especially if the healing of the wound has been attended with much inflammation, the tissues affected may be so bound together as to interfere seriously with the function of the part involved. The prognosis should be guarded in wounds involving joints; even when uncomplicated by infection such wounds are frequently followed by permanent weakness and diminution in range of movement.

Treatment of Incised Wounds.—In discussing the treatment of incised wounds it is convenient to separate all such wounds into two classes:

(1) Operation wounds, and

(2) Accidental wounds, including wounds inflicted with suicidal or homicidal intent.

Operation Wounds are deliberately made by the surgeon for a definite purpose, and they are nearly always preceded by certain preparatory measures designed to secure and maintain an aseptic condition of the wound. The measures to which reference is here made are very varied in their character and are justly considered of the highest importance. Dr. Moore, of Minneapolis, has discussed this subject in great detail in Volume I (pp. 691 *et seq.*), and I may therefore limit what I have to say to a few remarks of a general character.

Conditions Favorable to Wound Infection.—Given the specific agent, the pathogenic bacterium, certain conditions of the wound favor its development and increase its power for evil. The presence of pent-up secretions in the wound favors the development and multiplication of the pathogenic organisms by furnishing them with a suitable pabulum, moisture, and a favorable temperature. The conditions are rendered still more favorable if the tissues have been more or less devitalized by the original injury or by subsequent influences, such as rough handling or irritating solutions. On the other hand, a dry condition of the wound and the absence of blood clot are distinctly unfavorable for their growth.

Mode of Entrance into the Wound.—Bacteria may be carried into the wound by the instrument making the wound or by subsequent contact with infected material, such as clothing, instruments, dirty fingers, or other objects. They may be introduced adhering to particles of dust which find lodgment in the wound, or possibly from the air directly, but this must be a comparatively infrequent source of infection. The skin of the person wounded is without doubt one of the chief sources from which the infective bacteria are introduced.

Preparatory Measures Employed to Prevent Infection.—The result aimed at in operation wounds, when made through unbroken skin and uninfected tissue, is the elimination of the pathogenic bacteria as factors to be reckoned with in the healing process. To attain this result certain preparatory measures must be carried out in minute detail: ligatures, sutures, dressing materials, and instruments must be carefully prepared and sterilized; the skin at the site of the proposed operation must be cleansed; and the clothing and hands of the operator and his assistants must be especially prepared before the operation is begun.

Management of the Wound Itself.—One of the chief precautions to be observed is *to do as little injury as possible to the tissues consistent with thoroughness in attaining the object of the operation.* Every additional injury to the tissues adds to the chances for subsequent infection and consequently to the gravity

of the operation; therefore, all unnecessary handling of the tissues, either with the fingers or with instruments, is to be avoided. By rough handling and careless methods of retraction of the edges of the wound the tissues are bruised and lacerated, the muscular planes separated, and the superficial cells devitalized to a greater extent than is necessary. For a like reason all strong applications of chemicals to non-infected wounds are not only useless, but decidedly injurious.

Arrest of Hemorrhage.—After the operation has been completed, permanent arrest of all hemorrhage should be secured by means of one or more of the methods which will be described when we come to the treatment of accidental incised wounds. This is necessary in order to put the wound in the best condition for rapid repair; for, if the wound is aseptic, repair will progress more favorably if there is no accumulation of blood clot present; and if the wound is infected, the absence of blood lessens the danger of that infection by lessening the amount of pabulum for the bacteria, and thus retards their multiplication. After hemorrhage has been controlled, all clots of blood should be carefully removed from the wound by gentle irrigation with warm sterile water or normal salt solution, and the wound dried by gentle sponging with sterile gauze mops or pads.

Approximation of the Walls of the Wound.—After the wound is clean and comparatively dry, the walls should be approximated and brought into as perfect apposition as possible, care being taken to obliterate all dead spaces. When necessary, buried sutures should be used in order to better approximate the deep structures. These should be of absorbable material, usually of catgut.
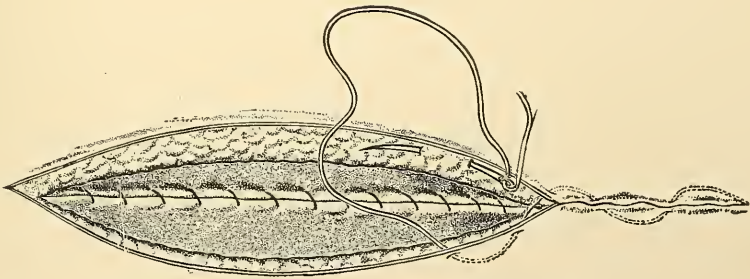
FIG. 187.—Subcuticular Suture. (Halsted.)

The muscular tissue should be united layer by layer if it has been deeply divided, and care should be taken not to tie the sutures too tightly, and to enter the needle a sufficient distance from the edge to prevent the stitches from tearing out. When the deeper layers have been thus brought together the edges of the skin should be accurately united by interrupted sutures of catgut or by the subcuticular suture (Fig. 187). The advantage of this suture over the open suture lies in the fact that it is less liable to produce stitch abscess, because

it does not penetrate the cuticle, but it is more difficult to remove and also to apply. Before the skin wound is entirely closed by tightening the sutures, all blood and serum which may have accumulated in the wound should be pressed out by manipulation with the fingers, and the wound should be temporarily covered with a gauze pad and slight pressure made until the final dressings are ready for application.

Dressing the Wound.—The preparatory measures and the measures undertaken during the operation having been carried out, as above indicated, we now protect the wound from the possibility of any infection and promote healing by certain other measures which will now be considered. The most important of these is protection of the newly made wound. As already mentioned, the material usually employed at present for this purpose is sterile absorbent gauze or gauze impregnated with some chemical bactericide, such as mercury or iodoform. Dressings may be applied dry or moist.

Dry dressings are usually the best for aseptic wounds, and it is generally not necessary to use antiseptic gauze in direct contact with the wound. The line of incision should be covered with a few thicknesses of sterile absorbent gauze folded into a thin pad of sufficient size to reach a couple of inches beyond the wound in all directions. This plan is better than to have the bulk of the dressings in direct contact with the wound, as it makes removal easier and as adhesions due to drying will take place only between the small pad and the skin, the large pad being readily removed. The small one can then be easily moistened by a gentle stream of water and thus readily detached. Over this small pad, extending for at least four inches in all directions from the wound, is placed a pad of sterile gauze of generous thickness, this depending upon the amount of discharge to be expected. The superficial layers alone, or all of this pad, may be of antiseptic gauze if preferred. The reason for using antiseptic gauze for the outer layers is that it prevents bacteria from penetrating, by growing inward from the surface, after the secretions from the wound have permeated the thickness of the dressings. In this connection it should be remembered that bichloride gauze undergoes changes which render the mercurial agent inert. Over the gauze the bandage may be fitted directly, or sterile cotton batting may first be placed over it. The amount of cotton used will depend upon the location and extent of the wound; enough should be used to exert constant gentle pressure, to prevent shifting of the dressings, and to lessen the discomfort due to tight bandaging. Formerly, it was customary to place a piece of oiled silk or other protective over the line of incision, but this is now rarely employed. Sometimes a mild antiseptic powder, such as boracic acid, oxide of zinc, or aristol, is sprinkled on, but in ordinary surgical practice this is not necessary, and unless drainage tubes are used such drying powders may prevent the escape of serum from the wound. Silver foil is also sometimes used as a protective in immediate contact with the wound. As regards an outer impervious covering for the dressings, such as

rubber tissue, macintosh, or oiled silk, little can be said in its favor. It prevents the gentle gradual evaporation of moisture through the dressings and causes maceration of the skin if the secretions from the wound are free, and for these reasons it has been discarded.

Infrequency of dressing should be aimed at whenever the condition of the wound will permit. Changing the dressing disturbs that rest which is so necessary to the rapid healing of wounds. When the first dressing is properly applied and no contraindications occur, it is usually not necessary to remove the dressings until the tenth or twelfth day, and then only in case nonabsorbable sutures have been used for uniting the skin. Healing at this time is usually complete. If, however, drains have been used, it may be wise to remove them and apply a fresh dressing at the end of forty-eight to seventy-two hours. If the dressings at any time become stained with serum or blood, the wound should be redressed. The body temperature is a guide as to the necessity of applying a fresh dressing. If it remains normal, or if, after a temporary rise, it drops to normal and continues at this level, there is rarely necessity for disturbing the wound. If, however, after the first day or two there is a rise in temperature and this rise continues, with perhaps remissions, infection of the wound is probable and the dressings should be renewed and an examination made. In changing dressings the most strict antiseptic precautions should always be observed.

Rest.—Rest for the wounded part is essential for the most rapid healing of the wound and is secured by compression, immobilization, position, and by anodynes.

Compression should be gentle and uniform and is usually made by a suitably adjusted dressing. When properly applied it lessens the flow of blood to the part, prevents excessive exudation and accumulation of lymph, and favors absorption of serum. It also lessens muscular spasm arising from the irritation of the wound, and thus promotes the rest of the injured part. As a rule, sufficient compression can be secured by using plenty of cotton wool and covering this by a snugly fitting roller bandage. If a limb is the part wounded the cotton batting should extend entirely around it, and the bandage should be so applied as to secure uniform compression without constriction at any point, a separate bandage being first applied carefully to the distal part of the limb.

Immobility is secured by properly applied bandages and compresses or by splints of various kinds. Splints may be made of various materials, as wood, plaster of Paris, felt, pasteboard, leather, tin, wire gauze, etc. Wire gauze, plaster of Paris, and felt are particularly suitable for immobilization on account of the facility with which they can be moulded to conform to the irregularities of the wounded parts. Wire-gauze splints can be cut into any size or shape by strong scissors or wire-nippers, and can be readily fitted to the irregularities of the part wounded. They are easily disinfected and permit of free ventilation of the surface to which they are applied.

Plaster of Paris is a most valuable splint material for immobilizing wounds. It should be fresh and heated in order that it may set quickly and well. This may be done over an ordinary stove fire. The part to which it is applied should be enveloped in a smooth layer of cotton batting or in a flannel bandage over which a roller bandage, into the meshes of which the plaster of Paris has been rubbed, should be applied after soaking for a few minutes in warm water. As many layers as necessary may be applied to give the splint sufficient rigidity, care being taken to rub plaster cream over each layer. The Bavarian splint is a modification of the ordinary plaster splint; it is so made as to be readily removable. If, when a plaster splint is used, it is found necessary to have an opening at the site of the wound, this may readily be effected before the plaster has thoroughly hardened. On the other hand, if it be found that the establishment of such an opening will leave the splint too weak, the latter may be strengthened by incorporating in it iron rods or pieces of wood.

The wounded part should if possible be put in such a position as to relieve all tension and should be elevated and suspended, if practicable, and placed in a position to facilitate drainage.

The Use of Anodynes.—If there is pain or restlessness after the operation it is well, if no contra-indication is present, to administer some preparation of opium, preferably morphine, to insure the quiet and rest which are so important at this time. The anodyne relieves pain, promotes sleep, and controls muscular spasm. It should usually be given in small doses, to be repeated as often as may be necessary.

Treatment of Accidental Wounds.—A. *Arrest of Hemorrhage.*—In accidental wounds *hemorrhage*, if severe, demands the first attention of the surgeon, who must frequently, under such circumstances, disregard the principles of aseptic surgery and, at the risk of infecting the wound, stop the bleeding by any means which he may have at his command. But, whenever the situation of the wound is such that the hemorrhage can be controlled by pressure or by constriction without interfering with the wound itself, these means should be used temporarily until preparations have been made for aseptic work. Only where delay is dangerous, and where no other means for controlling the hemorrhage are applicable, should undisinfected fingers, instruments, or other agents, be thrust into the wound.

There are several methods for controlling hemorrhage, but only a brief description of these will be given here.

Exposure to Air.—Where the hemorrhage is from minute vessels, mere exposure of the cut surfaces to the air, by removing coagulated blood and allowing the edges of the wound to retract, may be all that is required; the oozing then ceases spontaneously.

Position.—Elevating the wounded part will materially lessen the amount

of hemorrhage. This is especially the case in wounds of the extremities and where the hemorrhage is from small vessels.

Flexion.—In wounds below the knee or elbow, forced flexion of the joint may be effective, at least as a temporary means of diminishing the bleeding.

The Application of Cold.—The application of cold has long been employed as a hæmostatic measure under certain conditions and within certain limits. Cold may be applied dry by surrounding the part by ice bags, or as moist cold by evaporating lotions, by irrigation with ice-cold water, by cold compresses or sponges, or by the direct application of ice to the bleeding surface. Cold causes the soft tissues to retract and diminishes the calibre of the blood-vessels, whether applied directly to the wound or to contiguous parts, but its continued application increases shock and, when directly applied to wound surfaces, depresses in a marked degree the vitality of tissue and thus is likely to retard the reparative process. When the application of cold is long continued the vascular tone is diminished and pathological processes are more likely to take place in a wound than when this agent is not thus employed.

The Application of Heat.—Hot water is a very efficient means for controlling hemorrhage from small vessels. It acts by exciting the contractility of the vessels and surrounding soft tissues, and, if very hot, may act also as a coagulant. Unlike cold, it stimulates the tissues, conserves their vitality, and favors rather than lessens the chances for union by first intention. Where shock is present or threatened, it has a most beneficent effect. The water may be applied either by irrigation or by means of compresses dipped in hot water and frequently changed. The latter method is the better one, because pressure on the wound surface may be made at the same time. In applying water in this way it should first be heated to boiling to destroy any pathogenic bacteria that may be present, and then cooled to from 140° F. to 120° F. Some surgeons prefer hot normal saline solution to the plain water, as it is less irritating to the wounded tissues.

The cautery is a means by which the escharotic effect of heat is obtained, and under certain conditions it is a valuable agent for controlling hemorrhage. It is especially useful where the bleeding vessel is deep-seated and in operations on very vascular parts. The cautery coagulates the blood at and near the point of application and cooks and devitalizes the tissues. Bleeding is likely to recur after the use of the cautery, particularly if the conditions of asepsis cannot be rigidly maintained. In applying the cautery for the control of hemorrhage, only a black or dull red heat should be used. If it is too hot it destroys the tissues without permanently sealing the vessels. The cautery now generally used is the galvano- or thermo-cautery.

Direct Pressure.—This may be applied by pressing the finger on the bleeding point, by grasping the tissues between the thumb and fingers, or by the use of compresses or tampons of gauze or other suitable material held in place by

the hand or by a bandage. Pressure by compresses is especially useful where the bleeding is from numerous small vessels.

Direct pressure by hæmostatic forceps is the most generally useful method for the temporary control of hemorrhage. The ends of the bleeding vessel, if it be of considerable size, are caught with the forceps and immediately tied, or the forceps is left on until the operation is over. If the vessel is small, a little of the tissues surrounding it is often grasped in the bite. The smaller vessels, after being crushed in the jaws of the forceps, usually cease to bleed when the pressure is removed, only the larger ones requiring ligatures. Before the hæmostatic forceps is removed torsion may be employed, thus further reducing the number of ligatures required in the wound.

Indirect Pressure.—Indirect pressure may be applied in several ways. One plan is to make digital pressure on the main artery supplying the parts at a point proximal to the wound, where the vessel is near the surface or where it passes over some bony prominence. This is a temporary expedient, and, though useful, pressure thus applied can be maintained for but a very short time. Instead of using the fingers, pressure may be applied by means of an ordinary tourniquet, with the pad so adjusted that it will press upon the artery and temporarily control hemorrhage from its branches. Or the rubber tourniquet may be used with or without the elastic bandage. This, when applied properly to a limb, absolutely controls the circulation. Care must be exercised in applying this tourniquet, as great damage may be done by having it too tight or by leaving it on for too long a time—mistakes which are particularly liable to happen when an inexperienced person employs the method. Nerves may be compressed too tightly or for too long a time, causing subsequent paralysis; muscular tissues may be lacerated by the pressure of the constrictor, or vasomotor nerves may be so affected that temporary paralysis of the vessel walls may occur and troublesome oozing may follow the removal of the tourniquet and persist for hours.

Acupressure.—In this method needles or pins are passed through the tissues in the vicinity of the vessels in such a manner as to compress them; or the needle is passed beneath the vessel, which is then compressed by winding a ligature in a figure-of-8 manner about the head and point of the needle. The needle or pin is usually withdrawn after from twenty-four to forty-eight hours. The pin should have sufficient length to transfix the tissues and should be strong and have a sharp point. In applying acupressure the point of the pin should be made to pierce the tissues at some little distance below the vessel and then to emerge near to it; then the head of the pin should be sharply elevated and carried over the vessel through an arc of about 90°; finally, when the pin is in this new position, its point should be made to pass deeply into the tissues beyond the vessel. In order to obtain a still greater degree of compression the needle may be entered near the vessel and

made to pass for a short distance parallel to it; then it is to be pushed out through the tissues, rotated ninety degrees, and finally carried over the vessel.*

Torsion.—The twisting of the vessel temporarily controlled by hæmostatic forceps has already been mentioned. This method is frequently used and, where applicable, obviates the necessity for ligatures. The vessel is caught with forceps and drawn out for a short distance from its sheath; it may then either be twisted by rotating the forceps about its own axis (Fig. 188) or, better, it may be caught by an-

Fig. 188.—Torsion by Hæmostatic Forceps.
(Wharton and Curtis.)

other forceps held perpendicular to the axis of the vessel and thus fixed while it is being twisted with the first forceps. The twisting should be sufficient to divide the internal coat of the vessel and bruise thoroughly the other coats. In small vessels the rotation may be continued until that part of the vessel which is between the forceps is twisted off; in the larger arteries the twisting process should continue until resistance of the wall ceases, but not until the end of the vessel is twisted off. This is a very effective method for small and medium-sized vessels and by some operators is used almost to the complete exclusion of ligatures, even in arteries as large as the brachial and femoral.

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*W. G. Branch (British Colonial Medical Report No. 19, 1902) describes a method of employing acupressure which, as he states, has given excellent results in controlling hemorrhage in amputations through indurated structures, as in elephantiasis. "This pin is long, slender, and sheathed in a silver or german-silver cannula. The instrument is somewhat on the pattern of a hydrocele trocar and cannula, having a bayonet-shaped point with a shoulder, beneath which the end of the cannula fits closely. The shoulder of the pin passes readily through the cannula, and is as easily drawn back, because the end of the latter is slit for the purpose. The length of the pin and its flat and milled head allow it to be manipulated with facility. A little cup is provided at the upper part of the cannula, so that a ligature may be secured below it to allow the whole instrument to be withdrawn with ease, even if it is buried in the interior of a large wound, such as that resulting from the amputation of a limb. After the artery is secured. the point only of the pin is retracted within the cannula like a cat's claw drawn back into its sheath. Its solidity and inflexibility therefore remain unimpaired, while there is no possibility of irritation from its sharp point. The metal of which the sheath is made not being prone to rapid oxidation, there is no necessity on this account for an early removal. This little instrument has been found very useful in arresting the bleeding from the immensely thickened and indurated tissues in amputation of the leg for elephantiasis, in which operation it is often very difficult to secure bleeding points with ordinary ligatures. In arresting hemorrhage from other incisions, especially of indurated surfaces, the use of this pin saves much time and trouble. Its length makes it possible to pass it under many bleeding points by one movement, and these are held and compressed together by a single ligature passed around the pin. The bleeding from any incision can be quickly controlled with this instrument without the help of an assistant. The lips of large wounds can be quickly and accurately brought together without the trouble of threading needles, and independently of the aid of a second person. The firmness of a pin gives a grip on the depth of a wound that will often save the necessity of securing the cut arteries with separate threads, and thus the ligaturing of the vessels and suturing of the cut are effected by one process. In many cases, likewise, of alarming hemorrhage from wounds in specially difficult regions, perfect and immediate cessation of the bleeding can be obtained by passing the pin through the sound skin and below the track of the wounded vessel or vessels, and causing it to emerge at a suitable distance so as to allow a ligature to be thrown around the point and head of the pin, thereby firmly but not too tightly compressing the tissues together and holding them in a grip that can be regulated by slackening or tightening the ligature. These pins can be used over and over again, and kept aseptic by boiling after use. This little instrument may sometimes be of special service to surgeons accompanying troops into action, or in a field hospital · where work is done under pressure due to want of time."

Pressure; Ligation.—This is the most generally used and safest method for the permanent arrest of hemorrhage from any but the smaller vessels. It is safe and effective when reliable material is used, provided the ligature is properly applied. The materials generally used for ligatures are catgut and silk—ordinary aseptic catgut for the small vessels, and for the large ones either silk or catgut which has been rendered less absorbable by chromic acid or other means. The bleeding vessel is caught with hæmostatic forceps or a tenaculum and drawn slightly out of its sheath, and the ligature is then applied a short distance from the end and carefully tied by a surgeon's knot or reef knot (Fig. 189), and the ends of the ligature cut short. It was formerly taught that the pressure should just be sufficient to divide the inner coat of the vessel, but to-day it is believed that a pressure just sufficient to close the lumen of the vessel securely is all that is required. After ligation, coagulation in the vessel in the vicinity of the ligature occurs and extends to the first branch above; organization takes place in the clot, and the vessel is thus obliterated.

FIG. 189.—Surgeon's Knot, or Reef Knot.

The Use of Chemical Agents.—*Turpentine* is favored as a hæmostatic by some surgeons. It undoubtedly does exert a powerful effect on the capillaries, but it is painful and, when freely applied to a wound, has a deteriorating local effect on the tissues with which it is brought into contact, thus interfering with and retarding repair. When used it should be applied only to the bleeding points.

Alcohol, when locally applied, causes contraction of the vessels and is sometimes used as a hæmostatic, being applied directly to the bleeding surface by means of a piece of gauze moistened with it.

Adrenalin has been extensively used during late years for controlling hemorrhage in certain operations.

Iodine acts both as a hæmostatic and as an antiseptic. It may be carefully applied in the form of the tincture, diluted three or four times with alcohol, or it may be added to water until a faint claret color is produced, and this solution applied by means of a sponge or piece of gauze.

Coagulants—such as the salts of iron, tannin, etc.—have no established place in modern surgery as hæmostatic agents, and are mentioned only to be condemned as untrustworthy and injurious. They increase the traumatism by causing a further devitalization of tissue, and promote the wound secretions.

After hemorrhage has been controlled, a temporary dressing of sterile or antiseptic gauze should be applied as a protective against further infection, and allowed to remain until everything is ready for the thorough cleansing and proper dressing of the wound. Then the constitutional condition of the patient should be considered and the necessary measures taken to combat shock or the effects of hemorrhage.

B. *Cleansing the Wound.*—All incised wounds not made by the surgeon

under proper aseptic conditions should be regarded as having been exposed to infection, but not necessarily as infected. We should regard them as possibly infected and take measures to destroy or inhibit the growth of bacteria which may already have gained access to the wound. The neighborhood of the wound, the surgeon's hands, the instruments, and the dressings should also receive attention. Many accidental wounds are infected after the reception of the injury, by misdirected efforts to arrest bleeding, by dirty fingers, dirty clothing, or other infected material.

In cleansing a wound, therefore, the end to be kept in view is not merely the removal of all macroscopic dirt and other foreign substances, but also blood clot, devitalized tissue, and especially any infection which may have gained entrance at the time of the reception of the wound or afterward. The skin at and near the site of the wound should be cleansed with as great care as in preparing for an aseptic operation. It should be shaved, thoroughly scrubbed with soap, then with alcohol, then with ether, and possibly with a 1 : 1,000 solution of mercuric chloride, in the same manner as described for cleansing the site of operation wounds. The hands of the surgeon and of his assistants should be disinfected with the greatest care, and all instruments, ligatures, and dressings should be rendered sterile. The wound should next be carefully examined; and it may even be found necessary to enlarge it for this purpose. All foreign bodies, such as sand, gravel, pieces of glass, splinters of wood or metal, should be removed with the fingers, or with instruments, and by saline irrigation, and possibly by irrigation with a 1 : 5,000 solution of mercuric chloride or, better yet, with peroxide of hydrogen. After the wound has been cleansed and the extent of the damage determined, permanent control of hemorrhage, if it has not already been obtained, should be effected by ligature, torsion, or other means, as already described. (See Vol. I, p. 702 *et seq.*)

C. *Closure of the Wound.*—In order to restore the function of the wounded part it may be necessary to assist nature by uniting divided special structures. Thus, if nerves have been divided, careful approximation of the ends should be made by fine sutures. Divided tendons should be put in their normal positions and the ends accurately sutured, and the wound should be again irrigated with saline solution. The wound surfaces are then dried with gauze sponges, the layers of muscular tissue joined by buried sutures, and the wound drained from the bottom. The incision in the skin may be closed so as to leave openings through which the drains can pass when required. If, however, the surgeon feels at all doubtful in regard to infection, the sutures can be placed in position for uniting the skin wound, but left untied for a few days.

In wounds that have been much soiled by dirt forced into the tissues, or where several hours have elapsed since the reception of the wound, or where dirty rags have been packed into it, the measures for cleansing mentioned above may not suffice. In such cases the surgeon can use more radical treatment in

his effort to put the wound in condition for healing. After controlling the hemorrhage, removing from the wound all macroscopic dirt, irrigating with a 1 : 40 solution of carbolic acid or a 1 : 5,000 solution of mercuric chloride or with peroxide of hydrogen, and making the repairs of nerves and tendons, he may adopt either of the following two courses: He may, in addition to the measures named, elect to treat the wound by the open method, packing it with gauze impregnated with some substance capable of inhibiting the growth of the infective organisms; or he may introduce into the wound some agent which is capable of destroying these organisms. For this purpose some surgeons employ *pure carbolic acid*. This method is based upon the fact that alcohol has the power to neutralize the caustic action of carbolic acid. The skin about the edges of the wound is first wet with alcohol, after which the whole surface of the wound is swabbed thoroughly in every part with a sponge which has been saturated with liquefied carbolic acid. Or the wound may be filled with the acid, which is then allowed to remain there for one minute, after which it is withdrawn with a syringe, or sponged out, and the wound filled with ninety-five-per-cent alcohol to neutralize the remaining acid. After a time the alcohol is removed, and then the edges of the wound may be approximated, drainage having been provided for, or the wound may be packed with gauze and treated by the open method.

Another substance which is used for the disinfection of recent wounds is *tincture of iodine*. All the exposed parts are thoroughly coated with tincture of iodine, and then, after suitable provision has been made for drainage, the wound is closed as if it were a clean wound. There is a certain amount of devitalized tissue to be thrown off after the employment of these or similar strong chemical agents, and also a large amount of serum to be conducted away; but, under the circumstances requiring the use of these agents, this is a comparatively insignificant objection to their use. Instead of attempting to kill the bacteria *in situ*, the surgeon may pack the wound with iodoform gauze and allow it to heal by granulation; or, after granulation is well established, he may bring the edges of the wound together and endeavor to secure union of the granulating surfaces. The iodoform acts by inhibiting the growth of bacteria in the wound. Its bactericidal action is more energetic when in contact with the wound secretions than when the parts are dry. This is no doubt due to the liberation of iodine in the process of chemical disintegration of this compound. The occasional occurrence of toxic effects after the employment of iodoform must not be forgotten, although, when it is used in the form of gauze, poisoning is not as likely to occur as when it is used in the form of powder and is brought directly in contact with the tissues. Gauze impregnated with *colloidal silver salts* has also been recommended for use where a constant mild inhibiting action on bacteria is desired. Certain preparations of *formaldehyde* in combination with organic substances have been introduced during recent years for the treatment of infected wounds. They are supposed

to act by the gradual liberation of formaldehyde during their disintegration when in contact with pus or the wound secretions. Formaldehyde preparations have been used extensively in Germany, and the reports as to their efficiency are in the main favorable. One of these preparations is *glutol*, a combination of formaldehyde and gelatin. It is used in the form of a powder and is dusted over the surface of the wound. It is claimed that this agent gradually becomes broken up and liberates formaldehyde gas. Another similar preparation is *amyloform*, a loose chemical compound of starch and formaldehyde. It is said gradually to liberate formaldehyde gas when brought into contact with the tissues.

If the wound does not come under the observation of the surgeon until it has actually become septic, as evidenced by the presence of pus and inflammation of the tissues in and about the wound, or if the measures outlined above have failed, as shown by a rise in temperature, local pain, redness, and heat, with perhaps a purulent or offensive discharge, then other measures may be necessary. Thus, for example, if the wound has been closed it must be opened up by removing sutures and separating the edges sufficiently to permit of thorough evacuation of the septic products. If partial union has taken place it may be unnecessary and inadvisable to break down the recent adhesions; but, if thorough cleansing and drainage cannot otherwise be secured, this must be done. All sinuses and pockets must be cleansed by wiping out with gauze and flushing with antiseptic solutions. For this purpose a 1:5,000 solution of mercuric chloride or a 1:50 solution of carbolic acid or peroxide of hydrogen may be used to advantage. If, after the wound has been thus flushed out, it be found that there is much necrotic tissue in the walls, this should be removed by instruments such as scissors, curettes, or Volkmann's spoon. Frequently these more radical procedures will be found unnecessary; in the majority of cases all that is required in order to bring about a rapid change in the morbid process, is to furnish an outlet for the pus and to provide for subsequent free drainage and cleansing; the success of which measures will be shown by a sloughing off of the necrotic tissues and the formation of healthy granulations. The further treatment of the wound, after the pent-up pus has been evacuated, is comparatively simple. Some surgeons pack loosely with gauze impregnated with iodoform, or with boracic or salicylic acid. This should be loosely introduced into the wound so that every recess may be reached by the gauze, and the whole should be lightly covered by moist antiseptic dressings. These dressings should be changed frequently, the wound irrigated, and fresh gauze used, until the surface of the wound cleans off and the formation of pus ceases. The edges of the wound may now be approximated by secondary suture or the cavity may be allowed to fill by granulation. When the granulations are sluggish and show little tendency to repair the defect, stimulation is indicated. Naphthalin powder may be freely sprinkled over the wound to stimulate granulation, or balsam of Peru may be applied for the same purpose.

If these measures are not efficient the wound may be cauterized by applying pure carbolic acid to the whole surface with a gauze mop, and afterward washing out with alcohol to stop further caustic action. Fused silver nitrate may be used as a superficial cauterizing agent. If it is desired to limit its action, this can be done by washing out afterward with a solution of common salt. Chloride of zinc (forty grains to the ounce of water) acts well as a bactericide and stimulating application to septic wounds. It penetrates the tissues to a limited extent and its usefulness is thus increased. It may be applied by irrigation, or, if a more continuous effect is desired, the wound may be packed with gauze wet with the solution. These caustic applications should not be repeated too frequently, nor should any single application be continued for too long a time, if the best results are to be obtained.

In septic wounds, where the toxicity of the septic products is intense and the local inflammation severe, and where simply opening the wound, irrigating, and the application of moist dressings prove to be insufficient, resort may be had to continuous irrigation. This keeps the wound free from any accumulation of septic products, dilutes the toxins, and lessens the tendency to their absorption by changing the osmotic current outward from the local vessels. When the wound is situated on a limb the part may be submerged in a warm antiseptic solution (kept at a uniform temperature) and allowed to remain for hours or even days, the antiseptic solution being changed as often as may be necessary. Where this is not practicable, it is an easy matter to improvise an irrigator which will deliver a gentle continuous stream to the wound. In wounds of the trunk or in those which are situated high up on the limbs, the whole body may be put into the bath, the head alone being left exposed. For this purpose a portable bath tub is necessary, the patient being placed on sheets arranged as a hammock in the tub. Where the whole body or a great part of it is submerged, the water used should be kept at a constant temperature of 99° or 100° F., and, to secure this, constant care and attention will be found necessary. The patient should be removed from the bath once a day, and his body should be carefully dried and then rubbed with olive oil before he is replaced in the bath. The water used should be sterilized by boiling. Where irrigation is employed the fluids may be used at any temperature desired; however, for long-continued application, warm irrigations are better than cold, as the vitality of the tissues may be lowered by the latter. Plain sterile water may be used for continuous irrigation, or mild antiseptics, such as boracic acid, salicylic acid, mercuric chloride (1 : 10,000) or zinc chloride (1 : 5,000), may be added.

D. *Constitutional Treatment after Incised Wounds.*—Such treatment, of course, will depend to a great extent upon the severity of the injury. In severe wounds any disease or condition of the general system likely to interfere with the processes of repair must be carefully considered and appropriate measures instituted to counteract the bad effects of such disease or constitutional state.

In certain diseased conditions such as diabetes, syphilis, scurvy, nephritis, and chronic alcoholism, especial care must be taken of the general health. As regards general hygienic conditions the patient, after the effects of shock have passed, should be given a generous diet of easily digested food, the bowels should be kept open by mild laxatives if required, and proper cleanliness of the person should be secured. The sick-room should be well lighted and ventilated and the surroundings made as cheerful and pleasant as circumstances will permit. An abundance of pure food, air, and sunlight is especially necessary for the rapid recovery of those having wounds in which septic processes have taken place. For such patients suitable tonics and stimulants are also indicated.

II. PUNCTURED WOUNDS.

A wound which owes its origin to the penetration of the tissues by a pointed object, such as a needle, pin, trocar, splinter of wood, thorn, or nail, etc., is called a punctured wound. Punctured wounds have clearly defined edges, and their depth is great in proportion to their width—a point which has an important bearing upon the treatment of these wounds. The amount of devitalization and contusion of tissue along the track of the wound depends on the sharpness of the point and the smoothness of the surface of the vulnerating body. If the point is blunt the result will be a contused-punctured or lacerated-punctured wound. If the point is very sharp, as that of a needle, and without a cutting surface, the tissues are simply pushed apart, with very little division of tissue and with a minimum destruction of cells along the track. If the object has a cutting edge, like that of a trocar or an aspirating needle, the character of the wound will approach that of an incised wound.

SYMPTOMATOLOGY.

Pain.—The pain of punctured wounds made by the surgeon under aseptic precautions is usually trivial and final. This is due to the fact that a very small portion of the cutaneous surface is involved and only few nerve filaments are divided. If the wound is not made under aseptic precautions, the immediate pain may be slight, but often there soon succeeds a soreness of the part accompanied by throbbing pain due to the pressure caused by accumulation of serum in the deep parts of the wound. This pain will be more intense if fascial planes have been penetrated, or if there has been hemorrhage into the deeper parts of the wound. If inflammation supervenes, the pain becomes still more severe, and will increase until an outlet is established for the free discharge of the fluids which may have accumulated.

Hemorrhage in punctured wounds is usually slight. The fibres of the tissues

are separated and pushed aside rather than divided, and the small vessels usually escape injury, so that there may be only a few drops of blood after such a wound. Sometimes, however, larger vessels may be punctured, and, if the vulnerating body is of any considerable size, such hemorrhage may be persistent, for the reason that the vessel is only partially divided and is thus unable to retract. Clinically, false aneurisms sometimes follow injuries of this character. If an artery and vein are in close proximity, both vessels may be wounded, thus producing a condition favorable to the formation of an arterio-venous aneurism.

Retraction of the edges in this class of wounds is slight, and there is deficient drainage of the wound as a result.

The extent of the impairment of function will depend upon the part wounded, the severity of the wound—whether important organs or structures are involved, and upon the degree of pain.

If the wound is aseptic and remains so, and if the part is kept at rest, union will be primary and as rapid and eventless as in the case of a clean incised wound. The sides of the wound come into accurate apposition and unite by first intention, or the track fills with blood which soon coagulates and organization progresses rapidly in this aseptic clot. On the other hand, if infection has been carried into the wound by the vulnerating instrument, or if it becomes infected later, there is likely to be violent inflammation with the formation of pus along the track of the wound, and unless drainage is quickly established there will follow a rapid and perhaps extensive destruction of tissue, which, after the pus finds an escape, must be repaired by a tedious process of granulation and cicatrization.

Treatment of Punctured Wounds.—If the wound is aseptic and unaccompanied by hemorrhage or damage to important nerves or viscera, and contains no foreign body, the treatment is very simple. For example:

After a wound made by an aseptic aspirating or exploring needle, all that is required is to sterilize the surrounding skin and to cover the part with a simple dressing of gauze held in position by a bandage or adhesive strips; or the little wound may be sealed—after sterilization of its surroundings—with a pledget of cotton and sterile collodion. Wounds of small extent produced by needles, pins, small splinters, thorns, etc., may give little or no trouble and should be treated expectantly; that is, the wound should be carefully examined and any foreign body removed if present, and the surrounding skin should be cleaned carefully and disinfected with carbolic solution or a solution of mercuric chloride and dressed as an aseptic wound. If trouble follows, as shown by throbbing pain or local redness, the wound should be freely incised and thoroughly disinfected, and efficient drainage established. This should be done at once after symptoms of infection have become manifest, or with the belief that infection is present, without waiting for the formation of pus or extended infection. Especial care should be exercised if the wound involves a tendon sheath or a joint.

In wounds of a more severe character, such as those made by large splinters, rusty nails, jagged pieces of metal, etc., a more radical procedure is indicated. If hemorrhage is free, an attempt should be made to control it by properly applied pressure; and then, after thorough cleansing of the surface portion of the wound and disinfecting the surrounding skin, an aseptic dressing should be applied. In such cases it may be that any infective material introduced has been washed out by the free hemorrhage, and it is permissible to wait until we can ascertain whether such is the case. At the same time we should be prepared to open up the wound, disinfect, and drain if it be found that infection has occurred. If the hemorrhage is not easily controlled by pressure, it then becomes necessary, through a free incision, to tie the injured vessel on either side of the bleeding point and complete the division of its walls between the ligatures. We should then carefully examine the whole track of the wound, removing all foreign material, and, after disinfection, make provision for thorough drainage. To secure this it may be wise to make a counter-opening rather than attempt to drain a deep narrow wound by one opening only. If, in order to remove foreign bodies or stop hemorrhage, it has been found necessary to make a large wound, this may now be partially closed by sutures so placed as to leave openings for free drainage; and, at the same time, dressings should be applied in the same manner as has already been described in the section relating to incised wounds. It should not be forgotten that the ligaturing of a vessel in an infected wound is very liable to be followed by secondary hemorrhage; and should this form of bleeding occur from an infected wound the vessel should be ligatured at either side through non-infected tissue. The failure promptly to appreciate the foregoing facts has caused the death of many patients from repeated secondary hemorrhages.

Frequently the vulnerating body or fragments of it are left in the wound and difficulty is sometimes experienced in removing them. Where these consist of pieces of needles or other small objects it is often difficult or impossible to find them, and it may be advisable in many cases to let them alone rather than inflict damage by making an exploration which will probably prove useless. The use of the x-ray, however, has relieved this situation. Sometimes the easiest method of removal is to push the objects on through the part rather than attempt to extract them at the point of entrance; this applies particularly to such barbed objects as fish-hooks, which are difficult to pull out of the tissues, but may easily be extracted after pushing them onward and causing them to emerge from the skin at some little distance from the point of entrance.

In general, it may be said that punctured wounds are not especially dangerous in themselves, but derive their importance from the fact that they are very liable to have infective matter deposited in their depths at the time of the injury, or that they may subsequently become infected from the surface. Furthermore, it is very difficult to drain them, owing to the circumstance that they

represent narrow tracks which often extend deep down into the tissues. In this class of wounds the track, besides being narrow and long, is frequently tortuous and obstructed as a result of the change in the relative position of the parts after the reception of the injury. This may be due to the elasticity of the skin and its loose attachment to the deeper structures—conditions which permit a gliding movement of the skin over them; or the muscles, after the injury, may contract or relax, thus putting that portion of the wound track which passes through them out of axis with the rest. In this way there are produced obstructions and irregularities of the wound track which prevent or interfere with drainage. When infective material finds its way into such a wound there will be established ideal conditions for the multiplication of the infective organisms. Moreover, if, under these conditions, a free escape for the septic products be not provided, they may force their way along the lines of least resistance—*i.e.*, along tendon sheaths, between muscles, along the fascial planes—or may burrow for long distances beneath the skin or rupture into joints or other cavities. Besides the mechanical damage done by the destruction of tissue and by the subsequent cicatrization, contraction, and formation of adhesions, the products of infection are enclosed by the tissue so as to facilitate their rapid absorption and to cause a corresponding degree of toxicity. The only rational treatment for such wounds is freely to open them, and thoroughly to clean them by irrigation with an antiseptic solution and to drain the track with tube drains or iodoform gauze. If necessary, one or two counter-openings should be made. Antiseptic dressings should be applied to the region of the wound, and they should be renewed as often as necessary, a good guide being the soiling of the dressings. As fast as the track of the wound fills with granulations and the discharges lessen in amount, the drainage agents should be shortened, and the irrigations made less frequently.

STAB WOUNDS.

Wounds which are inflicted by thrusts with knives, daggers, stilettos, and similar weapons are designated stab wounds. They are punctured or incised-punctured wounds, and they vary in severity according to their depth and extent, and the part of the body implicated. They are prone to complications such as hemorrhage, infection, etc., and, when certain parts of the body are involved, they are always to be regarded as serious in character. Stab wounds involving the neck, chest, or abdomen are especially serious, and they should be thoroughly examined and treated with great care.

The surgeon, in the treatment of these wounds, should be governed by the same principles as those which have been laid down for the treatment of punctured wounds. Thorough antiseptic precautions should be observed, bleeding arrested, and the wound closed and protected from infection from without. On

the appearance of the first symptoms of infection the dressings should be taken off, the sutures removed if necessary, and the wound examined. If this examination shows that infection is present, the wound should be cautiously opened and carefully explored, enlarged if necessary, and free drainage established.

SWORD AND BAYONET WOUNDS.

Under this title all wounds made in warfare by cutting and piercing instruments will be considered. These include sword and sabre wounds, machete wounds, bolo wounds, bayonet wounds, spear wounds, and arrow wounds.

Sword and Sabre Wounds.—These wounds are comparatively rare in civilized warfare, except in those cases where cavalry comes in contact with cavalry. The range and efficiency of military fire-arms have so increased during the last century that, with the exception mentioned—of cavalry meeting cavalry—there is rarely opportunity for the employment of cutting weapons.

These wounds may be classified as incised, incised-punctured, or incised-contused; the variety being determined by the sharpness of the cutting edge, and by the facts whether the part wounded was covered or bare and whether the wound was made by the point or by the edge of the weapon. Most modern swords and sabres have rather blunt edges and sharp points. Cavalry sabres are heavy and have curved blades with the rather blunt edge on the convexity, except near the point, where it is double-edged. Infantry swords are either straight, with double edges, or, as in the United States Army, those carried by the infantry officers are light, but in other respects similar to the cavalry sabre. In the incised wound made by the stroke with the edge of one of these dull swords or sabres there is always considerable contusion of the edges and the wound is comparatively shallow. There is not as much hemorrhage as in wounds made with a sharp-edged instrument, and bits of clothing are likely to be carried into the wound. Wounds made by the point of a sword or sabre are punctured wounds with the minimum amount of separation and destruction of tissue. When the weapon is withdrawn the edges are usually in close apposition. The severity of such wounds will depend upon the part of the body wounded and upon the involvement or non-involvement of important structures.

Treatment.—These wounds are usually inflicted under circumstances favoring infection. Owing to the conditions of military service it may be hours or even days before the patient can have the proper surgical attention and rest. Every effort should be made to prevent further infection of the wound, and probing, washing, etc., are not permissible. The wound should not be handled unless hemorrhage demands it or unless foreign materials, such as pieces of clothing, etc., are visible in the wound upon examination. A sterile occlusive dressing should be applied to the wound and the part immobilized if practicable; it is better to let the wound alone until facilities for proper cleansing and treat-

ment are available. After the patient reaches a hospital such wounds should be treated on the same principles as those which govern the treatment of other incised or punctured wounds. These wounds, if they do not involve a vital part and are properly treated, heal kindly and quickly.

Bolo Wounds.—In the East Indian Archipelago many different kinds of cutting instruments are used in warfare. In the Philippine Islands these knives

Fig. 190.—Bolo.   Fig. 191.—Barong.   Fig. 192.—Campilan.   Fig. 193.—Moro Beheading Knife.   Fig. 194.—Straight-Edged Kris.   Fig. 195.—Serpentine Kris.

vary in shape and size in different parts of the archipelago, and are known by various names: in the northern and central parts they are called "bolos," while in the southern part, among the Moros, we find the "kris," the "barong," the "campilan," and other varieties of knives.

The bolo (Fig. 190) usually has a heavy, bellied blade, the widest and heaviest part of which is at or about the third quarter from the hilt, and a sharp slightly recurved point. These knives have a very sharp edge and they are very heavy in proportion to their length. They are primarily adapted for striking rather than thrusting, and, on account of the centre of percussion of the blade being so near the

point, they are poorly balanced as thrusting weapons, and the blow delivered is rather like that of an axe or butcher's cleaver than like that from a cavalry sabre.

The barong (Fig. 191), a weapon used by the Moros, is shorter and heavier than the bolo, the blade having a length of from fifteen to eighteen inches and a width of from two and one-half to three and one-half inches at the widest part. The back of this knife is rather straight and heavy, while the edge is bellied somewhat like a harnessmaker's knife. By a blow from this weapon an arm may be completely severed.

The campilan (Fig. 192), also used by the Moros, is a knife with a blade from thirty to thirty-six inches long, gradually broadening from the hilt to near the extremity, and then terminating rather abruptly; the edge is straight and the point blunt. The hilt is long, permitting the use of both hands in wielding the weapon. The Moro beheading knife (Fig. 193), which is used by these people in executions and in battle, has a long cleaver-like blade set at an angle into a stout handle.

The kris (Figs. 194 and 195) is of two varieties: the straight-edged kris, and the kris with an undulating or a serpentine edge. In construction and balance they resemble the swords of other peoples, and some of them are of very fine workmanship. They are effective either as striking or as thrusting weapons.

All the weapons mentioned above are used by the natives as implements of industry and husbandry except the kris, beheading knife, and campilan. The bolo is indispensable to the native, for with it he builds his house, clears his land, cuts grain, grass, etc., and has many other uses for it.

During the insurrection in the Philippines many American soldiers received bolo wounds. In the hands of the natives, bolos were accurate and effective weapons under certain conditions, especially in night attacks and ambuscades. The jungles by which most villages were surrounded afforded good cover and permitted them to approach closely to our out-posts without being discovered. Many of these wounds were severe in character, sometimes severing a limb or disembowelling the victim. These wounds frequently became infected because of the conditions under which they were received. Hemorrhage is very free on account of the extent of the wound and also on account of the clean division of the tissue by the keen edge of the bolo. Under proper treatment, however, these wounds, if not immediately fatal, as a rule do well. Their treatment differs in no essential respect from that of other severe incised wounds; especial care should be given to divided nerves and tendons.

Below are given the histories of two cases of severe bolo wounds reported by Captain H. C. Fisher, Assistant Surgeon, United States Army:

Case I.—"Sergeant——, while walking unarmed in the suburbs of the town of Cebu, was attacked by a number of bolo-men. Throwing up his left arm to ward off a blow, a bolo made a clean cut through all tissues of his forearm two inches below the elbow, with the exception of about two inches of skin; the same blow

made an incision from the centre of his forehead through the inner angle of the orbit to the right cheek, severing the outer table of the frontal bone. Another blow, upon the left shoulder, cut off the acromion process, all of the deltoid muscle, and other tissues upon the outer surface of the arm, cleaning the upper third of the humerus and incising the bone to a depth of half an inch. The sergeant knocked down his assailant with his right hand and then fell, receiving another wound in the outer surface of the right thigh, upper third, four inches long, down to the bone. The bolo-men then ran off, and the sergeant walked five hundred yards to the hospital, holding his all but severed forearm in his right hand. The wounds were carefully disinfected and the stump of the already amputated arm was covered by a skin flap from the forearm. The other wounds were sutured and they healed by first intention. The skin flap sloughed, but no pus formed. The patient was out of bed, feeling well, when, on the twelfth day after the injury, symptoms of tetanus developed and he died four days after."

Case II.—"Corporal —— was admitted to hospital September 4th, 1900, with a severe incised wound, six inches long, extending through the left ear and along the neck downward and backward, with compound fracture of the mastoid process, and with a severe incised wound, seven inches long, of the right arm and forearm, opening back of the elbow joint. Cut with bolo while in action against insurgents. In February, 1901, this soldier was discharged the service on account of ankylosis of the right elbow joint and deafness (left ear), caused by the bolo cuts received."

Machete Wounds.—In the West Indies and in parts of South America, Central America, and Mexico the natives are provided with an instrument, called a machete, which is similar in some respects to the bolo. This is used as an implement of agriculture as well as for the purposes of a weapon, and in many localities it is carried habitually by the natives suspended from the belt as a sword or by a strap extended from the right shoulder to the left hip. In the various insurrections in Cuba and Central America the machete played a prominent part on account of its availability and the relative scarcity of fire-arms. The following account of the wounds made by the machete is taken from a monograph by Dr. Noguera, of the Spanish Army, entitled "Machete Wounds" (published in Madrid in 1898). There are three varieties of machetes: First, the ordinary machete of husbandry, about thirty inches in length, with a blade two inches in width near the hilt and gradually broadening to about three inches at the junction of its middle and distal thirds; it has a blunt point and a single edge. It is slightly curved near the outer extremity and is very similar in shape and size to the familiar corn knife used by American farmers. Another form is about thirty-three inches long with a slightly curved blade one inch and a half wide and provided with a cutting edge and a sharp point. The third variety is about thirty-eight inches long, has a double-edged sharp point and a slightly curved blade, and is very similar to the sabre in weight and shape. All forms of the machete are inferior to the sabre as weapons, chiefly because the hilt is so constructed that the hand is not protected and because the weapon is not properly balanced.

The wounds made by the machete are clean-cut, incised wounds, with a minimum of laceration and contusion of tissue. Hemorrhage is usually free, and nerves, muscles, and tendons are frequently divided. The wounds, if properly treated, heal quickly. Noguera states that, if disinfected with a 1:1,000 solution of mercuric chloride and carefully closed by interrupted sutures—a simple gauze dressing being applied to the part—these wounds rarely suppurate. Hemorrhage, if considerable, requires the employment of ligatures, as these wounds tend to bleed more than ordinary sword wounds, and great care must be taken properly to unite by sutures divided muscles, tendons, and nerves.

Noguera, in his monograph, gives a series of fifty-nine cases which came under his personal observation. The regions implicated were as follows: Head and neck, 19; upper extremity, 33; lower extremity, 5; thorax, 2. Only one case died, the wound involving the brain; the others all recovered sufficiently to continue military service.

From the fact that the mortality was so low it is evident that the machete is not nearly so formidable a weapon as the Philippine bolo. This is chiefly due to the fact that it is much lighter and therefore less effective in the hands of an inexperienced swordsman than the heavier weapon.

Bayonet Wounds.—The bayonet, while an effective weapon in the mêlée attending the actual clash of opposing bodies of troops, causes a very small percentage of the wounds met with in modern warfare.

When armies are in close contact and the opposing forces have approached to within a comparatively short distance of each other, the moral effect of the bayonet on the combatants is undoubtedly considerable; but comparatively few men are wounded by bayonets, and the number grows relatively smaller as fire-arms are improved in respect of range and rapidity of fire.

So far as may be judged from reports from Manchuria, bayonet attacks have been rather more frequent than in previous recent wars, and the percentage of casualties from bayonet wounds may be greater, but this is doubtful. Night attacks and regular approaches by intrenchments in siege operations present more favorable conditions for bayonet encounters than do military operations in the open country, and it is under such circumstances that bayonet wounds will be met with most frequently.

Wounds made by the bayonet differ in character according to the shape of the weapons with which they are inflicted. There are several varieties of bayonets now used by civilized nations, the principal ones being the knife bayonet and the triangular bayonet. The knife bayonet (Fig. 196) is simply a short straight sword, the blade being about one inch and a half wide and from ten to eighteen inches long, with a single or double, rather dull edge, and with the point sharp and formed at the expense of both of

FIG. 196. —Knife Bayonet.

the edges. Wounds made by thrusts with this instrument are punctured wounds with very little lateral separation, the edges after the withdrawal of the weapon being parallel and in contact. The triangular bayonet (Fig. 197) varies in length from eighteen to twenty inches, presents three blunt cutting edges and fluted surfaces, and gradually decreases in thickness from base to point. The wounds made by it are punctured wounds, with considerable laceration and separation of tissue, and, on withdrawal of the weapon, the walls do not come naturally into such accurate apposition as in wounds made by the knife bayonet. Besides these forms of bayonet there is another, called the rod bayonet. It is simply a steel rod with fluted surface and blunted point fitted under the barrel of the rifle like a ram-rod, and can be pulled out and fixed in the extended position when required for use. Wounds made by this bayonet would present the same general features as those produced by the triangular bayonet, with perhaps a smaller amount of laceration.

Bayonet wounds differ in severity according to the part affected, their depth, and their extent. The force with which they are inflicted is usually great and is increased by the weight of the gun. Sometimes bones are fractured and limbs or the whole thickness of the body pierced. Bayonet wounds, like sword wounds, are more frequent

FIG. 197.— Triangular Bayonet.

on the left side of the body, this side being less protected than the right in right-handed soldiers. Vessels and nerves are frequently injured, and, in wounds of the former, traumatic aneurism is liable to occur. This is due to the fact that the wounds are frequently made in such a manner that on the withdrawal of the weapon the relative position of the muscles and other tissues changes and the wound is no longer continuous and straight, thus allowing the blood to accumulate in its deeper part. These wounds are prone to infection, their depth and tortuous tracks interfering with drainage. The treatment will depend upon the part of the body wounded. In general, these wounds should be treated in the same manner as any other serious punctured wound. If there are indications that a large vessel is wounded or an important nerve trunk divided, the wound should be enlarged and the vessel tied or the nerve sutured. In ordinary cases an occlusive antiseptic first-aid dressing should be applied and no further interference with the wound permitted until proper facilities for antiseptic work are procurable. The wound should then be cleansed and examined, all dirt, pieces of clothing, etc., should be removed, and thorough irrigation should be practised if the wound is so situated that this can be carried out. In order to clean the wound it may be necessary to enlarge the whole track and possibly make a counter-opening for drainage. This will almost certainly be necessary if the wound has not been treated for several days since its reception, and if pus is already present. In such a case radical measures are sometimes necessary to prevent the burrowing of pus

between muscles. The wound should be enlarged and flushed with a weak solution of mercuric chloride, and a free counter-opening should be made in order that through-and-through drainage may be secured. A thick antisepic dressing should then be applied, and if the wound is on a limb this should be immobilized by a suitable splint. The dressing should be frequently changed and the irrigation repeated. As the formation of pus lessens and the sides of the track assume a healthy appearance, the drainage tubes should be gradually shortened, thus allowing the wound to heal from within toward the surface.

Spear and Lance Wounds.

These are very similar to wounds made by the knife bayonet, and they possess no features peculiar to themselves. They are incised-punctured wounds and the indications for treatment are the same as for other wounds of that class.

Arrow Wounds.

Since fire-arms have become so common, even among barbarous and savage peoples, arrow wounds are met with very rarely. They belong to the class of punctured or punctured-incised wounds, and are apt to be followed by infection. Among certain savage tribes it is customary to poison the tips of the arrows, thereby rendering the wounds which they inflict very fatal. These poisons are either of animal or of vegetable origin, and some of them are very rapid in action, causing death in a very short time.

The gravity of arrow wounds depends upon the importance of the parts involved, upon the extent of the wound, and upon the character of the material used for making the arrowhead, etc.

If the arrow is still in the part it should be carefully removed without detaching the head, and, if necessary, the skin wound may be enlarged by incision. If the arrow has penetrated deeply and its point is near the opposite surface, it may be pushed on and removed that way more easily than by withdrawing it. After the arrow and its head have been withdrawn the track should be disinfected by irrigation with a 1:2,000 solution of mercuric chloride; then drainage should be established by means of a strip of gauze or a small drainage tube, antiseptic dressings should be applied, and the part should be immobilized.

Wounds Inflicted by Agricultural Implements.

Incised wounds made by reapers, corn harvesters, scythes, axes, etc., are common in agricultural sections of the country and are frequently severe in character. They generally happen under conditions which favor infection and in regions remote from facilities for prompt and efficient surgical treatment.

These wounds usually involve the limbs, especially the hands and feet. Muscles, tendons, nerves, and blood-vessels are frequently involved, or a limb may be actually severed from the body. Wounds by the modern corn harvester usually involve the leg and may be very severe in character; fatal hemorrhage may occur before relief is afforded, and infection is of very frequent occurrence, being due, doubtless, to the misdirected efforts to control bleeding and to improper dressing. Mowing and reaping machines make clean-cut wounds that usually involve the ankle or hands. Fingers are sometimes clipped off, while in children a leg may be completely severed by one stroke of the knife. Wounds made by these machines may be multiple and parallel, due to the rapid motion of the sickle, which may inflict several wounds in rapid succession. Scythe wounds are clean-cut and may be very extensive, hemorrhage being very free on account of the clean division of the vessels by the keen-edged instrument. Axe wounds are usually self-inflicted accidentally, and nearly always involve the feet or legs. A blow from an axe may almost completely cut off a foot, making a clean division of muscles, tendons, and bones. In the treatment of these wounds special care should be taken to clean them, as in all probability ample opportunity for infection has been present. Sometimes earth or other dirt may have been deliberately put into the wound in order to control hemorrhage, or dirty rags may have been stuffed in for the same purpose. After thorough cleaning, great care should be taken properly to approximate the divided ends of a muscle, tendon, or nerve. No matter how severe the wound, an effort should be made to save the injured part. This result may be confidently looked for under proper treatment, unless the main vessel has been divided. If a joint has been opened it should be washed out thoroughly with a saline solution or a 1:10,000 solution of mercuric chloride, and then closed. Provision should usually be made for drainage of all extensive wounds of this class, and after the dressing has been applied the part should be put up in a suitable splint. If tendons or muscles have been divided care must be taken to put the limb in such a position as to relax the muscles involved and prevent strain on the sutures. The patient should be carefully watched and, if evidences of infection become manifest, the wound should be opened up, washed out with bichloride solution, drained, and dressed frequently with moist antiseptic dressings. Gangrene often makes its appearance in these wounds, and under these circumstances it is due either to the poor blood supply occasioned by the division of the vessels, or to infection resulting from the application of earth to the wound. Tetanus is also of frequent occurrence in this class of wounds and is probably due to the latter circumstance also.

III. DISSECTION AND POST-MORTEM WOUNDS.

Under this title will be considered wounds received during the dissection of human subjects or at post-mortem operations, and also wounds received by surgeons while operating; in all of which cases the grave symptoms that often develop are due to infection received through the wound. Under the same head belong certain similar affections, such as disturbances due to infection from the bites of men or animals, and those which occur in persons engaged in trades necessitating the handling of the fresh carcasses of animals.

Etiology.—At various times during the past two centuries the theory has been advanced that a specific virus, generated in the dead body and introduced at the time of the injury, is the cause of the symptoms that arise from this class of wounds. By others the cause has been attributed to putrid material which has been inoculated into the wound. Those opposed to the latter theory brought forward as evidence against it the facts that fresh bodies are more apt to be dangerous than those in which putrefactive processes have become advanced and that post-mortem wounds are more dangerous than wounds received in the anatomical laboratory, where older material is used. It is now known that the affection, though microbic, is not due to a specific germ, but to the action of one or more of several varieties of bacteria. Of these, the Streptococcus pyogenes is frequently present as the infecting organism, while the Staphylococcus pyogenes is frequently associated with it, though rarely found alone in these infections. It is probable that any variety of the pyogenic bacteria may, under especially favorable conditions, be the cause of the infection. Besides the pus-producing organisms, certain other pathogenic germs may cause disturbances which properly come under this head. Among these are the anthrax bacillus and the bacillus of malignant œdema. Under favorable conditions the bacillus of tuberculosis is sometimes inoculated through a dissection or a post-mortem wound. The local lesion is known as "anatomical tubercle" or "necrogenic wart." Syphilis has frequently been produced by a puncture that has occurred during an operation on a syphilitic subject, or in the course of a post-mortem examination of the body of a person affected with this disease. In these instances a primary chancre makes its appearance at the point of puncture.

As stated above, wounds of this character occur with comparative rarity among students in the dissecting-room, for the virulence of the infective germs is diminished or destroyed by the invasion of putrefactive bacteria or by the preservative agents used in injecting the cadavers that serve for dissecting material. Persons engaged in the work of making post-mortem examinations, or surgeons operating on patients with certain virulent forms of infection, are usually the victims. Those who do post-mortem work or who operate on

individuals suffering from septicæmia, pyæmia, septic peritonitis, erysipelas, cellulitis, etc., are especially liable to infection. Some persons are more susceptible to infection than others, and a relative immunity may be gained by those frequently employed in handling such cases. The point of entrance of the poison may be through a cut or puncture made at the time of the operation or post-mortem examination, or through an old, unhealed abrasion or wound, which may have been so slight as not to attract notice. Fissures in the skin about the base of the nails are especially dangerous. Infection may also occur through the sweat glands or hair follicles. Persons in poor health and those who are debilitated from any cause are more susceptible to infection than robust individuals. The hands are usually the site of the point of inoculation.

Symptoms.—These are local and general. The local symptoms may be slight or severe. In the cases usually observed, the wound becomes painful, red, and slightly swollen; a pustule appears at the point of inoculation, and soreness extends some distance up the limb. Soon a lymphangitis is developed, and red lines extend up the arm, marking the extension of the infection by way of the lymphatics. It may be possible to feel the inflamed lymphatics as knotted cords. Soon the lymph nodes become swollen and painful. If the superficial lymphatics are involved, the nodes about the elbow become enlarged, tender, and painful, while if the deep set becomes involved the axillary nodes are affected. When the nodes are much enlarged and the infection is marked, suppuration usually occurs; but not invariably, for resolution may take place, the nodes slowly or rapidly returning to their normal size. The lymphangitis may extend beyond the axilla, progressing downward over the side of the chest and across to the middle line. In very severe cases it may extend to the opposite side of the body. There is elevated body temperature, its height depending upon the rapidity of the extension of the infection and upon the fact whether suppuration occurs in the nodes. If the latter supervenes there will be rigors or chilly sensations and severe pain, more or less localized in the affected nodes. If the abscesses are now opened and drained, the symptoms rapidly subside. In this class of cases the infection is confined to the lymphatics, and the nodes act as barriers against extension of the infective process.

In other cases the disease, instead of being limited to the lymphatic vessels, becomes more diffused; it attacks especially the cellular tissues. This cellulitis is prone to extend rapidly and is accompanied by symptoms that result from the absorption of the septic products. The skin becomes uniformly reddened and there is formed a brawny swelling which extends from the point of infection along the limb. Pus formation in this class of cases is sometimes very rapid. The symptoms are: Malaise, severe local pain at the point of inoculation, and rigors, accompanied by nausea and an elevated temperature. The severity of these symptoms and their character vary according to the nature and virulence of the infective material, the resisting power of the individual attacked, and

also the location of the point of inoculation. In wounds about the hands infection of the tendon sheaths frequently takes place; and when this occurs the pus extends upward beneath the palmar fascia, passes beneath the annular ligament, and reaches the more lax tissues of the forearm, where it becomes diffused, penetrating along and between the muscles and underneath the skin. Slight wounds involving the dorsal aspect of the hand are usually not so serious as those on the palmar surface. The extent of the cellulitis thus developed varies with the virulence of the poison and also depends much on the treatment employed. In the more serious cases, unless relieved by free incisions, practised very early, the infection, manifested by redness and swelling, rapidly extends up the arm and in very grave cases involves the trunk and may even extend to the other side of the body. In certain severe cases there is only a slight tendency to the formation of pus. Instead, there is developed a brawny swelling which, on incision, discharges only serum or a gelatinous material. In such cases the chances of limiting the destructive process are much less than where there is true pus formation, for the latter indicates such a reaction on the part of the vital forces as to encourage the hope that the tissues will sooner or later gain the upper hand in the struggle. In some cases there is death *en masse* of certain tissues. Thus tendons, cartilage, and cellular tissue may become gangrenous and slough, causing prolonged suffering and great deformity, while bones may be attacked and become necrosed. The further course of cases of this class may be toward recovery, by a slow process of resolution and cicatrization; or, the disease still progressing, the patient may succumb to acute septic intoxication; or death may ensue from exhaustion, septicæmia, or pyæmia.

Besides the forms of infection mentioned, there is another, which, while rare, is very fatal. It is really an acute septic intoxication and is ushered in by pain, rapid and weak heart action, rise of temperature, and delirium, and ends in collapse usually followed by death. The local changes are slight and there is almost complete absence of the inflammatory reaction so marked in the other forms.

Prognosis.—This depends on the resisting power of the individual and the severity and intensity of the infection, as shown by the condition of the patient after the first few days of the disease. If severe constitutional symptoms are present at the end of the first week, the prognosis is grave. The surgeon should be very guarded in his prognosis as to the usefulness of the limb, especially if the inflammatory process has extended beneath the palmar fascia or if thecæ of tendons are involved.

Treatment.—A few words in regard to *prophylaxis* will not be out of place here. In dissection work or in making a post-mortem examination, great care should be taken to protect the hands. A post-mortem examination should never be undertaken by one who has a wound, however slight, on the hand.

If the work must be done, however, he should protect the hands by wearing rubber gloves after coating the wound with collodion or carbolated vaseline or other antiseptic protective. The beds of the nails should be carefully inspected for fissures and abrasions, for it is through such little wounds that many surgeons have been infected. The hands should be smeared well with vaseline or other oily substance to prevent septic fluids from penetrating into the ducts of the sweat- and sebaceous glands and hair follicles. In making a post-mortem examination upon especially dangerous subjects, such as those dying of septic peritonitis or septicæmia, it is good practice to wear rubber gloves after oiling the hands as described above; and, after the examination is finished, great care should be observed in cleansing and disinfecting the hands. They should be thoroughly scrubbed with green soap and hot water, and then immersed in alcohol; after which they should be washed in mercuric chloride solution 1 : 2,000 and then washed off with plain water. Washing in a saturated solution of potassium permanganate for a few minutes and decolorizing in a saturated solution of oxalic acid constitute a good means of disinfection and one that has been highly recommended. In case a wound is received during post-mortem work the finger or other part may be ligated, if practicable, to encourage venous hemorrhage. Suck the wound if the lip be intact. The ligature should be tied tightly enough to prevent the venous flow, but not so tightly as entirely to arrest the arterial circulation. This prevents absorption and may wash away any infective material present. The wound and its surroundings should then be thoroughly cleaned with a 1 : 2,000 solution of mercuric chloride after a preliminary scrubbing with soap and water. If the wound be very small, and if it be found very difficult to reach the bottom of the cut, it may be enlarged. Carbolic acid (one in twenty) or chloride of zinc (ten-per-cent solution) may be used instead of the bichloride. The ligature should now be removed from the limb and a moist antiseptic dressing applied. This should be changed from time to time during the following three or four days, when, if no sign of infection is present, an ordinary dry dressing may be substituted for it—if, indeed, any further dressing be required. If these precautions have not been observed, or if they fail and infection has occurred, as shown by the formation of a pustule or bleb at the site of the wound, the skin should be thoroughly scrubbed with soap and hot water and disinfected with a 1 : 1,000 solution of mercuric chloride or a one-to-twenty solution of carbolic acid. The bleb, pustule, or papule should then be incised, curetted, and disinfected with one of the solutions above mentioned, with pure carbolic acid, or with a ten-percent solution of zinc chloride. Moist bichloride or carbolic dressings should then be applied and the case carefully watched. If a cellulitis develops, as many free incisions should be made as may be necessary to insure absence of tension and afford free drainage, and the part should be frequently or continuously

immersed in a warm bath of mercuric-chloride solution of a strength of 1:10,000. This should be followed by the moist dressings above mentioned. The incision made should be just deep enough to enter the site of the accumulation of pus, but it should not open up non-infected tissues and thus increase the danger of extension of the infection. Infected lymph nodes should be removed in severe cases. If the infection is limited to the skin and superficial cellular tissue, especial care should be taken to avoid wounding the deep fascia and carrying the infection below the barrier. When tendon sheaths are involved they should be slit open and thoroughly cleansed, all sloughing tendon and fibrous tissue being removed. In some neglected or especially virulent cases it may be necessary to amputate a part of the limb, or even the whole limb, in order to save life.

In the way of *general treatment,* it will often be found necessary to administer stimulants freely to these patients, in combination with nutritious, easily digested food. Alcohol, in the form of whiskey or brandy, and quinine, if the temperature is high, should be given. Later, as the fever subsides, iron should be administered, preferably in the form of the tincture of the chloride. The bowels should be kept open by aperients, and rest and freedom from pain secured by the use of morphine. Antistreptococcic serum has been used with reported success is some cases. About fifteen or twenty cubic centimetres of "Marmorek's serum" should be injected into the buttocks, or into the muscular masses of the back, and the injection should be repeated, in slightly smaller doses, every six or eight hours. If diarrhœa comes on and threatens to exhaust the patient, it should be combated by opium and astringents. Plenty of fresh air, daylight, and an abundance of wholesome, easily digested food should be provided during convalescence.

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GUNSHOT WOUNDS.

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GUNSHOT wounds are traumatisms produced by projectiles from fire-arms, whether made by primary missiles or by secondary missiles set in motion by them, or by pieces of the fire-arm itself in cases of explosion. The term is also made to include wounds by fragments from hand grenades, those received from exploding mines in warfare, and other like causes.

A missile producing a wound is spoken of as a *primary missile* when it is propelled directly from the source of explosion, and as a *secondary missile* when it is set in motion, directly or indirectly, by a *primary missile*. Surgeon-General Suzuki, of the Japanese Navy, gives an example of a wound caused by secondary missiles which occurred in the Russo-Japanese War in the case of a Russian officer who carried in his hip pocket a number of gold coins which were driven into his buttock by the impact of a fragment of shell, from which locality they were afterward extracted. A case came under the observation of the writer in which fragments of a watch carried in the waist pocket were driven deep into the groin from the impact of a bullet while the bullet itself glanced off and did not enter.

Gunshot wounds, especially those made by bullets, have special characteristics as to form and amount of tissue destruction and liability to infection. Also, in most of these wounds the greatest amount of tissue destruction is subcutaneous, therefore hidden from view, and the damage done must be estimated, not from the appearance of the external wound, but through knowledge obtained by past study or experience in like cases. These peculiarities put these traumatisms in a class by themselves, both for purposes of study and for the practical application of the science of surgery to the art of healing. As the characteristics of gunshot wounds largely depend upon the dynamics of a special class of projectiles—namely, those from fire-arms—some knowledge of these weapons, and particularly of their projectiles, is necessary to a definite understanding of the wounds which they cause.

FIRE-ARMS AND THEIR CLASSIFICATION.

Under the term *fire-arms* are included all kinds of weapons by which missiles are propelled by the action of expanding gases, whether produced by the explosion of gunpowder or by the sudden expansion of compressed air.

The different kinds of fire-arms are many, extending from the small toy pistol to the largest piece of artillery carried on shipboard or mounted for coast defence. Fire-arms are divided into two main classes: 1. Small arms, and 2. Artillery.

Under the term *artillery* are classed all fire-arms mounted on supports. The projectiles of these arms vary from less than an ounce in weight, as in the case of machine guns, which fire a bullet identical with that of the rifle, to shells many hundred pounds in weight. The pieces of field artillery, by which most
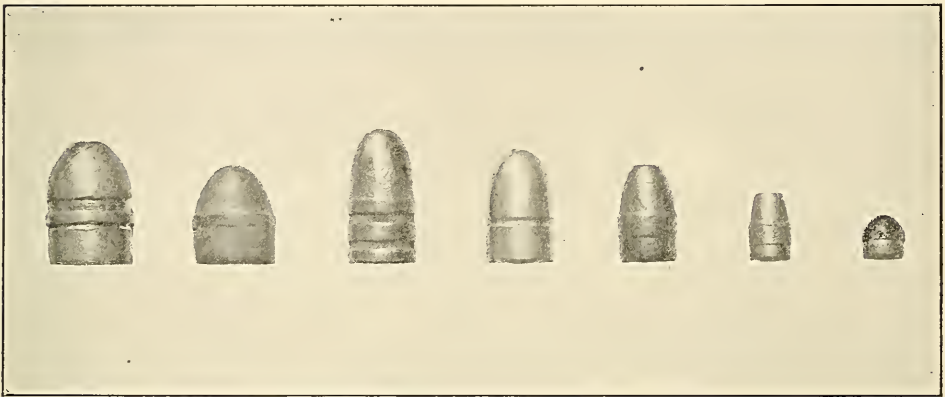
Fig. 198.—Revolver Bullets, .22 to .38 Calibre, all Unjacketed.

of the wounds from artillery fire in land engagements are made, use three kinds of projectiles: shells, shrapnel, and cannister.

Shells are hollow, cylindro-conoidal projectiles containing a bursting charge of powder. Shrapnel consists of a cylindro-conoidal steel case enclosing many lead bullets and a bursting charge. The wounds from shrapnel are, therefore, divided into those made by the unbroken shell, by fragments of the case, and by the bullets. Cannister consists of a thin, cylindrical iron case enclosing bullets, the case being broken by the explosion when the gun is fired. Cannister is now rarely used, as it is effective only at very short range.

Small arms comprise all fire-arms having no supports of their own. The term includes muskets, rifles, shotguns, and all kinds of pistols, both of the revolver and of the automatic types. Muskets are unrifled and fire a round lead ball. They are now used only by savage or semicivilized people. The pistols now used are mostly of the revolver type. These fire cylindro-conoidal lead bullets

(Fig. 198) varying from .22 to .45 calibre (22 to 45 one-hundredths of an inch in diameter). The initial velocity given by these weapons is comparatively low, and the bullets are readily deflected or arrested by bone, except in the cases of the largest sizes and at short range. It is from these weapons that most of the gun-
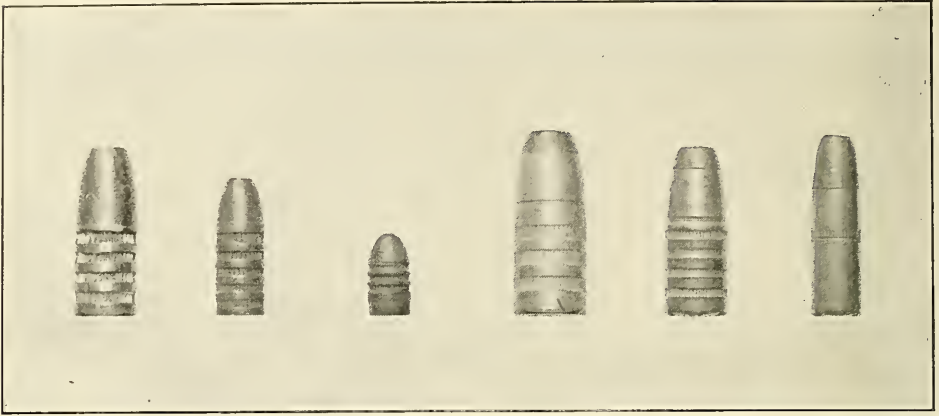
Fig. 199.—Hunting-Rifle Bullets, .22 to .38 Calibre. Three to left, unjacketed; three to right, soft-nosed.

shot wounds seen in civil life are made. The automatic pistols, such as the Luger, fire a small-calibre, jacketed bullet similar to that of the modern military rifle.

Rifles are divided into two kinds, hunting and military. With hunting rifles a somewhat larger bullet is used than with the military arms, the impressed
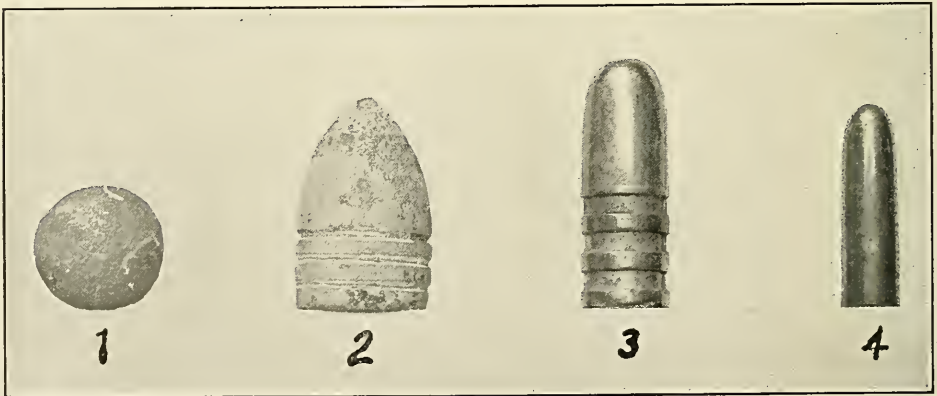
Fig. 200.—Evolution of the Bullet. 1, Old round musket-ball; 2, Minié bullet; 3, .45-calibre Springfield; 4, .30-calibre jacketed Springfield, model 1905. All of natural size.

velocity is lower, and the bullets are generally unjacketed or jacketed only at the base, so that they will deform in the tissues, produce large wounds, and have a maximum "stopping" effect (Fig. 199).

The modern military rifle has reached a high degree of perfection. It is the

result of the gradual evolution of fire-arms which has for its end great precision, long range, great penetration, flat trajectory, rapidity of fire, and small weight of ammunition. The result is a class of weapons all of which are practically identical in the particulars above named.

These rifles weigh approximately from 8 to 10 pounds; are of magazine type, carrying from 5 to 12 rounds in the magazine; vary in calibre from 6.5 mm. to 8 mm.; and use smokeless powder, varying from 1.94 to 2.74 grams for each charge. The projectile is a compound bullet consisting of a lead or hard-lead core swaged into a casing of steel or cupro-nickel. It has a calibre of from 6.7 to 8.19 mm., a length of from 30 to 31.8 mm., a weight of from 10.34 to 15.8 grams, and a muzzle velocity of from 1,968 to 2,800 feet per second (Fig. 200, No. 4).

With this weapon and projectile the danger zone has been greatly increased, the range being practically point blank up to 600 yards, while the weapon is capable of inflicting a mortal wound up to a distance of 5,000 yards.

The compound bullet used with this weapon has four properties of great importance: (a) High velocity; (b) great sectional density; (c) cylindro-conoidal form; (d) great resistance to deforming violence. These properties combine to give it great penetrating power, while its velocity at the time of impact has a marked effect upon the amount and form of traumatism which it produces in animal tissues; and its velocity and resistance to deformation combined make it much more liable to ricochet with sufficient velocity to produce deep wounds even after violent ricochet impact.

BALLISTIC DATA OF THE SMALL-CALIBRE RIFLES NOW ADOPTED BY DIFFERENT NATIONS.

Army.	Rifle. Designation.	Bullet.				Smokeless Powder.	Muzzle Velocity per second.
		Cal.	Weight.	Length.	Structure, Core, and Casing.		
		Mm.	*Grams.*	*Mm.*		*Grams.*	*Feet.*
Austrian	Mannlicher, 1888–1890.	8.19	15.8	31.8	Hard lead, steel case...	2.74	2,034
British and Canadian	Lee-Metford, 1893, Mark II.	7.89	13.9	31.5	Hard lead, cupro-nickel.	1.97	2,000
Brazil, Chile, Mexico, and Spain	Mauser, 1894–1895, 7.0.	7.22	11.3	30.9	Hard lead, cupro-nickel, steel.	2.39	2,288
Danish	Krag-Jorgensen, 1869..	8.19	15.4	30.0	Lead, cupro-nickel.....	2.19	1,968
French	Lebel, 1886–1893.	8.19	15.0	30.0	Hard lead, cupro-nickel.	2.79	2,073
German	Mauser, 1888.	8.10	14.7	31.25	Hard lead, cupro-nickel, steel.	2.74	2,034
Italian	Mannlicher Carcano, 1891.	......	10.5	30.5	Hard lead, cupro-nickel.	1.97	2,395
Japanese	......	6.5	10.56	32.0	Hard lead, German silver.	2.10	2,800
Russian	Kapit-Mozen, 1891.....	7.79	13.68	30.2	Hard lead, cupro-nickel.	1.97	2,034
Roumanian	Mannlicher, 1893, 6.5..	6.70	10.34	31.5	Hard lead, cupro-nickel, steel.	2.44	2,395
Swiss	Schmidt-Rubin, 1889 ..	8.10	13.7	31.7	Hard lead, steel point, paper jacket.	1.94	1,968
Turkish	Turkish Mauser, Belgian, 1890.	7.89	13.8	30.8	Lead, cupro-nickel.....	......	2,139
United States	Springfield, Model 1904.	7.87	14.22	30.63	Tin and lead, cupro-nickel.	2.21	2,200

FREQUENCY OF WOUNDS BY DIFFERENT WEAPONS.

In civil life gunshot wounds are usually dependent on accident or are from homicidal or suicidal intent. They are generally made by pistol bullets, revolver bullets, bullets from hunting rifles, or shot from shotguns.

In war the wounds are mainly inflicted by rifle bullets, revolver bullets, and the bullets from rapid-fire and machine guns, most of which are similar to the rifle bullet in shape and size. The comparative frequency of wounds by different arms in war is given in the following table in which the percentage of wounds inflicted by small arms, artillery, and side arms (meaning such weapons as the sabre, bayonet, etc.) is given as the result of four recent wars:

PERCENTAGE OF WOUNDS BY DIFFERENT ARMS.

Wars.	Small Arms (per cent).	Artillery (per cent).	Side Arms (per cent).
American Civil	90.1	9.8	0.37
Franco-German	94.	4.7	1.3
China-Japan, Third Division, Second Army Corps	90.8	7.6	1.5
Spanish-American (U. S. Regulars)	92.2	7.8	0.0

The relative percentage of wounds by different weapons in the Anglo-Boer War and the Russo-Japanese War is not yet obtainable, but probably does not differ materially from the figures already at hand, although it is stated that the number of wounds from artillery fire was considerably above the average, and that in some engagements in the latter war much hand-to-hand fighting was done and the wounds from hand weapons were consequently much more numerous than usual.

In all wars the relative proportion of wounds by bullets and shells differs materially according to the character of the engagement. In field operations the percentage of wounds by bullets is exceedingly high, while in siege operations, which are carried on mainly by artillery, the percentage of shell wounds is greatly increased.

As the projectiles from fire-arms vary in size from the smallest bird shot to the largest armor-piercing shell, the difference in form and variety of tissue destruction produced by them is exceedingly great. For this reason gunshot wounds are divided into four classes: 1. Bullet wounds; 2. Shotgun wounds; 3. Shell wounds; 4. Solid-shot wounds.

EXPLOSIVES USED WITH FIRE-ARMS.

As the explosives used in fire-arms are employed not only to propel the missiles from these arms, but to explode projectiles, mines, fugasses, bombs, and hand grenades, the composition of these substances and the manner of their action are naturally included in a discussion of gunshot wounds. The explosives used with fire-arms are the black or brown gunpowder, the smokeless gunpowders, and the fulminates.

Gunpowder is the most ancient of all explosives. It appears to have been known to the Chinese long before they came in touch with the occidental nations. Its discovery and first use in Europe were in the latter part of the fourteenth century.

Gunpowder is not a chemical compound, but a mixture of approximately 75 parts of saltpetre (potassium nitrate), 15 parts of charcoal, and 10 parts of sulphur. In this mixture the potassium nitrate furnishes the oxygen, the carbon of the charcoal supplies the fuel, and the sulphur promotes and equalizes the rapidity of the combustion. The quantity of each ingredient is varied within small limits in order to produce the especial effect which may be required with the especial fire-arm with which the powder is to be used. Gunpowder explodes when heated to 700° F. and gives off about 250 volumes of gas.

The smokeless powders are so called because they give off very little smoke as compared with black gunpowder. Their composition is kept secret by the manufacturers, but in a general way it is known that they are composed of some one or more highly unstable nitrogen compounds.

The nitro powders are made by the action of nitric acid upon organic substances; the action of nitric acid on glycerin producing nitro-glycerin, and on cotton producing gun-cotton. Dynamite is made by mixing nitro-glycerin with infusorial earth. The picric-acid powders all have picric acid as the base, this acid being made by the action of nitric on carbolic acid. With these and other unstable nitrogen compounds as the basis substances, many different proprietary powders have been invented and given trade names, such as Mellinite used by the French, Lyddite used by the British, Shimose powder used by the Japanese, etc.

They all have the property of great explosive force with small weight and bulk, and give very little or no smoke.

Fulminates are highly explosive compounds used to detonate smokeless and other powders, fulminate of mercury being most used. Fulminates explode with tremendous violence.

The wounds from explosives differ very greatly in character, and range from superficial burns or in-driven powder grains to extensive mutilations, such as the

tearing away of large pieces of flesh or the amputation of an extremity. In the latter class the injury is sometimes occasioned by the premature explosion of a piece of artillery the breach of which has not been closed, or by the discharge of a blank cartridge. When these accidents occur, the force of the explosive tears large gaps in the soft parts, tears limbs entirely away, or produces other serious injuries. Persons standing at some little distance from the point of explosion may be burnt or shocked only, or they may have powder grains driven more or less deeply into the body.

The large wounds so produced are always greatly lacerated and generally have foreign material driven into them and are usually much infected. The treatment of these wounds is that of an ordinary lacerated wound of equal size.

When powder grains are driven into the skin they may produce considerable disfigurement, and for this reason require removal. The removal of these grains is not always easy and is ordinarily best done under a general anæsthetic, when an elliptical incision along the line of the folds of the skin may be made, if required, so removing the in-driven grains together with the adjacent tissue.

The wounds most commonly seen as a result of the use of fulminates are those from toy pistols. The explosives for these pistols are minute quantities of one of the fulminates enclosed in some sort of envelope. The explosion of the fulminate drives pieces of the envelope or other foreign material quite deeply beneath the skin, and, as these wounds are generally received by children whose hands are soiled with dirt, the tetanus bacillus, so common in soil, may be driven into the wound and produce tetanus—a frequent result of these injuries. This clearly indicates that the treatment of these wounds, however small they may be, should consist in thorough exploration, cleansing, and dressing, with drainage.

THE BALLISTICS OF PROJECTILES.

All writers upon gunshot wounds have concurred as to the necessity of a knowledge of fire-arms and their projectiles for a full understanding of the peculiar traumatisms produced by them.

The trauma-producing qualities of the missiles from fire-arms depend upon their velocity, weight, size, and shape. The form of tissue destruction in each case depends upon a combination of these factors and the particular tissue or structure of the body upon which their influence is exerted.

A projectile can produce a traumatism only when it is in motion. The *motions of projectiles* in air are two, namely, translation, and rotation. The motion of translation is the resultant of three forces: (1) The pressure of the powder gas which urged it forward; (2) the resistance of the air retarding and gradually slowing it; (3) the force of gravity bringing it to the ground. The

result of these forces acting upon a projectile is to give it a curved line of flight which is called its trajectory.

The greater the velocity of a projectile and the more easily it penetrates the air, the longer will be its line of flight, and the flatter will be its trajectory. The same factors which flatten the trajectory increase the penetrating power of a projectile in the human body; and, as ordnance experts have constantly sought to increase the range and flatten the trajectory of fire-arms, they have at the same time increased the penetrating power of the projectiles fired from them.

The motion of rotation is the turning of a projectile upon its axis. In rifle and revolver bullets this motion is about their long axis and is given to them by the rifling of the pieces from which they are fired, the object being to keep the bullets end on and insure accuracy in their line of flight. The rate of rotation is more rapid as the twists of the rifling in the barrel of the fire-arm are shorter and the velocity of translation greater. With lead bullets the rate of rotation is comparatively low, but the jacketed missiles rotate on their long axis over 2,000 times per second. At first the theory was advanced that the rapid rotation of the bullet produced certain of the traumatic effects from it, but this has been disproved, although "wobbling" of the bullet toward the end of its flight may account for oblique impact.

The *velocity of projectiles* varies from about 700 feet per second, as in the case of ordinary revolver bullets, up to over 2,000 feet per second, as in the case of the jacketed missiles from the modern military rifle. Two phases of velocity are spoken of in regard to projectiles—initial velocity and remaining velocity. The initial velocity is the rate of motion of a projectile at the instant it leaves the muzzle of the gun. The remaining velocity of a missile is the velocity still remaining at any given point in its flight; this varies inversely as the distance from the firing place, and, in the case of gunshot wounds, is the velocity with which the projectile is impressed at the time it strikes the body.

The velocity of a projectile and its weight are the factors which give it energy, *i.e.*, capacity to do work; but the actual form of work done is the result of the shape and size of the missile in combination with the velocity and weight.

The initial velocity, the remaining velocity, and the energy at different ranges of the .30-calibre Experimental Springfield, which may be taken as an example of the modern military rifle, are as follows:

	Muzzle.	500 yards.	1,000 yards.	1,500 yards.	2,000 yards.
Velocity	2,000	1,103	804	627	495
Energy (in foot-pounds)	1,954	594	315	192	120

The Energy of Projectiles.—As with all matter in motion, the total amount of work done or that which may be done by a gunshot is represented by the formula MV^2 in which M = the mass or weight of the projectile, and V = the velocity.

But such expression of the work done by a missile in producing a wound is only true of those cases in which V = the velocity of the missile when it strikes the part, and when the missile expends all its energy in the part and comes to rest or lodges therein. Under these conditions $\frac{MV^2}{2}$ is an exact measure of the amount of work done (*i.e.*, energy expended), whatever the shape or the size of the missile. But, while under these conditions the work done will be the same whatever the shape of the projectile, the actual *form* of tissue destruction will vary according to the size and shape of the particular missile. Thus, given a flat fragment of shell and an undeformed small-calibre bullet, both of the same weight and striking the body with equal velocity and coming to rest in it, in the case of the shell fragment the wound will be larger and shallower while the

Fig. 201.—.30-Calibre Jacketed Bullets Deformed by Ricochet.

bullet will make a smaller but deeper wound. Both have done an equal amount of work, but the form of the work has varied with the size and shape of the missile.

In the human body the destructive capacity of a projectile depends in large part upon its transmitting its energy to the tissues. In the examples above given all the energy was transmitted and the missiles came to rest. When the projectiles do not come to rest, but have sufficient velocity to perforate a part, the influence of size and shape is particularly manifested. Given an undeformed small-calibre bullet and one deformed, both moving with equal but high velocity and perforating a soft part, the undeformed bullet will usually make a clean-cut track but little larger than the cross area of the missile, while the deformed bullet will produce a large and ragged channel much larger than the projectile itself. In the first case, the bullet, from its shape and size, passes readily through the tissues, loses but little of its energy in going through, and therefore has done a minimum amount of work and destruction of tissue. In the second case the striking area of the bullet is enlarged, the missile is more obstructed by the tissues, hence imparts more energy to them, does more work,

and emerges with a lower velocity than does the undeformed bullet. Herein we see the reason for the greater destruction produced by deformed or "dum-dum" bullets than that produced by those undeformed.

The shape of a bullet and particularly of its head has considerable influence upon the form of trauma which it produces. A spherical bullet or one with a flat head will penetrate less deeply than an oval-headed one, and will produce a larger and, at high velocity, a more widely extended trauma.

The oval head and elongated body now given to most bullets are the result of experiments having for end increased range and greater accuracy of flight. Bashfield's experiments showed that the shape of the head of a missile, by influencing the ease with which it penetrates the air, has direct effect upon its range. A flat-headed projectile offers the greatest resistance to the air—about twice that of a missile with an ogival head of two diameters, which offers the least. The oval head of the modern bullet, therefore, increases not only its range, but the ease with which it can enter the human body and the depth of the wound made by it.

The size of the bullet, and particularly the area of its cross-section, are also important in determining the form and depth of the trauma which it produces. Of two bullets of equal weight, the longer will have the greater penetration. The term "sectional density" is used to express the proportion between the area of the cross-section of a bullet and its weight. This ratio may be expressed by the formula

$$\text{Sectional Density} = \frac{\text{Weight of Bullet}}{\text{Area of Cross-section}}$$

The sectional density of a bullet is, therefore, high, and its penetrating power great, as its weight is great and the area of its cross-section small. The small-calibre bullets used in modern military rifles all have great sectional density and consequently great penetrating power.

Resistance to deforming violence is a factor directly related to shape, size, and sectional density. The modern jacketed missiles possess this quality to a high degree. They have a jacket of steel or nickel-steel, into which a lead core is swaged. The jacket, from its great strength, maintains the form of the bullet against considerable impact, so much so that the missile is rarely deformed in the human body, even by most compact bone. Unjacketed lead missiles have no such resistance to deforming violence, and are consequently readily deformed by contact with the body tissues and brought to rest in them.

RELATION OF THE STRUCTURE OF TISSUES TO GUNSHOT TRAUMA.

While velocity, weight, size, and shape of a projectile are factors, the *structure of the tissues struck* by the missile is of equal importance in determining the character of tissue destruction produced, particularly when the missile is of small size and is moving at high velocity.

The amount of work done by a missile in the destruction of tissue will be in direct relation to the resistance which the tissue offers to the bullet, so that with equal velocity, weight, size, and shape, the more resistant the tissue, the greater will be the tissue destruction, especially when the missile has sufficient velocity to pass through it.

This holds particularly with the small-calibre bullets now used in war, when at high velocity, and with such compact tissues as the shafts of the long bones and the fluid-saturated organs, such as the liver, spleen, and kidneys, and the brain, which is dense, saturated with fluid, and contained in a resisting bony case, the skull.

In certain tissues—skin, muscle, fascia, and adipose tissue—the effect is practically identical at all ranges. Jacketed bullets perforate these tissues cleanly and directly, cutting whatever lies in their way. The spongy bones, as those of the face, carpus, metacarpus, and epiphyses of long bones in young subjects, or bones softened by disease, it generally perforates cleanly or with little shattering at all ranges.

Upon the shafts of long bones or bones composed of compact tissue, upon organs with fluid contents (stomach, intestines, bladder), and organs of spongy texture containing large quantities of fluid (brain, liver, spleen, kidneys), the compound bullet at long range produces its minimum amount of traumatism, *but in these tissues and organs the destructive effect of the bullet is increased in proportion to the shortness of the range,* until, at about six hundred yards and under, it will smash the shaft of a femur or a humerus to fragments, and upon the brain, liver, kidneys, spleen, or stomach, unless the latter is empty, it will act practically with explosive violence.

From this wide difference in the traumatic effects produced by the compound bullet it is easy to understand why the wounds made by it are so frequently immediately fatal, or, on the other hand, give such excellent opportunity for recovery; for, in one case, the destruction wrought in vital organs will be so great as soon to cause death, and, in the other, the missile, when at lowered velocity, will pass cleanly through the tissues and, except in bone, the traumatism will be practically limited to its track.

Explosive Effect.—Much has been written of the explosive effect produced by the small-calibre bullet, and many theories have been advanced to explain

it. In the opinion of the writer, the theory which best explains this effect of the bullet is that the destructive effect of the bullet is the result of the lateral transmission of energy imparted to the tissues by a rapidly moving missile. If energy were transmitted only in a line directly in front of a bullet, the bullet would make clean-cut perforations in all organs or tissues through which it passed, and immediately fatal results would arise only from direct wounds of blood-vessels, perforations of the heart, or impingement of the bullet upon some vital part of the central nervous system.

Lateral transmission of energy, with explosive effect, is, therefore, a factor of great importance, for many severe traumatisms and immediately fatal results are due to it.

As this transmission of energy to an extent sufficient to cause extensive solutions of continuity occurs only in certain organs and tissues, and in these only when the velocity

Fig. 202.—Empty Leaden Vessel, showing Aperture of Bullet. ("Wounds in War," Stevenson.)

of the missile is great, it must follow that it is because these best transmit the energy imparted by the bullet.

As the structures which transmit this energy with explosion-producing violence are either compact bone or organs containing fluid, or those practically saturated with fluid, it seems most probable that this energy is transmitted in two ways—either through the transmission of vibration by the closely knit, compact bone tissue or through the incompressible fluid in fluid-saturated or fluid-containing organs. In compact bone, with the missile moving at high velocity, by the suddenness of the shock, the bone is disrupted, and the osseous particles, acting as secondary missiles, are forced outward, increasing the disruption and traumatism by lateral transmission of the energy imparted.

In fluid-containing organs or fluid-saturated organs the impact of the bullet when travelling at high velocity is so sudden and violent that its energy is transmitted in all directions by the molecules of the incompressible fluid, and disruption in all directions occurs.

With the bullet moving at lower velocity the shock in bone or organ is less, the disruption consequently less, and, with still lower velocity, the ball may enter and pass through the same tissue or organ with practically no lateral destructive effect. In a broad way the result may be likened to the difference in the effect produced by dropping a bullet into water contained in an open leaden vessel or firing it into it. In the first case the bullet will enter, making slight commotion and that mainly upon the surface of the water, while, if the

bullet is fired into the water, the containing vessel, even though open at the top, will be completely destroyed through the lateral transmission, by the incompressible fluid, of the suddenly impressed energy. (Fig. 203.)

As a result of the conditions by which a bullet transmits its energy to living tissues and produces its destructive effect in them, traumatisms by bullets may be divided into three types relative to the general area and form of destruction which are seen in these cases. These may be named the cylindrical, conoidal, and spheroidal types of bullet traumas.

The cylindrical type is found in all of those wounds where the bullet passes through soft tissue and the spongy ends of bones. In these cases there is little lateral distribution of energy from the missile, and the wound is but little larger than the diameter of the projectile, its length depending upon the thickness of the part or, in the case of a lodged missile, upon the velocity of the projectile.
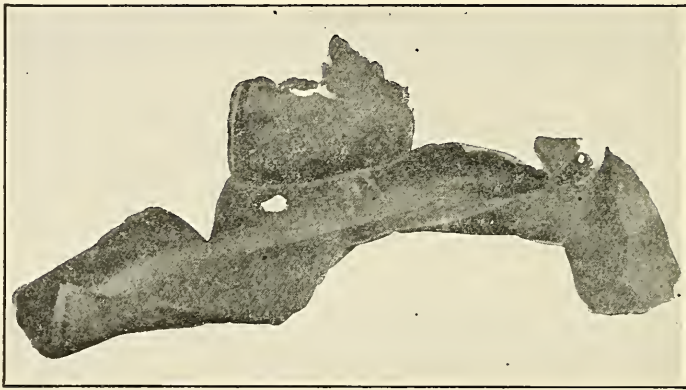
Fig. 203.—Leaden Vessel Filled with Water and Sealed; Showing Explosive Effect Produced by Small-Calibre Bullet Passing through the Water at high Velocity. ("Wounds in War," Stevenson.)

The conoidal type of wound is exemplified where the bullet travels at high velocity and impinges upon a fluid-saturated organ or upon the shaft of a long bone, or where a deformed missile of the dum-dum type, owing to its deformity, readily transmits its energy to the tissues. In these cases the energy is transmitted laterally and forward from the missile, the trauma exhibiting a small wound of entrance while the subcutaneous destruction of tissue gradually widens toward the wound of exit, which is considerably larger than the wound of entrance, thus forming a trauma of conoidal form.

The spheroidal type of injury is illustrated where the bullet, travelling at a very high velocity, strikes the shaft of a long bone, or passes through the skull and brain. In these cases the sudden impingement of the missile upon the compact structure of the bone or the fluid-saturated brain contained in a bony case, from the abruptness of the impact, causes the energy to be distributed in all directions, and the trauma, instead of being along the course of the missile,

or more widely distributed toward the wound of exit, extends in all directions: the skull, for instance, being broken up as an egg-shell would be if dropped upon the ground.

With varying velocities and differing deformity of missiles these different. types of trauma insensibly grade into each other, but in almost every form of gunshot wound some one type predominates.

SHOTGUN WOUNDS.

Wounds from shotguns differ greatly in character according to the range at which the injuries are received. At very short range, before the shot have scattered and while they are moving at high velocity, the charge acts much as would a large jagged piece of metal. If the shot is a glancing one, quite large pieces of skin and underlying tissue are torn away, and the smaller extremities, such as the fingers and toes, may be amputated, and, if the charge strikes the face, great disfigurement may result. When the wound is direct, quite large and deep, ragged excavations may be made, into which pieces of clothing, the wadding of the charge, and other foreign materials may be driven.

The probability of the occurrence of infection in all of these wounds is very great, both from the likelihood of infectious material being directly driven into the tissues, and from their large size, which favors secondary infection from without.

When bones are struck by the charge before the shot have scattered, they may be fractured, but the amount of comminution is generally not great.

Hemorrhage is ordinarily not severe from these wounds, for, from the laceration of the blood-vessels, the coats readily retract and stop the bleeding. When nerves or tendons are struck by these large masses of shot, quite considerable portions of them may be torn away, and operative restoration of their continuity may be very difficult.

At longer range, and after the shot have separated, each shot makes its own wound, and, from the small size and comparatively low velocity of these missiles, the wound is ordinarily not deep and is usually uninfected. Wounds of this kind are rarely of serious moment unless the shot strike the face, where they may produce disfiguring scars or serious injury to the eye.

Shot wounds of the eye from large shot may so damage the eyeball that immediate enucleation is required. Small pellets commonly give rise to marked intraocular inflammation. If the wound is very small, the inflammation may subside and the eyeball be saved, although blindness or greatly impaired vision usually results.

When the wounds are made by *buckshot*, they are of moderate size and of a. depth corresponding to the range at which they are received. At very short.

range wounds of gravity may be produced, on account of the deep penetration of the missile.

The United States Army is now supplied with a multiball cartridge for use in the service rifle. This cartridge contains two round lead bullets weighing 42 grains each. These bullets are similar to buckshot and give like wounds. The multiball cartridges are issued for use in riot service, the jacketed service bullet having so long a range and being so destructive in its effect that it is not prudent to use it in the streets of cities, where riots ordinarily occur. The small bullet used in the multiball cartridge is much more humane and equally effective against mobs.

Treatment of Shotgun Wounds.—The large lacerated wounds made at short range should be thoroughly explored in order to remove all foreign material, such as pieces of clothing, wadding, etc. Following this, ragged tissue should be cut away and the wound made as smooth and clean as possible. If nerves or tendons are cut, these should be repaired if possible, and the skin should be approximated as well as may be over the wound. The after-
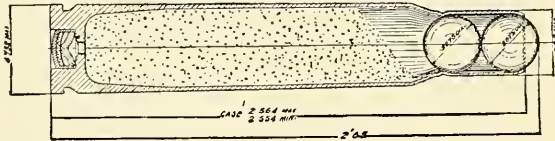
Fig. 204.—United States Army Multiball Cartridge.

treatment is that of lacerated and infected wounds, consisting of drainage, application of absorbent or mild antiseptic dressings, and, later, the application of balsam of Peru to stimulate and protect the granulating surface.

When the wound is made by scattered shot, little treatment other than occlusive dressing will usually be required. The shot rarely require removal unless they lodge in the joints and thereby interfere with the function of the part. If they lodge superficially in the face, they may require removal on account of the disfigurement which they produce. Ordinarily they become encysted in the tissues and give rise to no inconvenience.

Wounds by Solid Shot.—Wounds by broken projectiles from artillery are among those least frequently seen in war, but are, also, among the most severe, for, from the weight and velocity of these missiles, the traumatisms are generally extensive, large parts of the body being torn away, the soft tissue pulpified, and the bones comminuted. Such wounds have to be treated as are the wounds from large shell fragments, to which section the reader is referred.

Windage Wounds.—A somewhat rare but interesting form of injury is occasionally produced by large missiles travelling at reduced velocity, when they strike a part very obliquely, not breaking the skin. In such case there may be extensive subcutaneous destruction of the soft tissues and fragmenta-

tion of bone without any external wound. These traumatisms were formerly called *windage wounds,* under the belief that they were produced, not by actual contact of the projectile, but by the force of air compressed between it and the part near which it passed. This theory is now disproved, a glancing blow and the elasticity of the skin accounting for the peculiarities of the injury.

WOUNDS BY SHELL FRAGMENTS.

Wounds by fragments of shell present a very great variety of form and size, according to the shape, size, weight, and velocity of the particular fragment which produces the injury. With the exception of the small wounds, made by very small fragments, they are all more or less lacerated and are generally infected. The character and amount of laceration vary from superficial tears to large deep wounds in which the soft parts are extensively destroyed or torn away and the bones crushed and comminuted or an extremity amputated. All surgeons agree as to the gravity of these large, lacerated, infected wounds. Dent says of those observed by him in the South African war that they were the most terrible and the most difficult to treat of all the wounds which came under his care. Where the fragment has sufficient velocity to perforate a part, the wound of exit is generally large and the tissue destruction from the irregular and jagged missile is great. In a few instances the opposite condition—*i. e.,* a small wound of exit—is observed, although no explanation can be given.

Lodgment of shell fragments frequently happens. In treating wounds with comparatively small inlets, fragments of shell several times larger than the inlets are often found. The presence of such large fragments should always be suspected, and, if the wound is slow in healing, careful search should be made for them under aseptic precautions or with the *x*-rays.

Suzuki, in his description of the shell wounds which came under his care in the Russo-Japanese naval war, states that the larger number of such wounds are uninfected, as the shell fragments are made sterile by heating during explosion, and that wounds caused by small shell fragments generally healed by primary union. This is undoubtedly true of wounds caused by small fragments, but in the wounds caused by large fragments the great size of the wound makes it very liable to secondary infection, even if the missile itself was sterile.

Pieces of clothing are frequently found driven into the wound and are carried in by shell fragments much more frequently than by bullets, on account of the greater size and irregular shape of the missiles. Lodged pieces of clothing invariably give rise to suppuration and delay in healing, and, in every case of prolonged suppuration, careful search should be made for the presence of foreign bodies, such as pieces of clothing, etc., in the wound cavity.

Multiple wounds by shell fragments are not uncommon, especially in recent

wars. The modern explosives, maximite, lyddite, shimose powder, etc., by reason of their great power, break shells into many small fragments which are hurled in every direction. A person standing near is very apt to receive more than one wound, sometimes several dozen, or even over a hundred. The size of the wounds varies greatly, from mutilation of the whole body to wounds as small as a millet seed.

In fractures by shell fragments the bones are generally greatly comminuted, but it sometimes happens that only the superficial layer is sliced off or the bone merely fissured. When the wound is made by a fragment of large size its gravity lies mostly in the great extent of the comminution and the large avenue for infection which may lead to prolonged suppuration, osteomyelitis, ostitis, and like conditions.

Hemorrhage of wounds from shell fragments is ordinarily not great, the laceration of the tissues favoring the clotting of blood, while the lacerated vessels curl up and close by retraction of their coats. In cases of penetrating wounds the resistance of the arterial walls is such that the vessel may be pushed out of the way and not torn.

The *treatment* of wounds caused by shell fragments, on account of the great difference in size and form of the injuries, varies from suitable dressing for the small wounds to extensive operations in the larger ones. At the first place of assistance, such as the dressing and ambulance stations on the battlefield and during the engagement on board ship, only the urgent aid can be given. The arrest of hemorrhage, the application of ready-made splints in cases of fracture, and dressing with sterilized gauze and bandages are about the only measures that can usually be employed.

FIG. 205.—Wound by Perforating Fragment of Shell. (From the "Surgical History of the Naval War between Japan and China." Official.)

A *first-aid packet* for shell wounds is supplied to all batteries of artillery in the United States army, and a similar one is used in the navy. The Japanese navy has a similar dressing. This first-aid packet for the use of the United States army and navy consists of one large piece of antiseptic gauze enclosed in wax paper and a six-inch bandage several feet in length, with safety pins, the whole being done up in oiled cloth for ordinary use and in tin cases for use in tropical climates. The Japanese first-aid packet contains four small pieces of antiseptic gauze and a triangular bandage. Both kinds of packet are probably about equally good, as in each there is sufficient gauze to cover and protect quite a large wound.

As soon as possible after an engagement the wounded should be transferred

to permanent hospitals at the rear, where aseptic and antiseptic work can be done. Here each wound should be minutely examined. Fragments of shell or pieces of clothing should be sought for, and the wound should be thoroughly cleaned, and loose pieces of bones removed. Experience has shown that to cover these wounds with skin is a great protection against infection and materially hastens the healing process. The skin should, therefore, be brought over the wound as much as possible. In cases of compound fracture pieces of detached bones in the wound cavity should be extracted, but those not completely detached are best left *in situ*, unless the injury is so grave that formal excision is required.

With modern methods of asepsis conservatism can be practised to a great extent. This is evidenced from the reports of the Japanese methods of treatment in the Russo-Japanese war, in which it appears that only urgent aid was given to the great majority of the wounded, such aid as the application of dressings, splints, etc. They were then transferred to a base hospital as soon as possible, where constant attention and antiseptic technique were available, to limit infection and promote healing. Nevertheless, the same extreme conservatism cannot be practised with large open wounds as with the small aseptic wounds made by bullets. In many cases of fracture by shell fragments the bone is destroyed to such an extent in its continuity that excision, either formal or informal, will not be followed by recovery with a useful limb. Equally unfavorable results may be expected where such wounds become infected, as ostitis, osteomyelitis, and prolonged suppuration are then almost sure to follow, and these processes will endanger the patient's life or will, by extensive cicatricial formation, so impair the use of the part as to make conservatism unwarranted. In such cases amputation should be resorted to as soon as danger to the patient's life is evidenced.

BULLET INJURIES OF THE BODY TISSUES AND STRUCTURES.

Bullet Wounds of the Skin.—The entrance wounds of small-calibre, undeformed bullets differ in shape according to whether the missile impinges perpendicularly or obliquely, or strikes a more or less deep fold of the skin. When the bullet impinges at a right angle, the wound is circular, slightly smaller in diameter than the bullet which produced it, is somewhat depressed, and usually has one or more short radiating fissures extending outward. With oblique impact, oblong wounds, varying in length according to the angle of incidence of the bullet, are made. When the missile strikes a skin fold, a slit-like wound may be made, which may be partly or almost wholly concealed unless the fold is opened. Soon after the receipt of the wound a dark scab forms which seals the wound quite firmly, and, unless disturbed, acts as a protection

against infection from without. In some cases, after a few days the edges of
the wound about the scab take on the appearance of slight superficial necrosis
or infection.

Wounds of entrance by bullets of large calibre and by shrapnel bullets have
practically the same appearance as those made by small bullets, except that
they are apt to be less regularly circular in outline and radiating fissures are more
common and longer.

The entrance wounds by deformed bullets differ in size and shape according
to the amount of deformation of the missile. Where deformation is marked,
the wounds resemble those made by fragments of shell and may be mistaken
for them.

Wounds of exit by undeformed small bullets are usually somewhat larger
than those of entrance and resemble them in shape and character. In fact,

Fig. 206.—Entrance and Exit Wounds in Both Thighs and the Scrotum. ("Surgical Experiences
in South Africa," Makins.) Small-calibre bullet passed from right to left, showing round entrance and
exit wounds, through smooth skin; slit-like wounds through the skin; and small "explosive" exit, the
bullet having set up on contact with the front surface of the femur.

they are often so like them that it is impossible to determine from observation
of the skin wounds alone which is the wound of entrance and which that of
exit. With large bullets the exit wounds are generally considerably larger than
the corresponding wounds of entrance; are more irregular in outline and more
fissured. The size of the exit wound is usually considerably increased if the
bullet has passed through a bone and especially if bone fragments are driven out
through it. With deformed bullets the exit wound is almost always large and
jagged.

Multiple wounds from jacketed bullets used with military or hunting rifles
are common on account of the high velocity and great penetrating power of these
missiles. They are much less common in wounds of revolver bullets and for
this reason are rarely seen in civil life. In these wounds the second wound of
entrance is usually larger than the first and is more liable to be infected, prob-
ably from contamination of the bullet in passing through the skin twice, and

through several layers of clothing. Similarly, the second wound of exit is usually larger and more irregular in outline than the first.

Effects of Bullets on Muscles and Fasciæ.—When undeformed small bullets pass cleanly through muscles or fasciæ, a minimum amount of trauma is produced, and this is almost entirely limited to the track of the bullet, whatever the range at which the injury is received. When no important nerve or vessel is injured, the shock and disability produced are not great. Wounds through the neck, fleshy part of the arm, and parietes of the chest or abdomen give little trouble, and men with wounds deep through the buttock, thigh, or leg, walk with little difficulty. The sensation from a wound of the soft parts inflicted by a small-calibre bullet is that of a sharp blow from a heavy cane, while, when a bone is struck, the sensation is like that of a blow from a heavy iron bar.

With large lead bullets the shock in flesh wounds is much greater, and this is further increased when the missile is deformed. Similarly, the tissue destruction is greater, and, when the bullet is travelling at a high velocity, the trauma may take the conoidal form. In these cases particularly, and in a certain number of wounds by smaller missiles, even when uncomplicated, the resulting cicatrix in the deeper parts of the wound is often of extreme density, and may produce impairment of function of a limb by involving tendons or tying the traversed muscles together. This tendency should be combated early in the course of the case by the employment of passive motion and later by systematic and early instituted exercise.

The liability to considerable destruction of muscular and fascial tissues is materially increased on the distal side when a missile has passed through bone, as bone fragments may be driven or displaced outward into the soft parts, increasing the amount of destruction and favoring the formation of a large callus which may further impair the function of a limb.

Wounds of Tendons.—With slow-moving lead bullets, such as those fired from revolvers or the older military rifles, the tendons, from their resistant structure, are frequently pushed aside and escape injury.

With jacketed high-velocity bullets this rarely occurs. These missiles pass directly through the tendons, cut them entirely or nick them. When the tendons are severed, the ends are usually somewhat frayed and there is actual loss of length corresponding to the diameter of the bullet. When a tendon is cut by a deformed bullet, the loss of continuity and the fraying may be considerable. In addition to the injury to the tendon, that to the tendon sheath is of importance, and, when several tendons are cut, as in transverse shots of the front of the wrist, the function of the part may be greatly impaired, even after the best treatment, by the resulting cicatrix binding all the parts together.

The *treatment* in all cases of severed tendons is early operation. If there is delay, retraction of the tendons will occur, together with binding in the cicatrix. Before retraction occurs, stretching the tendon will usually allow

direct union of the divided ends, while careful asepsis in clean wounds and anti-sepsis in infected ones, with early passive motion and exercise, will often result in complete or nearly complete restoration of function.

Wounds of Blood-Vessels.—Blood-vessels are usually cut or severed by the jacketed high-velocity bullet now used in war. The comparatively slow-moving bullets formerly used frequently shoved the vessels aside and passed them without severing or wounding them. The same is true of the slow-moving lead bullets fired from revolvers.

From the high velocity and great penetrating power of the jacketed bullets, they do not slip by the vessels, but sever, perforate, or make clean-cut lateral wounds. In war the greater proportion of deaths upon the battlefield are due to hemorrhage. The rifle bullets now used penetrate deeply and sever the vessels so cleanly that contraction of their ends and spontaneous arrest of hemorrhage are not favored.

In injuries of the blood-vessels by bullets, the vessels may be either contused, or lacerated without perforation, or they may be perforated, cut laterally, or severed.

When a slow-moving lead missile strikes a blood-vessel, it may contuse or destroy only a part of the wall, and very oblique impact by the jacketed bullet may have the same effect. Following such injury two things may result. Either the weakened wall will dilate, giving rise to a traumatic aneurism, or the healing of the wound may cause contraction of the vessel at the point of injury. In some wounds in close proximity to large vessels a diminution of the normal calibre of the artery has been observed, marked by absence or diminished pulsation of the vessel distal to the wound. Usually, with the lapse of time the pulse, aided by collateral circulation, returns to nearly its normal volume, but in some cases the obstruction to the vessel is permanent.

Instead of this contraction of the vessels, the formation of a *true aneurism* is not uncommon. This differs but little from the ordinary idiopathic aneurism, except that the tumor is more localized and generally has a thinner wall and more pronounced expansile pulsation.

The *treatment* of these aneurisms of traumatic origin is, first, rest—afterward operative treatment when necessary. It is well, in some cases, to postpone operative treatment when practicable, until the aneurism becomes stationary. If the wound be in an extremity, rest and elevation of the limb, which should also be lightly bandaged, will be found helpful. The ideal operative treatment is ligation and excision of the vessel on each side of the aneurism, with ablation of the sac.

In those parts of the body where this operation cannot be done, proximal ligation is generally followed by good results.

When the lumen of the vessel is opened by the bullet, the opening may be either lateral, central, oblique, or transverse to its long axis. Small-calibre

bullets may strike more or less accurately the centre of a vessel, perforating it, while lateral continuity is maintained.

When the vessel is perforated, particularly when the wound is lateral, *a false aneurism* frequently results. These false aneurisms of traumatic origin, or arterial hæmatomata, are really at first localized interstitial hemorrhages. The wall of the aneurism is not formed by one or more of the vessel's coats, these having been completely destroyed by the passing missile or so weakened that rupture occurred. If the hemorrhage is not excessive, a localized hæmatoma forms, walled by the surrounding tissues. These may organize into an enclosing sac continuous with the walls of the ruptured vessel and opening into it. The continuity of the interior of the sac with the lumen of the vessel gives rise to the pulsations which are sometimes noted. These false aneurisms are indicated by a soft, diffuse, fluctuating swelling, sometimes accompanied by pulsation. When expansile pulsation is present it indicates that the arterial blood passes into and out of a sac, and that an aneurism is formed. When the pulsation is absent, it usually indicates a condition of interstitial hæmatoma. In the early course of the case, when the amount of blood escaping is considerable, symptoms of hemorrhage may be present, and later, if the hemorrhage is recurrent, it is also almost invariably marked by an elevation of temperature, similar to the rise of temperature which occurs in recurrent intra-pleural bleeding.

The *treatment* of aneurism and interstitial hemorrhage is direct incision and ligation of both ends of the wounded vessel. The clot should be cleared out and the cavity thoroughly cleansed in order to remove the pressure which the clot produces, and which may, if not relieved, in connection with ligation of the vessel, produce gangrene by interference with the blood flow.

Proximal ligation alone is to be avoided, except in those parts of the body in which ligation of the vessel on both sides of the lesion is impossible.

All observers in recent wars have noted the frequent occurrence of *aneurismal varix* and *varicose aneurism*. The occurrence of these is usually dependent on the passage of a small-calibre bullet between an artery and a vein, wounding both vessels and producing a solution of continuity by which the blood may pass from one to the other. If the blood passes directly through, without dilatation of the connecting channel, an aneurismal varix results, while, if the new channel between the artery and vein becomes dilated, a varicose aneurism of greater or less size is formed. With large, slow-moving missiles and revolver-bullet wounds, such as those seen in civil practice, these forms of injury are rare. The small calibre of the missile and its clean-cutting properties, both of which belong to the modern war bullet, are the factors which determine the frequency of these arterio-venous communications. As a matter of course, they can occur only where the artery and the vein lie close together, and it appears that close proximity of the vessels favors the formation of a varix, while, if the vessels are somewhat further apart, with some tissue between, a varicose aneurism is more

likely to result. The close proximity of the popliteal artery and vein, and of the vessels in Hunter's Canal, together with the particularly firm adhesion which exists between them, favors the formation of a varix, while if the femoral artery and vein are wounded in Scarpa's triangle, where the vessels lie in a large areolar space, varicose aneurism is more likely to result.

The presence of aneurismal varix is evidenced by the existence of a purring thrill and a buzzing murmur. When a varicose aneurism is present, this condition is evidenced by a murmur and by expansile pulsation in the tumor. The purring thrill is a pathognomonic sign of both conditions and is commonly present in the fully developed stage. It is usually widely conducted superficially on palpation, and is much more pronounced with light than with forcible digital pressure.

Makins states* that one of the most striking symptoms, in both aneurismal varix and varicose aneurism, is the effect of the disturbance of the even flow of the blood on the heart, that the pulse-beat is increased up to 100 to 140 per minute, and that this acceleration of the heart action is, in cases of aneurismal varix, often the only symptom which particularly inconveniences the patient. As other observers have failed to note this symptom, its occurrence should be further investigated.

The *treatment* of aneurismal varix and varicose aneurism presents certain difficulties, as both artery and vein are involved. If operation is resorted to there is danger of producing gangrene if the vessels injured are in an extremity, and cerebral disturbance if the neck vessels are involved. With careful attention to asepsis, elevation of the limb, and the application of warmth after the operation, the probability of post-operative gangrene is lessened, but the possibility of this result should be remembered.

In *pure varix* non-interference in the early stages is advisable. Where the communication is between the carotid and the jugular vein, conservatism is especially advocated, because of the grave nature of the operation and its possible after-consequences on the brain. On account of the comparatively free anastomosis between the arteries of the upper extremities the varix operations in this part of the body are more promising, but operation upon the lower extremities for varix should be done only in those cases in which there is danger from the presence of the varix. The best operation is ligation of the artery above and below the varix, the vein remaining undisturbed. In fact, the ideal treatment of this condition is preventive, viz., primary ligation of the wounded artery. When these operative measures cannot be taken, proximal ligation of the artery alone or combined with double ligation of the vein; or, in an upper extremity, double ligation of both artery and vein, with excision of the injured parts of both vessels, may be adopted.

The treatment of arterio-venous aneurisms offers the same difficulty as does

* " Surgical Experiences in South Africa," p. 134.

the treatment of varix. From the presence of the sac, which may greatly increase in size, and with the danger of rupture, operative interference is more often necessary than with varix. In cases demanding operation, it is best to adopt the same method of treatment as with varix, viz., double ligation of the artery, trusting that, with the removal of the blood pressure through the artery, the sac may contract and become obliterated, and this with continued patency of the vein. In severe cases, double ligation of both vessels, with excision of the aneurism, possibly even with amputation then or later, in the case of an extremity, may be demanded.

Hemorrhage.—When blood-vessels are partially or completely severed by bullets, the occurrence of hemorrhage to a dangerous extent depends not alone upon the size of the vessel wounded, but upon its situation and the tissues in which it lies. With the small-calibre bullet quite large arteries of the extremities may be wounded and no great hemorrhage result, the track of the missile through the soft parts being so small that the wound is practically closed and the escaping blood forms a hæmatoma of small size only. In the case of large vessels that lie superficially, such as the femoral, axillary, or carotid arteries and veins, hemorrhage may be profuse and rapidly fatal.

Wounds of blood-vessels in the body cavities, even though the vessels be small, are very likely to give rise to dangerous internal hemorrhage, for in these cases there is no strong surrounding tissue to limit the outflowing blood. In many cases, hemorrhage, particularly if it be of a lower extremity, will cease spontaneously if the person wounded is kept perfectly quiet, the limb elevated, and if careful compression and cold are applied. The same is true of internal bleeding from small vessels, and the good effect of rest in intra-pleural bleeding has been particularly noted. The ideal treatment of hemorrhage, when a vessel of any size is wounded and the bleeding does not cease spontaneously, is incision under aseptic precaution and proximal and distal ligation of the vessel at the place of injury. This operative treatment cannot always be carried out at once. In such cases some temporary means of arresting the hemorrhage should be resorted to, as by means of the application of local pressure or by proximal occlusion of the vessel by means of a tourniquet. In applying a tourniquet the pad should be adjusted so that the pressure shall come directly upon the vessel to be occluded, and in no case should the tourniquet be left on for a long time, otherwise gangrene may result.

Recurrent Hemorrhage.—Bleeding which has stopped spontaneously sometimes recurs, the recurrence often being due to injudicious movement of the person wounded or to a return of the blood pressure after recovery from shock. The reason, therefore, for keeping a patient perfectly quiet and avoiding injudicious handling or exploration of the wound is evident.

Secondary Hemorrhage.—Formerly, this was one of the most dreaded of the sequelæ of gun-shot wounds with which the surgeons of pre-antiseptic times

had to deal. It is now known that in a great majority of cases infection of the wound was the main causative factor of this complication. When infection occurs, the resulting necrosis of the tissue leads to sloughing of the vessel which then bleeds profusely and often from the distal end. Maintenance of asepsis in non-infected wounds is, therefore, of great importance as a preventive measure; and, in infected wounds, the use of mild antiseptic irrigation and complete drainage, so that nature's attempts at repair are favored, will reduce the liability of the occurrence of this serious trouble.

The treatment of secondary hemorrhage is often difficult. Local compression can be used only to check hemorrhage until operation can be resorted to. In some cases, where the vessel is comparatively superficial, the wound may be opened, increased in size, and the vessel ligated. This operation, however, presents certain difficulties. It is seldom easy to find the vessel, or to ligate it high enough to insure that the ligature is placed above the diseased part. In any event, however, neither end of the vessel should be tied in an infected wound or through a wound communicating with an infected cavity unless there is no other recourse. The vessel should be ligated if possible through sound tissue on either side of the infected wound or cavity, but, when the operation must be done through an infected area, the ligation should be preceded by thorough cleansing of the infected tissues and the application of antiseptics, and should be followed by careful drainage. In cases where an extremity is the part injured, the choice of treatment will lie between ligation and amputation. Of these, if the case be a septic one, amputation may be preferred to proximal ligation, especially when the latter is certain to be followed by gangrene. In the upper extremity ligation may be attempted with greater hope of success, but the surgeon should be ready to resort to amputation upon the first appearance of symptoms of threatening gangrene.

Wounds of the Nerves.—Wounds of the nerves by bullets present certain interesting peculiarities. Principal of these is the extensive destruction of a nerve when struck or grazed by a small-calibre bullet travelling at high velocity. This destruction extends to a considerable distance beyond the point of impingement of the missile and consists particularly in a molecular disintegration of the nerve substance from the transmission of energy by the missile. With slow-moving missiles, such as those fired from revolvers, the nerve may escape direct injury, the missile displacing and slipping by it, but with the jacketed bullet of the military rifle such escape of the nerve is rarely seen.

Nerves may be contused or partially or wholly severed. When the contusion is by a missile travelling at low velocity, the nerve substance is generally not destroyed, and, while the function of the nerve may be temporarily abolished, it is ordinarily soon restored. When, on the other hand, a jacketed missile travelling at high velocity grazes or passes in the immediate vicinity of a nerve, what the Germans call "Erschuetterung" of the nerve trunk is produced. This

molecular disturbance is due to the dense structure of the nerve as a whole, the density of the tissues readily transmitting the energy of the missile with sufficient force to cause disruption of the nerve. As a result, even when the nerve is not directly wounded, rapid degenerative changes are set up which destroy the nerve for some distance. Equally, when a high-velocity missile partially or wholly severs a nerve, the destruction is not limited to the solution of continuity, but extends in both directions along the nerve trunk. This peculiar molecular destruction of nerve substance is of importance both in the prognosis and in the treatment of these cases. When a nerve is merely severed, as by a knife cut, the ends can be readily approximated with hope of restoring the function of the nerve. On the other hand, when the nerve is wounded by a high-velocity bullet, mere approximation of the severed ends will rarely, if ever, be followed by recovery.

In the operative treatment of these cases the fact must be borne in mind that the nerve is destroyed for some distance on either side of the place of injury. When the nerve is cut or severed by a slow-moving missile, this molecular destruction may not be present, and a more favorable prognosis may be given relative to the restoration of the function after union of the nerve. However, in all cases of partial or complete severance of a nerve by a bullet the prognosis is very much more grave than in those cases in which the nerve has been cleanly cut.

The symptoms of bullet injuries to nerves are paralysis, loss of sensation, hyperæsthesia, pain, and the symptoms of traumatic neuritis. When loss of motion and sensation persists, it is evidence that the nerve has been either severed or destroyed. Hyperæsthesia, pain, and neuritis most commonly indicate that the nerve has been either contused, or partially severed, or has become involved in the cicatrix. Referred pains in these cases are not uncommon, the pain being present, not in the injured nerve, but in one of the branches from the proximal stem.

The *treatment* of all nerve injuries and wounds is usually operative, under strict asepsis. If paralysis and loss of sensation are present, and are not restored within forty-eight hours, the nerve should be cut down upon and examined. If severed, it should be united by one of the methods used for this purpose. (See the article on Surgery of the Nerves in the present volume.)

Ordinarily, on account of the separation of the divided ends, some form of flap-splitting union will have to be resorted to. Where the case is one of molecular destruction, the nerve on inspection may appear normal, and in such cases conservatism only can be practised. When neuritis, referred pains, or trophic changes occur as a result of nerve injury, the wound should be carefully explored, and, if the nerve is found involved in the cicatrix, it should be released.

The symptoms of scar implications are frequently severe, and usually consist in neuralgic pains or painful sensations when the cicatrix is put on the

stretch. The neuralgia may not be constant, and is often more troublesome when the patient has been exposed to cold, extra fatigue, or depressing influences. In other cases well-marked signs of neuritis appear, such as glossy skin, pain, muscular wasting, and paralysis.

It must be stated that where there has been direct injury of a nerve by a bullet, surgical interference up to the present time has not been very successful, and this form of nerve trauma can in no wise be favorably compared with wounds of the nerves inflicted by sharp-edged instruments.

GUNSHOT FRACTURES.

Fractures caused by bullets differ in character according to the kind of bullet by which they are produced, being influenced by the weight, size, shape, and velocity of the projectile. Of equal importance is the structure of the bone struck, the trauma differing materially when a bullet of given size, weight, and velocity strikes compact bone from that produced in cancellous osseous tissue. The maximum destructive effect is produced when a missile travelling at high velocity strikes compact bone, such as the very resistant osseous tissue of the shaft of the long bones. In this compact tissue the energy imparted by the missile is readily disseminated, giving rise to long fractures and extensive comminution. In the less dense cancellous tissue the energy of the missile is not readily transmitted, and the bullet may perforate with little or no fragmentation. The difference is so marked, according to the structure of the bone injured, that, while the spongy bones of the face and extremities of long bones are generally perforated cleanly, or with little shattering at all ranges, the jacketed missile at about six hundred yards and under will smash the shaft of a long bone, such as the femur or humerus, to fragments.

Fractures of the Diaphyses of the Long Bones.—When the shaft of a long bone is struck by a slow-moving lead bullet, such as is usually fired from the smaller-calibre revolvers, the bone is generally broken obliquely, without fragmentation. The bullet rarely enters the bone, but flattens against it or glides around it.

With undeformed jacketed missiles the fractures produced will differ mainly according to the velocity of the missile and the angle of incidence. In general, it may be stated that the amount of damage caused in the diaphysis of a long bone by a bullet depends largely upon the range at which the injury is received, and that the amount of comminution decreases as the range increases. This general rule, however, is subject to some variations. The amount of comminution at a given range is greater if the missile strikes the bone in the median line than when it strikes it at one side. Also, observations in the Boer war indicate that at such ranges as two thousand yards considerable com-

minution may be produced by the bullet when it does not strike directly end on. This was observed during the experiments on the effects of the modern bullet, when it was seen that at extreme ranges the entrance hole made by the bullet was not a circular one, but oval and larger than the diameter of the missile. This is evidence that elongated projectiles, starting with high velocity of rotation, do not always strike with their points at extreme ranges, but with more or less extended area of their sides. The cause of this change of position which occurs
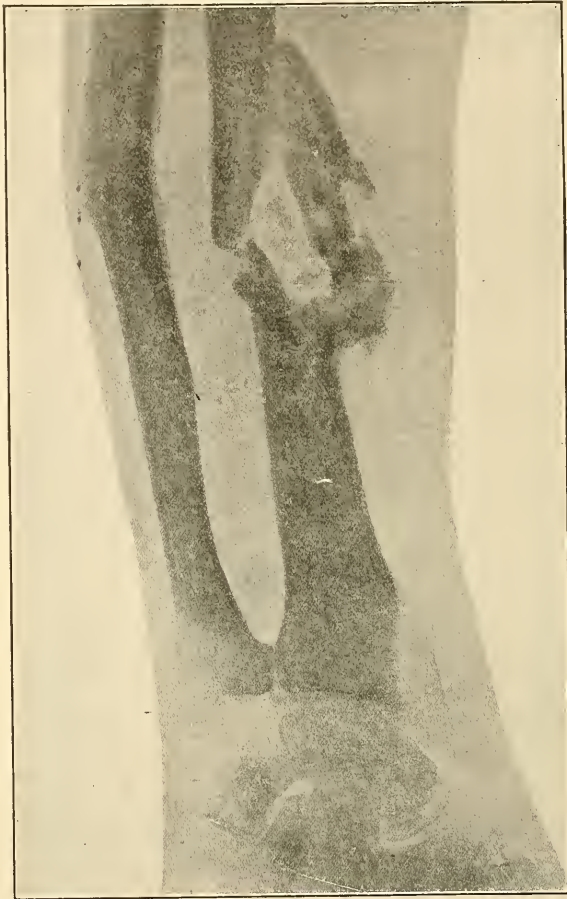
Fig. 207.—Fracture of Both Bones of Forearm by a Mauser Bullet. ("Wounds in War," Stevenson.)

in bullets toward the end of their flight is referred to by Nimier and Laval, in their work on projectiles, in these words: "In modern long bullets the centre of gravity does not coincide with the centre of the figure, but is behind that point; the result of this is that the projectile is inclined to lose its tangential position on the trajectory. Instead of travelling with its point in front, it oscillates, or wobbles, and thus may hit the target, not perpendicularly with its head, but obliquely, more or less crosswise: the surface hit is, therefore, larger."

There are six types of fracture by gunshot. These are: (1) Incomplete, (2) oblique, (3) transverse, (4) Y-shape, (5) butterfly, and (6) irregular forms.

The *incomplete form of fracture* is of two varieties: First, that form which occurs when the missile strikes a bone very obliquely, grooving the bone or chipping off a fragment from the side. This form of fracture is usually produced only when the bullet is travelling at quite low velocity. The second incomplete form of fracture appears when a small-calibre missile perforates a bone with short fissuring which does not extend to the sides. This incomplete fracture with perforation is most commonly seen toward the extremities of the shaft, particularly in the femur and tibia.

The *Y-shaped fracture* is produced under nearly the same conditions as is the incomplete fracture above described, except that the missile strikes the bone farther toward the median line and not only chips off a fragment, but causes a transverse crack across the shaft. This type of fracture is also usually produced only by small-calibre bullets travelling at comparatively low velocity.

The *oblique form of fracture* is by far the most common, and, even when the shaft of a long bone is badly comminuted, and when considerable displacement of some of the large fragments is produced, the main line of injury can often be seen to be oblique. This oblique form of fracture is the one most commonly seen in injuries by slow-moving lead bullets, such as those fired from revolvers. In these cases the bullet strikes the bone, flattens against it, or only partially penetrates it, but from the suddenly applied force the bone is broken obliquely.

The *X-shaped or "butterfly" fracture* is seen when the bullet strikes the middle of a bone at right angles, with sufficient force to perforate it, and the bullet makes a punched-out hole, from which the lines of the " X " radiate. In these cases the bullet not only has an expanding effect upon the bone, driving lateral fragments outward, but, if the missile is travelling at high velocity, great comminution of the bone in all directions may occur. It is this combination of median impact with high velocity which most frequently produces an explosive effect. The explosive effect may, however, be produced in the shaft of a bone (compact bone) by a modern jacketed missile travelling at very high velocity when it barely grazes it. This fact is due to the lateral transmission of the energy by the compact osseous tissue, and is a condition also observed in wounds of the cranium where the fragmentation of a skull bone may be great, although the bullet barely grazes it.

Transverse fractures of long bones are rarely seen, but may occur, generally under the same conditions that produce oblique fractures without comminution.

Irregular types are mostly seen as the result of missiles at high velocity producing explosive effect, or from the action of deformed bullets. When a high-velocity missile deforms and presents a mushroom head to compact osseous tissue, the impact of the missile is so great that the bone is broken into many fragments and a true explosive effect is produced. These wounds by deformed

missiles are often of a most severe character. The fragments produced are driven forward obliquely from the bullet's track, destroying the soft parts and producing a large wound of exit, sometimes several inches in diameter. This form of injury may be produced either by soft-nosed bullets intentionally made to deform, or by bullets deformed by ricochet but still travelling at very high velocity.

Comminution in Fractures.—The fragments into which compact bone may be reduced by bullets may be divided into three groups: Fine bone dust or débris, caused by direct impingement of the missile as it passes through the shaft; small splinters up to one inch in length; and the larger fragments due to the outward fissuring. The bone dust is produced by direct impact of the missile and is seen in all cases where the bullet passes through the bone. The smaller splinters are mainly proportionate in number to the velocity of the missile and the density of the bone. They are very numerous in explosive wounds, are much displaced, and are the principal cause of laceration of the soft parts. They are driven forward in the line of the bullet track or in directions radiating from it. They may in some instances be driven out through the wound of exit, as in one case of explosive fracture of the femur observed by the writer, in which the fragments were driven out through the exit wound in the thigh and into the second entrance wound in the calf of the leg.

Fractures of the Epiphyses of the Long Bones.—From the cancellous structure of the extremities of the long bone the osseous tissues of these parts less readily transmit the energy of the missile, and perforation, with little fragmentation and comminution, is the rule when the injury is produced by the small-calibre missile. It is in the extremities of the bones that the most cleanly cut perforations are seen, and, although the fracture may be complete, there are generally but one or two radiating fissures. The minimum amount of fragmentation is, of course, possible only in the epiphyses of such large bones as the femur, tibia, and head of the humerus. When the lower end of the humerus or the upper end of the radius or fibula is struck, or any of the smaller bones, the size of the bone relatively to the missile is such that simple perforation is not possible, and comminution is the rule. In the living subject fracture by a missile is more apt to be followed by fragmentation than in experimental cases. In experimental fractures in cadavers the missile alone produces injury, while in the living subjects the body weight is often thrown upon the bone in addition, producing lines of fracture not due to the missile.

With deformed missiles, comminution of the epiphyses is the rule. The large striking surface of the missile more than makes up for the non-resistant structure of the bone.

With slow-moving lead bullets of comparatively small calibre, such as those fired from revolvers, penetration of the epiphyses of the large bones, or grooving or guttering of their articular surface, is not uncommon, a fact of importance

in relation to the prognosis and treatment when such injuries are connected with wounds of the joint.

Fractures of Flat Bones.—In fractures of the flat bones, such as the scapula or pelvis, much depends upon the size of the missile. In the broad portions of the bone the missile may perforate, producing fragmentation or perforation not much greater than the area of the bullet. When the bullet strikes outlying portions, such as the coracoid or acromion processes, these may be completely shattered in the same way that the smaller bones are broken up, from their small size relatively to that of the missile. In the flat bones of the skull, on account of the density of these bones, considerable fragmentation is produced unless the missile be travelling at a very low velocity, when quite cleanly cut, punched-out holes are common.

The *diagnosis of gunshot fracture* is ordinarily not difficult. The most pronounced symptoms are the extreme mobility of the part, especially if the fracture be of an X or explosive variety. Then again, in this latter class of fracture there is little or no shortening of the limb. When the fracture is incomplete it is often of moment to determine whether or not the bullet has passed through the bone, for the incomplete fracture may so weaken the bone that, unless it is protected, complete fracture may result. The writer had under his observation a case of this sort in which a small-calibre missile passed through the upper portion of the shaft of the femur without producing a complete fracture, which was, however, soon afterward made complete through an attempt of the man to walk. Also, in complete fractures, where there is lateral displacement of bone fragments, the displaced fragments may give rise to trouble, and their presence should be determined in order that they may be removed.

Treatment of Gunshot Fractures.

One of the greatest advances in the treatment of gunshot fractures has been effected through the application of modern methods of asepsis and antisepsis, and, in the non-infected wounds, by non-interference. As quite a large percentage of bullet wounds are uninfected, the majority of fractures by gunshot may be treated in the same way as are simple fractures; for, while foreign material in small quantity or pathologic micro-organisms in small number may be carried into the wound or even down to the bone, these are often insufficient to overcome the natural resistance of the tissues, and inflammation or other pathologic processes do not follow. In fact, it may be stated that recognition of this uninfected nature of many gunshot fractures, and the application of the principles of non-interference, have been essential factors in saving limbs and lives after receipt of these injuries. In the old methods, every bullet wound was explored, generally with a dirty finger or probe, became infected, and all the evils incident to inflammation, suppuration, septicæmia, ostitis, osteomyelitis, and gangrene followed as a natural result.

With regard to gunshot fractures in general, it may now be stated that primary infection or non-infection of the wound rather than the amount of comminution is the factor which influences treatment. In an uninfected wound, even with
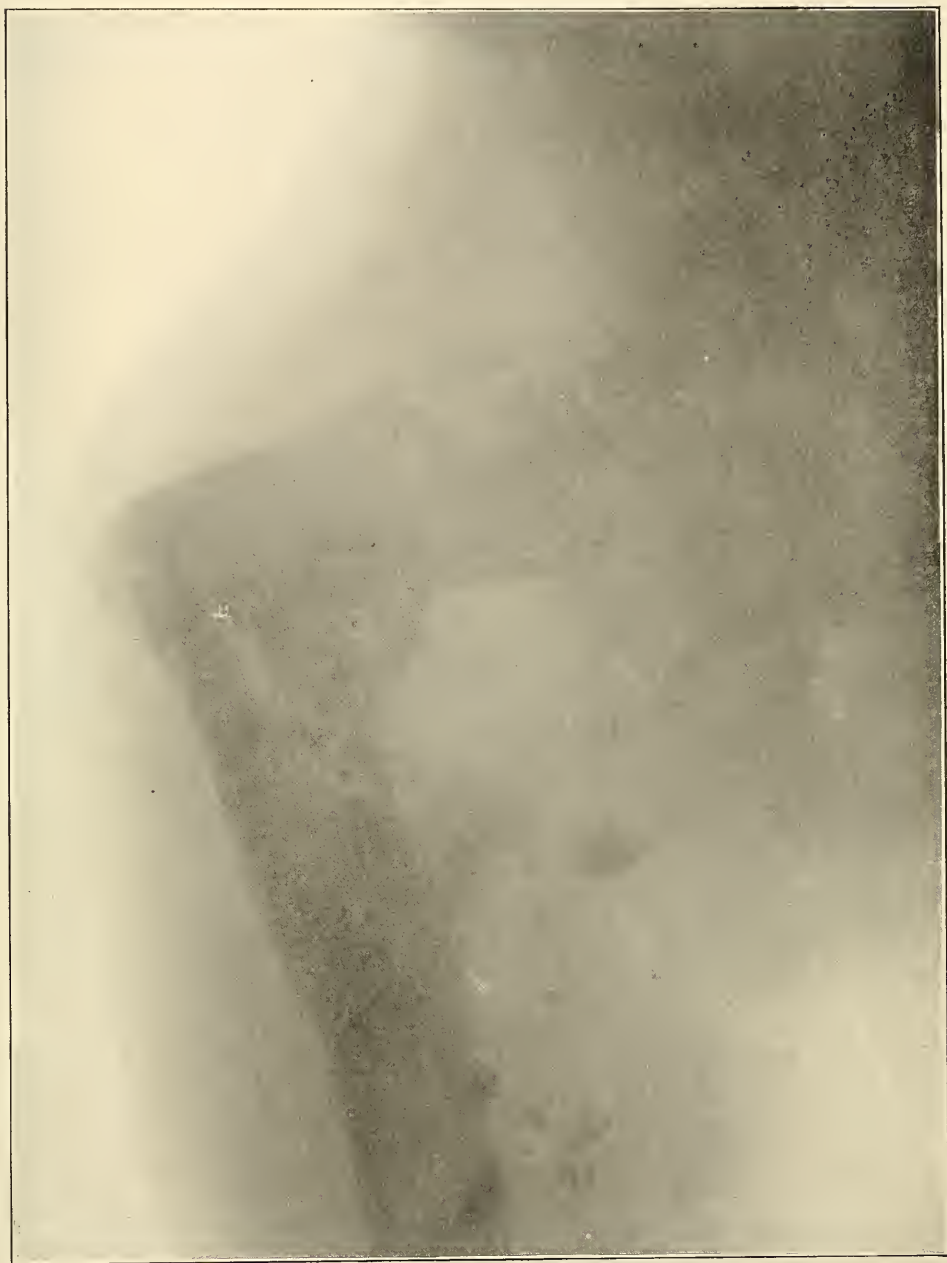
FIG. 208.—Skiagraph of Fracture of the Femur by a Half-Jacketed Remington Bullet, Showing Much Fragmentation of the Bone, Marked Displacement, and Many Large Pieces of the Bullet. The skiagraph was taken several months after the receipt of the injury. Chronic osteomyelitis had persisted; there were great deformity and shortening of the limb. Amputation at the hip joint; Senn's method of hæmostasis used; recovery. (Philippine insurrection.)

great comminution, immobilization of the limb and conservative treatment will ordinarily be all that is required.

When the displacement of bone fragments is so great as to make it impossible to bring the limb properly into position, or where the fragments press upon the vessels or nerves, or are so displaced that they will, if allowed to remain, impair the future function of the part, operative interference under antiseptic precautions should be instituted. The displaced fragments of bones which are still united with the periosteum should be put in place, wired there, if necessary, the free fragments removed, and the limb dressed after inserting a small drain, which, if the wound proves uninfected, can be removed at the end of forty-eight hours.

In infected wounds operation is always indicated. The part should be laid open down to the seat of the fracture, all loose fragments of bone removed, and the wound most carefully cleaned, in order to remove all foreign material. It should then be dressed, and free drainage provided, and, if the original operation has not removed all infection, frequent cleansing should be made in order to limit the infection and permit healing.

Unfortunately, in a certain number of cases of compound fracture by gunshot with infection these conservative measures are not followed by recovery. The long fissures in the bone opening the medullary cavity present excellent opportunities for the extension of infection, and, although by the use of antiseptic measures the infection may be kept more or less localized and septicæmia prevented, necrosis of the bone will occur, and suppuration, with all its debilitating effects and dangers, will persist. In such cases, a second operation, with complete cleaning out of the focus, may remove the trouble. In other cases the infection is so disseminated in the shaft of the bone that this procedure will prove unsuccessful, and amputation will then be required. It has been no uncommon experience of the writer's to see extensive pathologic conditions of the bone, such as above described, which have followed conservative, but too long continued, attempts to save the limb after infected gunshot fracture.

While conservatism is to be advocated, there is a possibility of carrying it too far, and it should never be persisted in when it is seen that the limb cannot be saved or when the patient's life is threatened.

GUNSHOT WOUNDS OF THE JOINTS.

Until recent years gunshot wounds of the large joints, such as the knee and hip, ranked next to those of the large body cavities in point of gravity.

Like the treatment of gunshot fractures, the treatment of gunshot wounds of the joints has been radically changed, and for the better. The credit for inaugurating this change is due to von Bergmann, whose brilliant results in the Russo-Turkish war with wounds of the knee joint, treated only by non-inter-

ference and immobilization, inaugurated a new era in the military surgical treatment of joint wounds, and has had an equally great effect upon their treatment in civil surgery.

In the battle of Gorne Dubrik, von Bergmann selected fifteen of the most serious cases of gunshot wound of the knee, in which, aside from the implication of the joint, there was extensive comminution of the bone, and treated them by immobilization and occlusive dressings. In these cases, recovery with movable joints resulted with but a single exception, where amputation had to be done and death followed. These results were obtained, notwithstanding the unfavorable conditions under which the patients were placed, for they were exposed to a pouring rain for days, and had to be transported across the country over rough and muddy roads. In the same war, of all other knee cases, treated by the older methods then in vogue, 95 per cent died. Previous to this time, the rule laid down for military surgeons was that gunshot wounds of the large joints demanded immediate amputation, except possibly in the case of the hip joint, where the results of the wound and the operation were about equally fatal.

The large joint cavities, when infected, gave rise to extensive suppuration, abscess formation, and cellulitis, which almost invariably caused death when conservatism was attempted, and, with this in view, primary amputation was common in pre-antiseptic days, and was the less dangerous method to adopt.

In military surgery the change from radical operation by amputation to conservatism, with the saving of both life and limb, has been made possible and successful by a combination of several factors. The principal of these are the recognition of the non-infection of many of the wounds made by small-calibre bullets, the maintenance of this non-infection by non-interference and occlusive dressings, and the ability given by antiseptic measures to limit and control infection when it occurs. Of less importance, but having a bearing upon the future use of the limb, is the fact that fractures of the articular ends of the large and long bones by small bullets are, as mentioned above, much less comminuted than those caused by the older and larger bullets, comminution except at quite short range being the exception, and, when it does occur, the fragmentation and displacement are generally slight. Resistance offered to the passage of the bullet by the cancellous structure of the large bone ends at the joints is so slight that the missile can expend but little of its energy, and, as a result, the injury is usually a grooved or cleanly punched-out tunnel. The same conditions are usually present in most of the wounds of the joints seen in civil life, where most of the injuries are made by comparatively small missiles having low velocity. In these cases the fragmentation of the bone by the bullet is ordinarily little, and the bullet, from its low velocity, is apt simply to plunge into the bone or lodge within the joint cavity.

When a bullet perforates a joint, the exit wound is seldom of greater diameter than the bullet, for the resistance of the spongy bone tissue is usually

insufficient to cause fragmentation of the bone, or to cause fragments of the bone to be driven out through the skin. When a wound is uninfected, anky-losis of the joint is the most serious result that follows. This can be rectified by operation at a late period if considered necessary, or the limb may be suffi-cient for more purposes in its ankylosed position.

Ankylosis is usually due to a displacement of fragments of the articular sur-faces which permits of more or less union of the opposite sides of the joint, and this latter is supplemented by the fibrous ankylosis which occurs in and around the joint in consequence of the impossibility of motion being employed during the treatment of the case. This result is more likely to follow injuries of the smaller than the larger joints, the elbow, ankle, and wrist being particularly liable to be so affected. The bones of these articulations are so small and brittle and are so closely articulated that even slight irregularities of the joint surfaces or dis-placement of the bones is apt to interfere with their normal motion.

That conservative treatment of joint wounds has been most successful is shown by Haga's statistics of the Japan-China war, and by those of the Spanish-American war, as compared with the statistics of the American Civil War and the Franco-Prussian war, as well as by the general experience of the surgeons in the Anglo-Boer war, although the statistics of this campaign have not yet been given.

PERCENTAGE MORTALITY FROM WOUNDS OF THE JOINTS IN FOUR WARS.

Joint.	American Civil War.	Franco-Prussian.	Japan-China (Haga).	Spanish-American (Regulars).
Hip	84.7	71.8	100.0	0.0
Knee	53.7	48.9	25.0	5.5
Ankle	26.9	24.0	0.0	0.0
Shoulder	31.1	35.5	0.0	0.0
Elbow	9.4	21.2	0.0	0.0
Wrist	12.9	12.6	0.0	0.0

In this connection the next table is also very valuable and interesting, as it shows that the deaths from joint injuries in two wars since the adoption of asep-tic and antiseptic methods and expectant treatment have all been from wounds of the larger joints.

The four deaths reported by Haga were from wounds of the hip and knee, and the single death from joint wound in the Spanish-American war, among the United States regulars, was due to a gunshot of the knee which was treated by amputation.

CASES AND DEATHS IN EACH CLASS OF JOINT WOUNDS IN TWO RECENT WARS.

Joint.	JAPAN-CHINA WAR (HAGA).		SPANISH-AMERICAN WAR (REGULARS).	
	Number.	Deaths.	Number.	Deaths.
Hip...........	1	1	0	0
Knee........	16	4	18	1
Ankle........	4	0	11	
Shoulder ...	4	0	3	
Elbow........	16	0	5	
Wrist........	6	0	6	
Total.....	47	5	43	1
Mortality, per cent....	....	10.6	......	2.3

Operation was done in but 2 cases of the 43 Spanish-American-war cases. These were both amputations: One for gunshot wound of the ankle joint, and an amputation of the thigh for gunshot wound of the knee joint, the latter amputation, as just noted, giving the only fatal result which followed gunshot wounds of the joints in the regular troops during the Spanish-American war.

In the Civil War, gunshot wounds of the knee joint, next to wounds of the skull, brain, spinal cord, and abdomen, gave the highest mortality of any class of wounds—approximately one-half of those wounded died;—while in Haga's 16 cases there were but 5 deaths, and in the American cases there is but 1 death in 18, and that followed operation. No stronger argument could be adduced for conservatism in the treatment of bullet wounds of the joints. The conditions present are very like those in penetrating abdominal wounds, for in each there is the probability that the wound is aseptic but that it will be made septic by operation, especially if the operation is attempted at a field hospital. The rule of conservatism should be as firmly adhered to in one case as in the other. In civil practice, with all the technique of asepsis, the surgeon may, when necessary, open a joint quite as fearlessly as he would the abdomen; but in military practice, in view of the high mortality from operation and the almost certainty of cure by conservatism, the military surgeon should open joints or amputate only when the life of the patient is in imminent danger. When the wound is made by a small bullet, the surgeon will be aided along conservative lines by the fact that small bullets, except at very short range, rarely fragment the articular ends of the bones to a marked extent. The bullet in many cases may pass through the joints and simply perforate or slightly fissure the bones. When this is considered in its relation to conservative treatment, it should be remembered that septic infection more frequently produces ankylosis and impaired function of a joint than does bone displacement, unless the displacement is marked, and that septic infection of a large joint is a great menace to life.

But in some cases operative interference will be demanded. This necessity will most ordinarily arise from extensive trauma from shells or deformed bul-

lets, or from infection of the wound. In such cases the operation which will best serve will have to be determined for each individual case, due weight being given to the fact that in a choice between excision and amputation some procedures have been found to apply best for wounds of certain parts. Thus, in general terms, it may be stated that where bone and tissue destruction is not too great, military surgical experience has shown that excision is to be preferred to amputation in all joints except the knee and ankle. With aseptic and antiseptic technique available, it is possible that more excellent results may be obtained in excision of these joints in the future than have been had in the past, but as yet a sufficient number of cases are not recorded from which to draw conclusions.

Joint wounds by deformed bullets are more serious than those by undeformed missiles in that the destruction of bone is greater and the liability of infection increased. Pieces of clothing and foreign material are much more liable to be driven into the joint cavity and give rise to inflammatory conditions of gravity, and the necessity for early operation in order to remove displaced fragments of bone and thereby lessen the probability of ankylosis is greater.

Lodged Bullets in Joints.—When a bullet has passed through a joint cavity and lodged in the bone, the condition does not differ from that of direct lodgment, the fact of the bullet having passed through the joint cavity having no bearing other than the possible infection of the joint or the displacement of bone fragments. The removal of the bullet in such a case is no more demanded than it would be if it lodged directly in the bone without involving the joint. When bullets lodge in the joint cavity, or in the articular surfaces of the bone, they may give rise to trouble from the pain produced when the joint is moved. These missiles almost always require extraction. The removal of a bullet from one of the large joint cavities is not always easy. Its exact location should be first determined by the use of the x-rays so that the operator may know exactly where to look for it. To open one of the large joints where a missile is lodged, and search for it before it has been definitely located, is most commonly followed by failure. In most cases the bullet will not be found free in the joint cavity, nor protruding from the articular surface, so that it may be felt. It is usually embedded in the head of a bone, where it can be neither seen nor touched. Localization by the x-rays is, therefore, of the greatest importance.

Wounds of the joints by shell fragments are much more serious injuries than are those from bullets, except in the case of very small shell fragments the wounds from which closely resemble those made by deformed bullets. When the wound is made by large fragments the joint is usually widely opened and invariably infected, and, in many cases, the destruction of the soft parts about the joint is so great that conservative treatment is contra-indicated or impossible.

Treatment of Gunshot Wounds of Joints.

This may be considered under the headings of conservative methods, excision, and amputation. The course to be adopted in each case will depend on four things: the presence or absence of infection; the degree of comminution of the bones; the amount of destruction of the soft parts about the joint; and the amount of interference with the blood and nerve supply to the limb below. Of all these conditions, the amount of destruction of the soft parts and interference with the blood and nerve supply are of immediate importance. When these are great, amputation is indicated. Cases of joint wound where the large vessels and nerves are severed, when treated conservatively with success, result only in an atrophied or paralyzed limb. Such conservatism is hardly advisable, and should be adopted only when there is a probability that the restoration of the limb may be had. Otherwise the surgeon risks the occurrence of gangrene, inflammation, and the possibilities of septicæmia, risks which are not warranted unless there is a reasonable surety that the patient's life will not be endangered and that the limb may be saved. Where the wound is by a shell fragment, and the joint cavity has been freely opened and infected, the treatment will be either by amputation or by antiseptic dressing and drainage. The treatment in each case must depend upon the character of the wound and the facilities which the surgeon has at hand. The same may be said of wounds made by deformed bullets where the bone ends are extensively comminuted and there is a large ragged wound of exit.

Excision.—Primary excision is a systematic operative procedure which will rarely be indicated. Where the bones are so extensively comminuted that excision may be thought of, the joint may also be greatly infected. In cases where the infection can be controlled and the displaced fragments are likely to produce ankylosis, their removal will be required.

Conservative Treatment.—Conservative methods are now most commonly used and are most to be recommended in military surgery. Many of the reasons for this have been set forth in the discussion on the character of joint wounds, the full reasons being that, as many of these wounds are uninfected, and as the military surgeon at the front rarely has facilities for aseptic technique, it is better for him to await developments than to open a joint with a practical certainty of infecting it. In civil surgery quite different conditions usually obtain. The civil surgeon, with the facilities of a civil hospital and control of aseptic technique, can quite as safely enter a joint cavity as that of the abdomen; and exploration of joint wounds under suitable conditions, and for proper reasons, should be the rule in civil surgery. By following this rule the surgeon is enabled at once to remove loose fragments of bone and foreign material which have been carried into the joint cavity. Under ordinary conditions, however, this treatment should not be instituted until an *x*-ray examination has been made of

the joint. In every wound which appears to implicate a joint, a careful pre-operative x-ray examination should be the rule. The bullet may have missed the joint entirely, or, if it has passed through it, it may have produced no frag-mentation or displacement of bone. In such cases, and where the wound is apparently not infected, the surgeon may resort to tentative conservatism, watching the case carefully and being ready to operate at the very first symp-toms of infective inflammation. Such delay will rarely be followed by any ill results if the joint is opened immediately upon the appearance of inflamma-tion and then irrigated thoroughly with antiseptic care and drained afterward.

It should be pointed out that conservative treatment of joint wounds does not by any means mean non-interference. Conservative treatment means treatment directed toward saving the limb and the function of the joint. It really, therefore, includes aseptic operative opening of the joint, the removal of loose bone, lodged missiles, foreign material, and, when necessary, antiseptic cleansing and drainage.

The civil surgeon who should practise non-interference and should base his practice upon the data obtained from the surgery of joint wounds in military prac-tice might err as widely as would the military surgeon were he to practise in war the methods of action permissible in civil life.

Lodged Missiles.—Bullets of low velocity, such as are fired from revolvers of small calibre, shrapnel bullets, and fragments of shell are very apt to lodge in the tissues. From the low velocity of these missiles, they are easily stopped by impact against bone or even the denser soft parts. Similarly, they are readily deflected from their course. With the modern jacketed bullets, travelling at high velocity, lodgment is much less common and rarely occurs unless the velocity of the missile has been much reduced by long range or ricochet. Unlike lead bullets of low velocity, these bullets are seldom deflected from a straight course, even by bone, and, as a result, while slow-moving bullets frequently take a devious course in the body, the jacketed missiles, unless deformed, usually make a straight track.

As regards *infection* in cases of lodgment, it would seem that bullets trav-elling with such low velocity as to be stopped in the tissues would very likely carry foreign material, shreds of clothing, etc., into the wound and so infect it. Experience has shown, however, that this is not true to any particular extent with undeformed bullets. Deformation of the missile or the irregular shape and large size of shell fragments produce a large wound of entrance, into which infec-tion is more readily carried, and these, rather than low velocity, are important factors in producing suppuration. This is of clinical importance, for the mere fact of lodgment does not prove infection nor determine the necessity for operation.

Treatment of Lodged Missiles.—It is well known that large missiles often become encysted in the tissues and cause no trouble. In other cases they pro-duce trouble by inducing suppuration or cause pain or neuritis by pressure upon

a nerve, or interference with motion by implicating a joint. Also, knowledge of their presence sometimes gives rise to mental disquietude, even though the bullet is doing no harm. In consequence, the questions for the surgeon to determine are: (*a*) Whether or not to operate for the removal of the foreign body, and (*b*) when the operation should be done. In reply to the first question, the answer is that a lodged missile should always be removed when it is producing distressing or dangerous symptoms, if its removal is possible and does not endanger life or necessitate operative traumatisms which will produce effects more serious than will arise from allowing the missile to remain *in situ.* It would be manifestly improper to allow a missile which is doing harm to remain in the tissues, providing it could be removed with safety to the patient; and, equally, it would be unsurgical to remove, or attempt to remove, a missile when the operation would be more immediately dangerous or entail greater future dangers or discomforts to the patient than would the presence of the foreign body.

In reply to the second question—as to when a lodged missile should be removed—the answer is that a lodged missile should not be removed except when aseptic technique is available, unless the danger arising from its presence is greater than that likely to follow operating under septic conditions. If infection occurs, recovery of the patient is delayed, and, even if no other serious results supervene, the functions of the wounded part are apt to be impaired in consequence of the cicatricial formations which result. Probably no single measure in the past did so much to increase the gravity of gunshot wounds as the immediate search for and removal of bullets through the wound.

The probing of bullet wounds should be entirely abandoned except in cases of urgent necessity. Recent experience has shown that most bullet wounds, even those made by large bullets, will generally heal without inflammation or suppuration if left alone. When it is necessary to search for a bullet the operation should be conducted under conditions of rigid asepsis. But even then it must be remembered that inflammation may be set up. La Garde and others have shown that, while bullets in original packages are usually sterile, this is not the case after they have been handled, and that firing infected bullets does not sterilize them. Also, Hobart, Delorme, and Taulhauber have shown that in wounds made by the small-calibre bullet minute particles of woollen, cotton, or linen fibre are carried in from the clothing. All bullet wounds, therefore, may be looked upon as contaminated, but not infected to an extent sufficient to cause inflammation; the natural resistance of the tissues usually being sufficient to overcome the few micro-organisms introduced.

No sooner is a traumatism inflicted than natural processes are brought into action for protection and repair. There is a local increase in vascular activity, serum is poured out, leucocytes accumulate, and the defensive factors of phagocytosis and the bactericidal action of the serum are brought into play. That

these factors may have the best opportunity for action, rest and non-disturbance of the tissues are necessary. Mechanical disturbance of the tissues by probes, by the finger, or by instruments will produce fresh trauma and cause disturbance of the defensive action going on, and trauma and disturbance, however slight, will favor growth of the bacteria and add to the difficulty of the defensive labor required of the tissues. Even aseptic or antiseptic operative or explorative interference may throw the scale on the side of the invading bacteria and lead to troublesome or disastrous consequences. For these reasons, and in consideration of the unreliability and danger of searching for a bullet through the wound (where no x-ray apparatus is available), it may be stated that searching is contra-indicated except in cases where the immediate danger from the presence of the bullet is greater than the possible consequences which may arise from the interference.

When a probe is to be used the strictest precautions should be observed and its limitations have to be borne in mind. In many cases it is impossible to locate the missile by the use of a probe introduced into the wound. With the probe it is possible to follow only a minority of bullet tracks. The contractility of the tissues and a change of position on the part of the patient may cause such shifting of the muscles and the fascial structures as completely to obstruct the path of the projectile.

In many cases where the lodged missile has been located by the x-rays, it has been clearly shown that it would have been impossible to have detected the missile with a probe. Not only is it difficult to follow the path of a bullet with a probe, but, even in doing so, assurance that the missile is touched by the probe is often impossible. The nickel-steel jacket of the modern bullet leaves no mark upon the porcelain tip of the Nélaton probe, and the sensation of contact as differentiated between the missile and fibrous tissue or bone is not sufficiently different to enable the examiner to determine that the probe is in apposition with the missile. This has been remarked upon by Treves who points out the fact that the telephonic probe overcomes this difficulty, and states that he has used it to advantage in such cases with the wounded of the Anglo-Boer war. The telephonic probe must have, however, an extremely limited use, for it is open to the same objections as the ordinary instrument, viz., the difficulty of passing it through the bullet track, the possibility of injuring the tissues, and the likelihood of introducing infection.

All the difficulties and dangers incident to the use of the probe are obviated by the use of the x-rays. This method of locating lodged missiles should always be employed whenever an apparatus is available. The great value in the use of the x-rays is that they make possible the localization and removal of lodged missiles without interference with the original wound. By them a missile may be accurately located, and, its place of lodgment being known, it may be removed through an incision carried in through the safest anatomical course.

With the powerful x-ray tubes now used, the discovery of lodged missiles is usually easy, and fluoroscopic or photographic methods, supplemented when necessary by some form of localizing apparatus, will determine their exact position.

For removing bullets, many kinds of bullet forceps have been designed, most of them to the end that they may be introduced into the bullet track itself or through a small wound. Of these the one devised by Senn is as good as any, but in actual practice the best result, except in operating in special organs, such as the brain, is obtained by making an incision sufficiently large to explore for the missile with the protected finger, and, when found, it can be readily removed with any toothed forceps. Following this, the wound may be closed without drainage, unless evidence of infection is present.

THE INFECTION OF GUNSHOT WOUNDS.

The infection or non-infection of a gunshot wound is of such primary importance relatively to both the prognosis of the case and its treatment that the determining factors of these conditions should be carefully considered. These factors relate both to the missile itself, its size, velocity, and shape, and to the conditions incident to the individual wounded, such as the degree of cleanliness of the skin and the condition of the overlying clothing. La Garde and others have definitely shown that infection of the bullet itself can be conveyed to the wound which it makes. It was formerly thought that the heat generated in the weapon at the time of firing might, or probably would, sterilize the missile, but this has been proven not to be the case. Equally, it has been shown that the majority of cartridges in their original packages are sterile and free from septic germs. The sterile condition of the cartridges is due to the disinfection and cleanliness observed in the process of manufacture. A sterile condition, however, is done away with when the cartridges are carried in the pocket or in a cartridge belt, and, under these conditions, the bullets may become contaminated with pyogenic micro-organisms or the bacilli of tetanus or other pathogenic germs. It has also been proven that the act of firing, from the heat and friction generated, will partially, but may not entirely, destroy the micro-organisms by which the bullet may be contaminated. Fortunately, however, in the majority of cases, the bullet originally is so little contaminated that the act of firing sufficiently sterilizes it, and, although it may carry some few micro-organisms into the tissue, the natural resistance of the body is sufficient to overcome them. On the other hand, the bullet may, from handling or otherwise, become so contaminated that the act of firing does not sufficiently sterilize it, or it may, by ricochet contact with dirty objects, become contaminated, while in flight before it strikes the body, sufficiently to cause the characteristic pathologic reactions attending infection.

High velocity in the case of uncontaminated bullets appears to favor non-infection of the wound. Undeformed bullets impressed with a high rate of velocity appear to pass through the clothing and the skin so cleanly that deleterious material does not readily adhere to them, and is therefore not usually carried into the wound. With a lower velocity such adhesion or in-pushing is much more apt to occur.

The *size* of the missile is of importance, and the general rule is that the larger the missile the more apt the wound is to be infected. With a large missile more foreign material is liable to be carried into the wound, and, the entrance and exit wounds being large, the liability to secondary infection from the entrance of foreign material after the injury has been received is considerable. In fact, the size of the wound bears a direct ratio to its liability to infection.

The *shape* of the missile also has a distinct bearing upon the question of infection. The cylindro-conoidal shape and oval head of the modern jacketed bullet allow it to penetrate objects easily, and, with its high velocity, cause it to enter the body so quickly that it is little prone to carry deleterious materials into the wound. When it is deformed, however, it then presents a broad, irregular face, which is much more apt to drive foreign material into the wound, and, if it has sufficient velocity to perforate the part, it produces a large jagged wound of exit into which secondary infection is very liable to find its way. If the deformation is due to ricochet, the bullet is very apt to take up material from the place of impact and may carry it into the wound. The irregular shape, as well as the generally large size of shell fragments, is an important factor in determining infection in shell wounds. As before noted, very small shell fragments may be driven into the body and produce no infection, but with large fragments this rarely occurs, particularly as they are very apt to carry pieces of clothing or other foreign material into the tissues.

From unjacketed bullets, either the oblong lead bullets fired from revolvers or the round lead bullets thrown from exploding shrapnel, infection is more apt to occur than from the undeformed jacketed missiles. The surface of these bullets is rough, dirt can accumulate in the roughened surface, and their lack of smoothness makes them more capable of carrying infection into the wound. At the same time, the small size of many of the revolver bullets by which wounds are produced in civil life, and as, from the shortness of the range at which the wounds are usually received, the bullets strike the body at comparatively high velocity, these missiles are apt to pass through the clothing and enter the body without becoming deformed, and consequently frequently produce uninfected wounds.

The *condition of the skin* has an important bearing upon infection. Where the skin is clean, the wound is much less apt to be infected, but wounds received through the hairy scalp and wounds of the hands and feet are little likely to escape contamination.

The condition of the clothing has to be considered, not only by itself, but in connection with the condition of the skin. When the bullet passes through clothing of any sort, experiments have definitely determined that minute particles of clothing are driven into the tissues in every case, this occurring even with the small-calibre, jacketed bullet. In wounds from small, high-velocity missiles the particles of clothing carried into the wound are microscopic in size, and, if these are reasonably clean, infection of the wound does not result.

The *character of the clothing*, as well as its degree of cleanliness, has a bearing upon infection. If the clothing be of cotton, holes made by bullets are ordinarily slit-like and a minimum amount of material is carried into the wound. If the clothing be of wool, the holes in the clothing are of a punched-out appearance and a greater amount of the clothing is indriven. The thickness of the overlying clothing, together with its condition, is also important. A reasonably clean skin, with comparatively thin and clean clothing, does not favor infection, while a dirty skin and thick and soiled clothing distinctly favor infection of the wound. This has been noted with regard to the infection of bullet wounds in the Russian army in the late war with Japan. Hoff states that in the summer, when the men were able to bathe and wore comparatively light clothing, the large majority of the bullet wounds were uninfected, while in winter, the men not being able to bathe, and wearing heavy woollen clothing or sheepskin coats, the body and clothing became very dirty, with the result that nearly all wounds, even those made by the small-calibre, jacketed missile, were infected. All of these factors are of importance to a surgeon in arriving at a conclusion as to whether a given bullet wound is infected or not. The appearance of the entrance and exit wounds will help to determine the character of the missile. If these be small, the missile is probably small in calibre, and, if the skin is reasonably clean and the overlying clothing thin and clean, the probability of the wound being uninfected is vastly greater than if the opposite conditions obtain.

The micro-organisms which produce infection in gunshot wounds are most commonly the staphylococci, less frequently the streptococci, and still less frequently the tetanus bacilli or some other of the pathogenic or saprophytic micro-organisms.

Staphylococcus infection is the most common, for the reason that this pathogenic micro-organism is the germ most commonly found on the skin or in the clothing. As a result of infection by this germ, localized inflammation and abscess formation are the rule; but, under conditions of delay or neglect in treatment, severe inflammatory extensions, leading to loss of life or limb, will result. In the older surgery, before the days of antiseptic surgery, such extension of inflammatory action was common and was the frequent cause of metastatic abscesses, pyæmia, and local sloughing or gangrene.

When streptococcus infection occurs, the case is more likely to go on to diffuse

inflammation, with marked involvement of the lymphatics, systemic toxæmia, and the other pathologic conditions grouped under the general term Septicæmia.

Mixed infections by the staphylococcus and streptococcus are not uncommon, and in these cases the pathologic effects of both germs present themselves.

In wounds involving the intestinal tract the Bacillus coli communis is generally the germ which most predominates in producing infection, and the presence of this micro-organism, either alone or with the staphylococcus or the streptococcus, is to be expected as the causative agent in the inflammatory conditions which result.

Rarely, the bacillus of malignant œdema may be introduced into a gunshot wound. When this occurs, the case usually goes on to a rapidly fatal termination. The progress of the infection in malignant œdema is exceedingly rapid, and the depressing effects of the resulting toxæmia are so great that the patient rapidly succumbs.

The occurrence of *tetanus* following gunshot injury has been noted by all observers of gunshot wounds; and that infection by the tetanus bacillus should take place in gunshot injury would logically be expected.

The fact that the tetanus bacillus is anaërobic and grows only in the absence of oxygen, together with the deep punctured character of gunshot wounds, whereby the bacillus may be carried deeply into the tissues from which air is excluded, thus in every way favoring its growth, combines all conditions necessary to the development of this particular germ. Also, the fact that gunshot wounds are often made through clothing or skin soiled with loam, which is the natural habitat of this bacillus, further favors the direct infection of the wound by it.

The occurrence of tetanus from wounds from toy pistols has already been discussed, and the necessity for the thorough cleansing and drainage of these wounds has been pointed out. Probably both in civil and in military surgery the number of cases of tetanus following gunshot injuries will be much smaller in the future than in the past, due both to the fact that the small-calibre missiles now used are not so likely to carry infection into the wound, and to the non-likelihood of wounds being secondarily infected by the surgeon. In the American Civil War 505 cases of tetanus occurred in 246,712 wounded, or 0.20 per cent. In the Spanish-American war but one case of tetanus was reported: this after gunshot wound of the forearm. Stevenson, in the addition to his "Wounds in War," written subsequently to the Anglo-Boer war, made no mention of tetanus as having occurred in the South African campaign, and Makins mentions but one case. The treatment of tetanus following gunshot injury is the same as that laid down for tetanus following other traumas, and the reader is referred to the discussion on tetanus in Volume I of this work.

In considering infection in gunshot wounds, the utmost importance is to be placed upon the measures by which secondary infection may be prevented.

Undoubtedly, in the practice of the older surgery, secondary infection through operation was not uncommon, the surgeons then not realizing the necessity for even gross cleanliness. Under ordinary modern surgical methods such secondary infection is not at all likely to take place. Direct infection of a gunshot wound having occurred, the surgeon can exercise his skill only toward removing it or limiting it, but in a non-infected wound every effort should be made to prevent the entrance of pathogenic micro-organisms. The means of such prevention will be discussed later, under the head of General Treatment of Gunshot Wounds.

SYMPTOMS OF GUNSHOT INJURY.

These are pain, primary hemorrhage, shock, and thirst, together with the local conditions which obtain at the seat of the injury.

The amount of *pain* which follows the infliction of a gunshot wound generally varies with the kind of missile by which it has been inflicted, together with the kind and location of the injury, and the condition of mind of the person hit. When the wound is by a projectile of considerable size, the shock of impact is so great that pain is usually deadened, either by annihilation of function and sensation of the part wounded or by the state of stupor into which the shock throws the patient—such cases occurring from wounds inflicted by unbroken or large-calibre projectiles or large fragments of shell. In bullet wounds the amount of pain varies largely according to whether the injury is to a fleshy part only or whether a bone be struck. In wounds of a fleshy part, unless the missile is deformed, the pain is usually not very severe, nor is it of a lasting character unless a nerve be involved or pressed upon by a lodged missile.

When gunshot fracture occurs, the pain is much more severe, the original pain being like that due to a blow from a heavy iron bar; the after-pain, if the part is kept quiet, being no greater than that following any ordinary fracture. When the skull is struck by a missile, or the brain entered, unconsciousness almost always immediately results, with a longer or shorter period of coma and stupor, later followed by photophobia, severe headache, strabismus, and other general or local symptoms of disturbed nerve function.

The *shock* which follows gunshot injury is frequently complicated by the symptoms of hemorrhage, and it is often difficult to determine whether the patient is prostrated by shock alone or by it combined with the result of the outflow of blood. In determining which of these two conditions exists, the surgeon may be guided by the fact that shock immediately follows the receipt of the injury, while in hemorrhage, unless a very large vessel is wounded, the symptoms do not occur until some little time has passed.

When a large bone is suddenly shattered, a body cavity opened, an important

organ wounded, a part of the body struck by a heavy fragment of shell, or a limb carried off by a shot, the amount of shock is great. The person wounded trembles, totters, falls, is pale, faint, and perhaps vomits; the surface of the body loses its natural warmth, the features exhibit the vacancy of stupor and more or less anxiety; the circulation is weak and fluttering, and the respiration is feeble and shallow. This prostration of the person wounded, and which is due to shock, may be directly carried over into, or carried on coincidentally with, the symptoms of hemorrhage. If hemorrhage does not occur, the symptoms of shock disappear more or less rapidly, according to the severity of the injury, its location, and the general condition of the patient. As the shock disappears, the pulse gradually resumes its regularity the pallor gives place to a more nearly normal color, the mind gradually regains its power, and the general symptoms of prostration give place to a more or less normal condition of the body.

The effect of shock on hemorrhage is generally more or less favorable in that the lessened impulse of the heart's action and the prone position of the person injured favor the cessation of the bleeding. When shock is recovered from, hemorrhage may return in volume, and the surgeon, bearing this in mind, should adopt preventive measures at the same time that he institutes those for the relief of the shock.

In severe shock measures for relief should be at once undertaken. Even in a transverse wound completely severing an artery the size of the common carotid, it takes at least five minutes to produce death from hemorrhage; while in intense shock, symptoms of fatal collapse may appear almost immediately. The patient should be placed in a dorsal recumbent position and treated by stimulants and the application of heat; inhalations of amyl nitrite, hypodermic injections of strychnine in doses of one-fifteenth to one-twentieth of a grain every half-hour, and internal administrations of alcoholic stimulants where the stomach is not wounded, and of camphor and ammonia, are indicated.

Patients reviving from shock should not be transported until signs of safe reaction have occurred, and no operation of any importance should be performed until the patient has completely recovered from the immediate effects of the injury.

Hemorrhage, as a symptom, may either appear as a bleeding from the external wound or may be evidenced by the constitutional symptoms of internal hemorrhage. These signs will differ with the rapidity of the bleeding and will determine in part the gravity of the case. The loss of blood under high pressure from the large vessels near the heart or brain is evidenced by alarming symptoms. The loss of a pint of blood in two or three minutes produces more distinctive symptoms than the loss of three times that amount by gradual oozing. When a large vessel is wounded, acute cerebral anæmia is produced, characterized by deadly pallor of the face, cold extremities, dilated pupils, small and rapid pulse, and shallow and rapid respiration, interrupted by yawns or deep sighs.

If the loss of blood is more gradual, the pupils become widely dilated, the face and lips assume a wax-like appearance, the pulse is small and faltering, the breathing is shallow and irregular, with yawns and sighs indicating "air hunger," the surface of the body is cold, and the forehead is bathed in clammy perspiration. Where the hemorrhage is gradual, vomiting and distressing thirst are prominent symptoms. The patient is restless, complains of a roaring noise in the ears, and the pulse is rapid and weak. In considering each case, the surgeon must determine both from the location of the wound as showing the vessel prominently injured, and from the gravity of the symptoms, how severe and dangerous the hemorrhage is. Severe hemorrhage combined with pronounced shock is most difficult of treatment, and most severely taxes the surgeon's skill. If the danger from the hemorrhage is imminent, immediate operation to secure the bleeding vessel must be done even before recovery from shock occurs, the operative procedure being accompanied by efforts to support and revive the patient by the use of heart and cerebral stimulants and by the hypodermatic or intravenous use of normal salt solution to give the heart fluid on which to act. (See article on Surgical Shock, Vol. I, p. 463.)

Thirst, as a symptom of gunshot injury, is almost invariably presented, and may be well marked whether hemorrhage occurs or not, but is more pronounced with the latter. It is a symptom that may be very distressing to the person wounded.

GENERAL TREATMENT OF GUNSHOT WOUNDS.

The treatment of gunshot wounds divides itself into the immediate and the more remote treatment. When the gunshot wound is received, measures looking to the immediate relief of the patient, the treatment of shock or hemorrhage, if they be present, and suitable protection of the wound and wounded part, are the surgeon's first care. The remote treatment consists in those operative or other measures which may be instituted to prevent disability or save the life of the person injured after the conditions which call for immediate attention have been attended to.

The Immediate Treatment of Gunshot Wounds.—The treatment of shock and hemorrhage is given above, and, with these conditions, which directly and immediately affect the life of the individual wounded, attended to, the next most important consideration is the care of the wound. So much has this been emphasized that Volkmann has stated, "The fate of the wounded rests in the hands of the one who applies the first dressing." While this bold statement can hardly be taken as authoritative in its fullest sense, it is true within limits and is an aphorism which a surgeon in treating gunshot injuries should always remember. As before stated, in the older surgery the fate of the wounded

was too often settled, and that for the worse, by the exploration of the wounds with unclean fingers and probes and the application of septic dressings. Manipulation of a gunshot wound *under conditions other than those of asepsis, unless it be to rescue the individual, is absolutely to be condemned, for such interference runs directly counter to the restorative and reparative actions of the tissues.* This is particularly true in non-infected wound by bullets. Upon the receipt of such an injury, there forms in the small skin wound a blood clot which quickly dries up, producing a dried blood crust. This dried blood crust is nature's occlusive dressing. It forms a shield that opposes the entrance of foreign material and micro-organisms, and protects the underlying tissues, so that they may go on to repair with a minimum amount of interference. Wounds so protected by nature should never be disturbed by a surgeon except where conditions are present which demand it. The first-aid packet used in war, and the dressings used in civil surgery, if applied to these wounds, have their greatest use in the protection which they afford. Bertelsmann, during his service in the South African war, observed that the dry air had a good effect in causing a speedy desiccation of the blood in the opening of a wound and around it. The ideal first dressing is one which will further this process. Dryness of the wound by the removal of all secretion lessens the liability to bacterial invasion. Bacteria do not multiply in a dry medium, and nature's dry blood clot and the surgeon's application of an absorbent dressing are the important factors in preventing secondary infection of the wound.

When the wound underlies the clothing, the overlying material should be at once cut away, exposing the part to the air and thus allowing the blood to dry in the opening of the wound as soon as possible. If sterile water is available, it may perhaps be advisable carefully and gently to clean the wound superficially and the surrounding skin; then the parts should be dried and an absorbent dressing applied. But under no conditions should ordinary water be used for this purpose. It is far better to expose the wound to the air and apply dressings than to attempt any cleansing of the wound except by aseptic technique.

Schimmelbusch's statement relative to possible infection by water and air is here important. He states that investigation in the von Bergmann clinic proved that in the operating-room, with auditorium occupied, the number of bacteria which settle upon the surface of a wound a square decimetre in extent, in the course of half an hour, is about 60 to 70. The Spree River flows past the clinic, and the water of this river has an average number of 37,525 bacteria to the cubic centimetre. He states: "The individual coming to the clinic, with a wound open and undisturbed, although exposed to the action of the air, would receive, upon the surface of this wound, in the lapse of one-half hour before application of the dressing, at most from 60 to 70 germs which are scattered only loosely and very superficially over the blood clots. If, in accordance with the usual cus-

tom, the wound should now be irrigated slowly and thoroughly with a litre of Spree water, for the purpose of '*cleansing*,' we may readily estimate that over 37 million micro-organisms would be brought in contact with it, and all efforts at numerical calculation are defeated when, in addition, the part is wrapped in a dirty cloth, to which are usually adherent masses of decomposed material rich in bacteria."

It appears, then, that aseptic cleansing may be allowed, or, this not being possible, exposure to the air and immediate application of a suitable dry and absorbent dressing are indicated.

The first dressing is so important that it should be well adapted to the particular conditions which present themselves in gunshot injuries. To prevent invasion of pathogenic micro-organisms and to inhibit their growth if they be present, are the main considerations. That nature may form a dry scab over the wound and that the wound may be kept dry thereafter require absorbent material in direct contact with the wound. The material which best meets the requirements is gauze, either aseptic or impregnated with some antiseptic.

Various antiseptics have been advised, but there appears to be no ideal one that may be employed for the purpose. The antiseptic should be both efficient and durable. Carbolic acid is volatile; iodoform does not possess any decided antiseptic properties, and its persistent odor may be a serious objection. Its use has been sanctioned by the highest authorities, however, including von Bergmann, Fraenkel, Pfuhl, and others. Iodoform liberates iodine, but for a comparatively short time, and then becomes inert, as far as its bactericidal action is concerned. Citrate of silver, salicylic acid, and boric acid have all been advocated. Senn has recommended a combination of salicylic and boric acids in the proportion of four to one. He claims for this powder that it does not irritate the skin, that it is non-toxic, odorless, and retains antiseptic properties for an indefinite period of time. The use of such a powder as a part of the first dressing may be possible in civil surgery, but its bulk and the difficulty of applying it do not render it practical in military practice. In using powders directly upon the wound, care should be taken that they do not form an impenetrable crust and obstruct the discharge.

Probably the best preparation of gauze for military surgery so far arrived at is that made mildly antiseptic with bichloride of mercury. It is true that bichloride of mercury is an unstable compound, but if the gauze impregnated with it is wrapped in waxed paper, as in the first-aid packets, it will retain for some time its mild antiseptic quality and its general effectiveness. One of the main functions of the overlying gauze is to absorb all secretions and keep the wound dry. Outside the absorbent gauze, a layer of cotton should be placed to exclude bacteria and to assist in protecting the wound, and over all a bandage should then be applied.

Primary occlusive dressings, made by applying over the absorbent material

an impermeable dressing of gutta-percha tissue, oiled silk, collodion, or other impervious substance, are by all means to be avoided. The exclusion of atmospheric air from the dressing prevents evaporation of the wound secretions, maintains heat and moisture under the dressing, and thus creates a condition most favorable to the growth of pathogenic micro-organisms. The dressing material should always be dry and should remain so, for this favors the desiccation of the blood and the formation of a dry crust in which bacteria do not readily grow.

The First-aid Packet.

In military practice in the field, the first-aid packet is to be used for the primary dressing of wounds. The first-aid packet for the dressing of bullet wounds is now supplied to the soldiers of all civilized countries. The packets are about the size convenient to be carried by each soldier.

The British packet is one and one-fourth by two and one-half by five inches and contains a wool pad, a square piece of gauze, and a piece of waterproof, together with bandage and pins for holding it in place. It is covered by a piece of gray muslin upon which a paper label, containing instructions, is pasted.

The Spanish dressing is one and three-eighths by two and three-fourths by five inches. It is covered by a firm gray drilling and its label is printed upon paper pasted upon the outside. Its contents consist of two pledgets of styptic cotton, each about one inch and a half in diameter and one-fourth inch in thickness, a compress of cotton and gauze, a piece of protective, a two-inch gauze bandage, and a triangular bandage of the usual form, together with safety pins. These are placed between two bits of bristol board and wrapped in a piece of oiled paper, upon which is pasted a label containing the instructions for use of the elements of the packet, and the whole wrapped again in the outside cover.

The American packets of the latest form are of two kinds: The larger, for shell wounds, is one and one-eighth by two and one-fourth by four and one-fourth inches; and the smaller, for bullet wounds, one and one-fourth by two and three-eighths by three and five-eighths inches. Both contain the same constitutents, viz., two antiseptic compresses of sublimated gauze in waxed or oiled paper, one antiseptic bandage of sublimated gauze with safety pin, and one triangular bandage, with illustrations of the methods of application and a safety pin. The cover is a piece of rubber sheeting with the cloth side out, upon which is printed the list of contents and the directions for use. Before wrapping, the elements of the packet are compressed by hydraulic pressure and, after the application of the cover, the packet is sealed with cement as tightly as possible and dipped in varnish. It is then hung in a hot oven to dry, and this process is repeated daily for from six to ten days until the coating is from one sixty-fourth to one thirty-second of an inch thick.

The Russian packet measures three and three-fourths by two and one-eighth by one and one-sixteenth inches, and consists of two strips of absorbent cotton, each enclosed in a fold of gauze, a short gauze bandage, and a safety pin, the whole enclosed in a cover of rubber cloth.

The Japanese packet for bullet wounds measures two by three and three-fourths by one inch. It contains three compresses of bichlorided gauze, tightly folded and enclosed in waxed paper, a triangular bandage, and two safety pins, the whole enclosed in a cover of rubber cloth.

All of these first-aid dressings are practically of about the same utility. They are all absorbent and protective, thereby meeting the main conditions requisite to the proper first-aid dressing of gunshot wounds.

Where the gunshot wound is lacerated or of large size, from having been made by a deformed missile or a fragment of shell, the first care of the wounded is not materially different from that above given for bullet wounds.

The absorbent dressing should be large enough to cover completely the surface of the wound, and, if the wound be deep and lacerated, the dressing should be loosely packed into it, to insure drainage and dryness of the wound's surface until secondary methods of treatment can be instituted. Large wounds, if dressed in this way, may be left undisturbed for days, provided that the gauze is of sufficient quantity to absorb the blood and secretions of the wound and is protected from outside contamination by overlying cotton. In military surgery, the fact that large wounds, lacerated and undoubtedly infected, can be packed with gauze and be left undisturbed for a considerable period of time without danger to the person wounded is a matter of much importance. Operative interference with wounds on the firing line or at the first stations of assistance can rarely be effectively done in battle, and it is fortunate that, with absorbent dressings properly placed, the person wounded can be transported for some distance and the secondary treatment deferred until he arrives at a field or base hospital where there are suitable facilities for aseptic and antiseptic work.

In general, therefore, it may be stated that the primary treatment of gunshot wounds of all varieties is directed toward combating shock, arresting hemorrhage, the appliance of sterile, absorbent, and protective dressings upon the wound, and fixation of the wounded part.

Shock and hemorrhage having been attended to and the wound dressed, *fixation of the injured part is indicated*. Rest of the wounded part, whether the injury be a trauma of the soft parts or of the bone, is conducive to healing, for placing the tissues at rest serves as a prophylactic measure against infection and an additional safeguard against displacement of the dressing.

When the soft parts only are wounded, immobilization by slings, body bandages, or, if necessary, by the application of splints, to keep the wounded part at rest, will be required. When the chest or abdomen is wounded, firm circular compression by bandages, or, in the field, by the cartridge belt or gun strap,

to limit the movements of the walls of the abdomen and chest and to check internal hemorrhage and favor healing, should be employed.

In gunshot fractures immobilization is of the utmost importance. At the time of first assistance immobilization by extemporized splints may be employed, or, these latter not being .at hand, the body of the patient or the opposite limb may be used for the purpose. A fracture of the arm or forearm can be immobilized by bandaging the extremity to the chest. In a fracture of the lower extremity the opposite limb can be used as a temporary splint by bandaging the wounded limb to it with handkerchiefs or other articles of clothing, or, in the field, by a cartridge belt or gun strap.

That immobilization of the wounded part is a distinct factor in preventing the recurrence of hemorrhage should not be forgotten. The immediate fixation of the part not only lessens the liability of the recurrence of hemorrhage, but favors the formation, over the wound, of the dry clot of blood and, by confining the tissues, enables repair the sooner to begin. When the wounded person has reached a. place where careful and adequate attention can be given the injury, substitution of the proper splints for extemporized ones can be quickly and readily done.

The further treatment of the wound must depend entirely upon the amount and kind of tissue destruction and the presence or absence of infection. This treatment is to be instituted as soon as the surgeon can determine the conditions which are present, and when, if operative measures are necessary, they can be done with the aid of aseptic and antiseptic technique.

Cleansing of the wound and surrounding skin by sterile water or a mild antiseptic solution, approximation of the skin as much as possible over the wound, removal of all foreign material, ragged tissue, and loose bone fragments, etc., and drainage of the wound with gauze, may be instituted when necessary. In fact, under asepsis and antisepsis, careful and thorough exploration, removal of foreign bodies, excision either formal or informal, amputation, or any necessary operation may be instituted.

GUNSHOT WOUNDS, ACCORDING TO REGIONS.

Bullet wounds differ greatly in gravity and in their after-effects according to the region of the body in which they occur. Difference in structure causes difference in the physical peculiarities of traumatisms, especially in those made by small projectiles; and wounds of important or vital organs not only present the physical peculiarities which are incident to the structure of the organs wounded, but they are often complicated by disturbance or arrest of function which results from destruction of tissue or from the pathological processes which follow the injury.

These factors markedly influence the prognosis and treatment of bullet wounds, for the result in all cases is materially affected by the importance of the organs or structures injured and by the liability of certain tissues, such as the peritoneum and the meninges of the brain and cord, to dangerous inflammatory action.

The treatment is likewise affected by the regional location of the wound; for, while it must conform in all cases to the general rules of surgery, it must also be adapted to the anatomical and physiological peculiarities of the part wounded.

Furthermore, the result of treatment can be conclusively determined only by a study of cases according to the region or structure injured.

For purposes of surgical study the regions of the body are properly divided as follows: Cranium, spine, face, neck, thorax, abdomen, back (flesh), pelvis, perineum and genitals, upper extremities, lower extremities.

The Relative Fatality of Gunshot Wounds of Different Regions.—Most modern projectiles have dynamic and traumatic properties materially different from those of the older bullets; consequently these differences, together with the advent of modern aseptic and antiseptic surgery, have materially altered the relative fatality of wounds of various regions. This is shown by comparing the statistics of the mortality of the wounded in war, the American Civil War being taken as the standard of wars in which the wounds were mostly made by bullets of the old type and in which the wounds were treated by the old methods, and these statistics being compared with the regional mortality of the wounded in the war with Spain and the Philippine insurrection, where the modern bullet and surgial methods were employed.

NUMBER OF DEATHS BY REGIONS, AND REGIONAL MORTALITY.

	CRANIAL REGION.	SPINAL FRACTURE.	FACE.	NECK.	CHEST.	ABDOMEN.	BACK (FLESH).	PELVIS, PERINEUM AND GENITALS.	UPPER EXTREMITIES.	LOWER EXTREMITIES.
	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.	Mortality Per Cent.
Civil War............	28.9	55.5	5.8	15.0	27.8	48.7	6.9	29.7	6.5	13.8
War with Spain.....	19.8	66.6	7.5	18.6	9.5	42.6	1.6	0.0*	0.02	1 06
Philippine insurrection, 1899–1900.............	12.3	66.6	2.2	14.5	14.0	44.9	0.08	22.7	1.4	3.2

* Flesh wounds only; hence not to be compared with the others.

From the regional fatality of the wounds shown above it appears that, with the exception of wounds of the spine, there has been a reduction of mortality in all regions. The regions in which the reduction is most marked are the back, extremities, chest, and head. The reason for the reduced mortality in

each region will be discussed under wounds of that region, but, in general, it may be stated that the decreased mortality now seen in cases of gunshot wounds is probably mainly due to the recognition of the asepticity of most bullet wounds, the maintenance of this aseptic condition, the non-use of probes, the frequently lesser traumatic effect produced by the modern bullets, the employment of antiseptics in infected wounds, and the conservative treatment made possible by these factors. These conclusions hold equally for surgery as practised in civil life as for surgery practised in war.

Wounds of the Cranial Region.—Wounds of the skull and brain are very important, both from their relatively high frequency and from their gravity when the cranial contents are involved or are subjected to the grave results which follow infection.

Frequency of Wounds of the Cranial Region.—In war the number of wounds of this region is always relatively high, being, in general, about six per cent of all wounds. According to Longmore, the target area of the head (cranium and face together) equals 5.89 per cent of the whole body; but, from the exposed position of these regions, wounds of the cranial region equal or exceed the theoretical percentage for the entire head. This is due to the fact that the head is much exposed, whatever the nature of the engagement. When the men are behind intrenchments, the head and upper part of the body are alone exposed. When they are advancing over open ground, the inequalities of the surface may shield the lower part of the body; and, when they are lying down to avoid exposure, the head, being most advanced, is most liable to be struck.

The mortality of the wounded who come under treatment for cranial wounds in which the cranial contents are not involved is low; but when the skull is fractured, the mortality is high, as the gravity of wounds of this region depends almost entirely upon injury or infection of the intracranial structures. In consequence, cranial wounds, in respect of their gravity and fatality, may be divided into two groups.

The *first group* comprises all wounds of the cranial region in which the cranial contents are not involved. This includes: (*a*) Contused, incised, lacerated, punctured, and gunshot wounds of the scalp; (*b*) contusion of the cranial bones; and (*c*) fracture of the outer table only. The mortality from wounds of this group is low and is almost entirely due to the remote effects which follow extracranial infection and which, by aseptic or antiseptic treatment, may now be largely prevented.

The *second group* comprises all wounds in which the cranial contents are involved or directly laid open to infection. This includes: (*a*) Fractures of the inner table only; and (*b*) all fractures involving both tables in which the cranial contents may be injured and a route is opened through which they are exposed to infection. In wounds of this group the mortality is high, the mortality being due to direct injury of the brain or to inflammatory processes following infec-

tion. It is this class of wounds which gives the surgeon most concern, taxes to the utmost the resources of his art, and in which, in spite of modern surgical methods, the result is frequently fatal.

Gunshot flesh wounds of the cranial region. About two-thirds of all gunshot wounds of the cranial region are flesh wounds. These wounds vary in character according to the missile by which they are made. When they are made by shell fragments, quite large portions of the scalp may be torn off. Even in wounds inflicted by the modern jacketed projectile, Makins states that there is always actual loss of tissue in the track of the bullet. From the thinness of the scalp, wounds of the soft parts are necessarily not deep, and unless grave infection occurs they usually yield readily to treatment. Even with pre-aseptic surgery the mortality was low (Civil War, 3.2 per cent), and with modern methods it is less than one per cent.

Scalp wounds from shell fragments, owing to the irregular and jagged form of these missiles and the already infected state of the hairy scalp, are more or less lacerated and become invariably infected. Flesh bullet wounds are also liable to be infected, for, as the bullet passes superficially, it generally gutters the scalp, so making rather a large wound which readily becomes infected. Perforating bullet wounds of the scalp without fracture of the cranial bones are rare. These wounds may occur at the important temporal and occipital regions, but all wounds of the head by the modern bullet should be regarded with suspicion, especially if they occur where the curves of the skull are the sharpest, as fracture is almost certain to happen when the modern bullet but barely grazes the bone.

Treatment of Scalp Wounds.—The wound should in every case be carefully cleansed and thoroughly explored to insure against overlooking a fracture. In the case of a lacerated wound all loose tissue should be removed and the parts made as smooth as may be. If possible, the edges should be approximated and retained in place with sutures of silver wire or silkworm gut. If the wound is manifestly infected or already suppurating, a gauze drain should be left in the lowest part. When there is actual loss of tissue, if the loss is not great, healing will take place by granulation, but, if it be extensive, skin grafting by the Thiersch method may be resorted to, at once or later on.

Gunshot Contusions of the Skull.—Contusion of the cranial bones by gunshot without fracture of one or both tables is rare. It may occur, however, by the glancing impact of slow-moving lead bullets or fragments of shell; the periosteum being torn and the bone contused. These cases may be complicated with symptoms of concussion of the brain, which, if persistent, may lead to doubt as to whether there may not be accompanying fracture of the inner table of the skull with brain injury. In the Civil War 328 cases of contusion were reported, with 55 deaths. In 49 of these cases there was concurrent brain lesion. The treatment of contusion of the cranial bones divides itself into treatment

of the external wound and treatment of the brain complications when they
occur. Treatment of the complications will be discussed under the head of
Complications and Sequelæ of Gunshot Fractures of the Cranium. Treatment
of the traumatism itself consists in the thorough application of antiseptic
methods. The chief danger in these cases is from necrosis of the bone follow-
ing infection, with possible extension of infection through the inner table and
subsequent infective meningeal inflammation.

Gunshot Fractures of the Cranium.—From their high fatality, their complica-
tions, and their sequelæ, these wounds are among the most important of gunshot
injuries. Fractures of the skull by gunshot are in most cases different from the
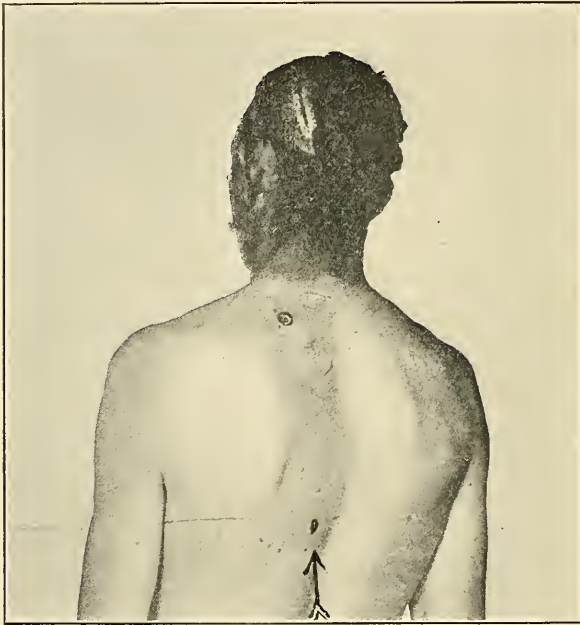
FIG. 209.—Multiple Wound of the Back and Head by Mauser Bullet. Small oval entrance wound;
large, circular exit wound; gutter wound of the scalp. (Spanish-American War.)

dissimilar fractures of the skull seen in civil surgery. This is particularly true
of fractures by bullets and is due to the great energy concentrated upon a small
area of the skull.

In civil life fractures of the skull are usually produced by the impact of large
bodies having less momentum than the projectiles from fire-arms. The solu-
tion of continuity is the result of a force applied at the place of impact with
crushing effect, and it therefore produces a comparatively slow in-driving of the
bone with tendency to fissuring. This mechanical force acts by the extreme
tension which it exerts on the bony arches, breaking them as a bow is broken by
overstraining. With slowly moving missiles of large size, such as large shell

fragments, and slowly moving lead bullets, fractures of a somewhat similar character may be produced.

With the small jacketed bullet of the modern military rifle, impressed by the high velocity common at near ranges, the mechanism of the production of fracture is entirely different and the extent of the lesion increases with the velocity. The fracturing effect of these projectiles is due to the tremendous energy concentrated on a very small area of the skull at the place of impact, and to the dissemination of this energy by molecular vibrations. The area of the skull impinged upon by the ball is instantaneously disintegrated and driven aside by the rapidly-moving projectile, and fissuring of the skull is produced, not by over-bending of the bony arches, but by excessive molecular vibrations set up by the energy and motion derived from the sudden impact of the rapidly moving bullet.

As the form and extent of the fracture and the disturbance produced in the surrounding tissues by these missiles are due to the transmission of concentrated energy, expressed by the formula MV^2, the effect produced must differ materially according to the velocity of the missile. With low velocity these missiles expend most of their dynamic effect upon the bone at the place of impact, and in the soft tissues their effect is mainly limited to the line of their track; consequently, fractures produced at long range present but little fissuring or damage to the skull beyond the place of impact or to the brain beyond the track of the bullet. With increased velocity, fissuring of the bone and destruction of brain substance beyond the track of the bullet are greater, due in part to the excessive molecular vibrations set up in the skull itself and in part to the transmission of motion to the molecules of the brain by the rapidly moving projectile. It is these factors which make traumas of the cranium and brain from bullets different from those produced by large slow-moving objects, and introduce elements of gravity in prognosis and treatment. In point of fatality, fractures of the skull by gunshot are exceeded only by gunshot fractures of the spine and penetrating wounds of the abdomen, while for serious after-effects they are equalled or exceeded only by wounds of the spinal cord.

Frequency of Cranial Fractures.—The highest per cent of fractures of the skull occurred in the Franco-Prussian war, where 42.2 per cent of all wounds of the cranial region were fractures. The percentage of fractures in the Spanish-American war, where the wounds were mostly made by jacketed bullets, was about the average proportion (34.9). In view of the properties of the modern bullet, by which it readily produces destruction of osseous tissue and is rarely deflected by bone, it was expected that the relative number of fractures would be increased by its use. The statistics do not show such result; it is probable that the relative number of fractures was lessened by the fact that so many extremely slight flesh wounds were reported, the conditions favoring the reporting of all wounds, however trivial, conditions which would not obtain in wars of greater magnitude. The same may be said of the low percentage (27.3) of fractures

recorded in the Philippine insurrection, but to this is to be added the further fact that a large proportion of these wounds were by Remington bullets, and in many cases the insurgents used reloaded cartridges, the bullets for which were of soft lead, cast by the natives in extemporized moulds, like bamboo sticks, etc. In this connection the returns from the Anglo-Boer and Russo-Japanese wars will be of interest when they are compiled.

Fatality of Fractures of the Skull by Gunshot.—In recent wars about one-half of all cases of gunshot fractures, including all varieties which came under treatment, terminated fatally. Taking the American Civil War (fatality 57.7 per cent) and the Franco-Prussian war (fatality 51.3 per cent) as standards of the results in pre-antiseptic days and with the use of the older missiles, the Spanish-American war, with its fatality of 56.7 per cent from this class of wounds, shows that the mortality from cranial fracture has been maintained, notwithstanding modern aseptic and antiseptic methods. This is undoubtedly due to the greater penetrating and destructive properties of the modern bullet.

In most cases of fracture by the older lead bullets the extent of the fracture was not great. The bullet deformed upon impact with the skull, fractured it moderately, and failed to penetrate. With the modern bullet, with its concentrated impact and great resistance to deformation by violence, the amount of comminution, even though more restricted in area, is much greater. The missile is rarely deflected or arrested by the resistance encountered in the cranial bones, and the proportion of fractures with injury of the brain and its membranes is increased. These factors of increased destruction of tissue tend to counterbalance the good effect of modern aseptic and antiseptic methods, and so maintain the mortality in this class of wounds. It is true that in the Philippine insurrection these wounds show a reduction in mortality (fatality 42.5 per cent), but the fact of the frequent use of the unjacketed bullets by the insurgents is to be taken into account. Wounds of these missiles would be largely of the type observed in former wars, and, when treated by modern methods, should give a reduced mortality.

Classification of Gunshot Fractures of the Cranium.—The treatment and result in cranial fractures depend upon the character of the bone lesion, the presence or absence of intracranial disturbance or destruction, and the presence or absence of infection. Direct infection can take place only when both tables are fractured. Where the fracture is extensive, the external wound large, and the missile has penetrated the brain, the probability of severe infection is increased. Injury to the cranial contents may be due to depressed or in-driven fragments of bone, or may be due to direct destruction by penetrating or perforating missiles. For these reasons fractures of the cranium are best discussed under the following heads:

I. Fractures of the outer table only; no direct route for infection; no direct injury (concussion excepted) to cranial contents.

II. Fractures of the inner table only; no direct route for infection; possible injury to the cranial contents by depressed fragments of bone.

III. Fractures of both tables; direct route for infection.

Sub-class A { Without penetration by the missile. Cranial contents may or may not be injured by depressed fragments of bone. Includes gutter fractures.

Sub-class B { With penetration or perforation by the missile. Direct injury to the brain by the missile, with or without additional injury by in-driven bone fragments.

Fractures of the Outer Table only.—This form of injury by gunshot is rare and seldom occurs except in the frontal or mastoid regions. In the frontal region fracture of the outer table may be produced by perpendicular impact of slowly moving missiles and by vertical or transverse shots by similar missiles or by the modern bullets. In these fractures the frontal sinuses are often involved, when infection from the nasal cavities may occur. In the mastoid region, injury to the internal ear and to the facial nerve has always to be reckoned with, and permanent deafness and loss of function of the facial nerve are common in these cases.

In the treatment of fractures of the outer table, the possibility of an overlooked fracture of the inner table must always be borne in mind. If there are symptoms indicative of intracranial trouble from depressed fragments of bone, the fracture should be carefully explored under strict asepsis and if necessary the trephine or the bone chisel should be used. Where the outer table only is injured, aseptic, and, where necessary, antiseptic cleansing should be employed to insure healing of the wound without infective ostitis, which might lead to meningitis by extension.

Fractures of the Inner Table only.—This is a rare but classic form of fracture, and, unlike fractures of the outer table which are due to direct destruction by a glancing shot, fractures of the inner table only are due to over-extension of the inner table through pressure upon the outer. This form of injury can be produced only by missiles moving so slowly that, by impact upon the skull, they fail to break the outer table, but cause a localized bending of both tables, when, the inner table being on the side of greatest extension, solution of continuity occurs in it from molecular separation; while the outer table, being on the side of compression, may remain intact (Teevan). It is possible that in a very elastic skull this effect may be produced by an extreme glancing impact of the modern bullet when the missile is near the end of its course and capable of being deflected when it strikes the skull very obliquely. The modern bullet can produce marked intracranial trouble when it strikes the skull so obliquely as to produce no fracture of the outer table. A case of this kind was observed in the Spanish-American war, in which the brain symptoms must have been due either to fracture of the inner table or to concussion of the brain.

The *treatment* of fractures of the inner table must depend entirely upon the symptoms of intracranial trouble which are present. If the fracture has caused intracranial hemorrhage sufficient to produce dangerous symptoms, trephining should be done at the earliest possible moment. If the symptoms are only those of local irritation or compression, operative interference may be somewhat delayed if necessary, at least until the operator can proceed under aseptic technique; for, as the cranial cavity, in this class of fracture, is not opened and infected, operation under septic conditions is fraught with danger from the grave meningeal inflammation which may result. The most scrupulous aseptic care should be used.

Fractures of Both Tables Without Penetration or Perforation by the Missile.— The production of these fractures depends upon two totally different causes: first, the more or less direct impact of missiles of relatively large size and low velocity; second, extremely oblique impact by bullets travelling at high velocity.

Fractures without penetration of the missile result from the impact of missiles not having sufficient force completely to overcome the resistance of the skull and penetrate the cranium. In these cases the bone may be merely fissured or may be fragmented, and the fragments may or may not be depressed or driven inward. The inner table is usually more shattered than the outer and is more liable to have its fragments depressed or driven inward. This form of fracture, where the resistance of the skull is sufficient to arrest or deflect the missile, was quite common in former wars, and may still be produced by fragments of shell, shrapnel bullets, or unjacketed lead bullets. With the jacketed bullet this form of fracture is rare, and can occur only when the velocity of the bullet is low or when the bullet strikes the skull very obliquely.

Oblique impact by the jacketed bullet produces a form of fracture peculiar to this missile, known as *gutter fracture.* When bullets of the old type struck the skull obliquely, they either glanced off, were deflected inward and penetrated the skull, or were actually split upon the edge of the fracture.

With the modern jacketed projectile such deflection or arrest of the bullet does not occur. This missile ploughs directly ahead through the bone, cutting gutters of varying length according to the angle at which it strikes and the relation of its course to the curvature of the skull. These fractures are of different degrees, according to the depth of the gutter made by the bullet, and are complete or incomplete according to whether the bullet ploughs through both tables or grooves the outer table of the skull only.

The great point of practical importance in these gutter fractures is that, whatever the depth of the gutter and however superficial it may be, the internal table is always badly shattered and the fragments are usually small and many in number and are generally driven into the brain. These fractures, therefore, are always to be considered as depressed fractures and treated accordingly.

Fractures of Both Tables with Penetration and Perforation by the Missile.—With the use of the jacketed bullet, if of small calibre, these wounds have assumed great importance, both from their frequency and from the fact that the number of recoveries from this form of injury has not been materially increased. In the American Civil War there were but fourteen survivals from perforating wounds of the cranium. In the Spanish-American war and the Anglo-Boer war many sensational cases of recovery were reported, but these remarkable recoveries have been in a large part offset by the increased frequency with which penetrating wounds occur and by the high mortality which still obtains in these injuries.

In fractures by undeformed bullets, the gravity of the wound depends upon:
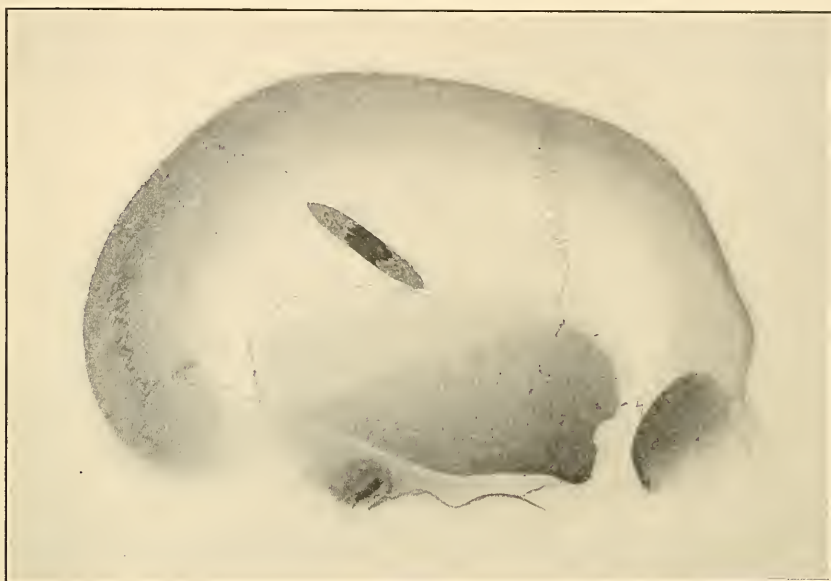
Fig. 210.—Gutter Fracture of the Second Degree, Perforating the Skull in the Centre of its Course. External table alone carried away at either end. (Makins: "Surgical Experiences in South Africa.")

(*a*) The part of the brain penetrated or perforated; (*b*) the velocity of the missile; and (*c*) the occurrence or non-occurrence of infection.

In penetrating fractures by deformed bullets and shell fragments the fatality depends upon (*a*) the amount of tissue destruction, and (*b*) the degree of infection.

The Effect of Bullets Relatively to the Part of the Brain Perforated or Penetrated.—When the base of the brain is penetrated or perforated, or the base of the skull is fractured, except in the frontal region, the prognosis is always unfavorable. Superficial perforations of the upper part of the brain, and even deep perforations of the frontal regions, may end in recovery if the velocity of the bullet is low and if grave infection does not occur. Superficial perforations are next in

degree of severity to the gutter fractures, being the result of bullets passing somewhat deeper. With low velocity of the bullet, the bone comminution is confined to the neighborhood of the wounds of entrance and exit, and the brain is cleanly perforated.

Cases of transverse, vertical, and oblique perforations and penetrations of the frontal region by bullets of low velocity may recover, and are sometimes unaccompanied by primary symptoms of severity, but may be accompanied by ocular, olfactory, and sensory symptoms of more or less gravity, depending on the depth of the wound. Wounds of the same character in the fronto-parietal regions almost invariably present symptoms of damage to the cortical motor areas. Wounds of the occipital region show marked effects of injury to the visual centres. Primary total blindness, ending in some restoration of vision but with great contraction of the visual field, usually follows recovery from wounds of this region.

The Relation of Velocity to the Traumatic Effect Produced.—The amount of bone comminution and brain destruction is increased directly according to the velocity of the bullet. With low velocity the entrance fracture is small and the radiating fissures are short. The inner table is more comminuted than the outer, and small fragments may be driven into the brain. The exit fracture is usually somewhat larger, the outer table suffers more than the inner, and brain substance may be driven out through the wound.

With increased velocity the skull and brain destruction is much greater. The energy and motion of the bullet are transmitted to the brain in a cone-shaped area; the apex of the cone being at the wound of entrance, while the base of the cone is at the wound of exit. The brain substance in this area is violently agitated, apparently, as though dashed forward toward the area of the skull surrounding the exit fracture. The exit fracture is large and irregular and the fissures are long, showing a tendency to radiate from the wound of entrance to that of exit, or *vice versa*, and brain matter is forcibly extruded from the wound.

At very high velocities the energy of the bullet is transmitted in every direction, and the so-called "explosive effect" is produced.

With the higher velocities the prognosis is invariably bad. Death occurs immediately, or, at the furthest, in a few days, and is due to respiratory or heart failure from the effects of the shock, or to pressure from hemorrhage or rapidly increasing intracranial œdema. When deformed bullets or shell fragments have sufficient velocity to penetrate the skull, the prognosis is in the highest degree unfavorable. These missiles generally produce extensive fragmentation at the entrance fracture and great destruction of brain tissue. The entrance flesh wound is lacerated, and the missille invariably carries infection inward, so that, if death does not occur from brain destruction and shock, it later occurs from septic inflammation.

Treatment of Fractures of Both Tables.—Where the missile does not penetrate the skull, it is evident that immediate intracranial trouble must be due to concussion or irritation, or to compression by depressed bone or extravasated blood, or to a combination of these factors. It is also evident that in all fractures of both tables there is a direct route open through which infection may reach the intracranial structures. In fractures by undeformed jacketed bullets, the wound is frequently not infected, and, as the results of infection are dangerous, treatment in those cases, unless there is some imperative indication for interference, should, in the opinion of the writer, be expectant until aseptic operative interference can be adopted. The consensus of opinion by late observers is that all fractures by jacketed bullets should be explored, but it is to be noted that traumatisms by these missiles are unlike the fractures formerly so common in war when intracranial trouble was largely due to depressed bone fragments. In penetrating wounds by the modern bullet the brain tissue is actually pulpified, and bone fragments pressing upon or drawn into the disorganized and pulpified tissue can hardly cause much additional trouble; certainly not sufficient trouble to warrant the surgeon in exposing the patient to the danger of infection by operating except under rigid asepsis.

With manifestly infected wounds, such as those made by shell fragments, or where there is serious irritation or compression by depressed bone fragments, delay is dangerous, and immediate exploration of the fracture should be made. The depressed bone should be elevated, the wound should be thoroughly cleaned with antiseptics, and a drain of iodoform gauze should be inserted.

Lodged Missiles.—Where a missile is not deeply lodged, or where the conditions are such that the removal is indicated, careful search may be made for it, but, in doing this, the operator must avoid damaging the brain or infecting the wound. Aseptic precautions and great care should be used.

The Roentgen rays afford means of localization in cases of lodged missiles which reach hospitals that are supplied with apparatus, but the fact of lodgment alone is not an indication for the removal of these missiles. When trouble is caused by lodged missiles in the brain, the surgeon will have to consider in each case the difficulties and dangers attendant upon the removal of these bodies as compared with those which are due to the presence of the missile itself.

The Complications of Gunshot Fractures of the Skull.—The conditions which may complicate gunshot wounds of the skull or brain are shock, hemorrhage, concussion, and compression. Shock is always a prominent symptom in gunshot fracture of the skull, and particularly in cases of penetrating and perforating wounds. Where the missile enters or passes through the brain, the injury to the brain necessarily greatly affects the vital centres. In such cases and in all fractures by bullets, concussion is rare, or, if present, is so closely related to the destruction of brain tissue by the bullet that the symptoms of shock and concussion are difficult or impossible to separate.

In all cases of gunshot wound of the brain, immediate unconsciousness, with marked depression of the vital forces, usually occurs. The general symptoms of shock are: Lividity, surface coldness, a weak and slow pulse, shallow breathing, and dilated pupils. The graver cases progress rapidly to death. Where the fatal termination is not immediate, the stage of depression may be followed by one of exaltation marked by delirium, restlessness, rise of temperature, rapid pulse, photophobia and other ocular symptoms, together with muscular weakness and paralysis. In the cases in which there is no gross traumatism of the brain, and the injury is molecular only, after-effects, such as epilepsy, neuralgia, and mental weakness, frequently occur.

Compression of the Brain.—Compression of the brain may be either local or general, and is due either to intracranial hemorrhage or to depressed bone. General compression, due to the accumulation of escaped blood within the cranium, is rare. The usual presence of a free exit through the wound prevents this complication.

Local compression by depressed bone fragments is more common, but symptoms of this condition are present only when the skull is depressed without extensive trauma to the underlying brain, for when there is extensive destruction of brain tissue, pressure of displaced bone fragments upon the disorganized brain structures gives rise to no manifest disturbance.

When the wound is a penetrating or perforating one, the symptoms of brain injury, rather than those of compression, are present. The symptoms of compression from depressed bone necessarily appear immediately after receipt of the injury, and are usually complicated with symptoms of shock and sometimes with those of concussion. It is also a fact that these latter conditions may be followed by symptoms of general compression from intracranial hemorrhage.

The *treatment* of the complications of gunshot fracture of the skull depends upon the nature of the injury, the condition of the patient, and the conditions under which the treatment has to be carried out. In many cases, from the presence of the symptoms of different complications occurring together, or from one condition being obscured by the presence of the more prominent symptoms of another, it will be impossible to arrive at a definite diagnosis regarding the complications, and, fortunately, accurate differential diagnosis in this respect is often not necessary. In arriving at a diagnosis the surgeon should take into consideration the character of the wound and of the missile which inflicted it. If the wound is a penetrating or perforating wound by a small-calibre bullet, the symptoms will be largely due to shock and destruction of brain tissue. In such cases the primary application of the first-aid packet, followed by a complete shaving and cleansing of the scalp and by exploration, as soon as this can be done with reasonable surety of asepsis, will be indicated.

When the missile has not penetrated the skull, the complications are due rather to indirect brain injury than to destruction of brain substance. In such

cases, compression, if present, is due to depressed bone or to intracranial hemorrhage, and, as these conditions are most frequently produced by shell fragments, which make lacerated and infected wounds, the sooner such wounds are carefully treated the better.

Cranial hemorrhage should be checked by compression or ligation. If the hemorrhage occurs within the cranium, the bleeding vessel should be secured by enlarging the wound, or, if this is not practicable, by opening the cranium over the location of the main trunk.

Hemorrhage from the larger sinuses may be rapidly fatal, unless controlled (preferably at first) by gauze packing. Compression from intracranial hemorrhage should be treated by removal of the clot and arrest of the bleeding, and, when due to depressed bone, by elevation of the depressed fragments, a trephine or cranial cutting forceps being used for the purpose if necessary.

The Complications and Sequelæ of Gunshot Fractures.—Nearly all deaths following gunshot fractures of the skull in which the fatal result is not directly due to the traumatism, occur later from the effects of complicating inflammatory processes arising from primary or secondary infection of the wound. Inflammation following intracranial infection is first manifested by meningitis, and, later, by such sequels as hernia cerebri or abscess of the brain. Many other sequelæ of brain injury by gunshot occur,—*e.g.*, Jacksonian epilepsy, paralysis, disorders of the intellect, and like afflictions due to cerebral trauma,—but these are not of such immediate gravity as the acute inflammatory processes.

Meningitis may be either local or general. If it is of the local type, the prognosis is fairly favorable. The general type invariably ends fatally. Fortunately, many cases are of the first-named variety. In these the inflammatory processes are limited to the neighborhood of the wound and are kept within bounds by free drainage and surgical cleanliness. The symptoms of meningeal inflammation are varied and depend upon whether the condition is general or not. When the inflammatory processes have extended beyond the immediate vicinity of the traumatism, the general symptoms are pronounced and consist of high fever, severe headache, photophobia, great restlessness, and delirium passing into coma. Other symptoms, such as muscular spasms, paralysis of certain muscles or of the cranial nerves, exophthalmos, albuminuria, etc., may be present, according to the extent and location of the inflammatory process.

When the inflammatory process is limited to the neighborhood of the traumatism, the general symptoms are much less severe. The temperature rise is lower, and, while headache is usually present, it is not as intense. The local symptoms are pain and tenderness in the neighborhood of the wound and other local inflammatory symptoms such as redness and the appearance of suppuration.

The treatment of meningitis is, first, preventive, *i.e.*, thorough exploration and cleansing of the wound, and, if the wound is manifestly infected, the maintenance of drainage. When inflammatory symptoms appear, the wound should

be carefully inspected under anæsthesia.   If any pent-up secretion is found, it should be drained away and provision made to prevent its recurrence.   If necrosed bone is found it should be removed.   In fact, every care should be taken to remove all necrotic tissue and infectious matter.   Drainage should be freely established and mild antiseptic dressings and cleansing should be used.

Hernia Cerebri.—Loss of substance of the dura mater and infection are the principal causative factors of hernia cerebri.   Loss of substance of the dura is invariably present in penetrating wounds of the brain, but in the less serious lacerations of the dura by depressed fragments in non-penetrating wounds this cause of the hernia may be absent.

Hernia cerebri is not a true protrusion of cerebral contents.   The protruding mass may consist in part of brain tissue, but is mainly made up of granulation tissue, the result of a low grade of inflammatory action due to infection and involving the cerebral tissue bordering the wound.

There is no special treatment for hernia cerebri.   The efforts of the surgeon should be directed toward the prevention of meningeal and encephalic complications, and, in favorable cases, to those measures which may aid reduction or removal of the growth and the covering of the site of the protrusion with a new growth of connective tissue and skin.   To this end careful protection, cleanliness, mild antiseptics, cold and moderate compression, if it can be borne, should be used.   Painting the surface of the growth repeatedly with absolute alcohol is frequently very efficacious.   The antiseptic and dehydrating qualities of the alcohol combat the infection and produce shrinkage.

In some cases, excision, cauterization, or ligation, while usually held to be dangerous, may be adopted if other means fail and if the danger from the existing condition is greater than from the employment of these more radical measures.   When the tumor has been reduced, and nature fails to throw a cicatrix across the defect in the brain coverings, skin grafting may be used.

Abscess of the Brain.—Abscess occurs in a considerable number of cases after direct destruction of brain tissue.   When abscess develops, the symptoms usually begin to manifest themselves in the second or third week, although in exceptional cases they may appear sooner.   The symptoms of traumatic abscess of the brain are marked by their insidious mode of appearance, and consist of headache of a varying degree, irritability of temper, drowsiness, twitchings of certain muscles, Jacksonian seizures, slow pulse, and slight rise of temperature. Marked symptoms of compression are usually absent.

The treatment of these abscesses consists in evacuation and drainage.   When symptoms of abscess formation appear, the track of the wound should be explored, this being a better guide than relying on localization symptoms, as localization symptoms do not have the same value in traumatic cases as in cases of idiopathic brain abscess.   Abscesses after gunshot injury almost always, if not invariably, arise from infection in the wound, and for this reason exploration of

the wound should be made as soon as the probability of abscess is evidenced. When an abscess has been evacuated, it is necessary to maintain drainage until the cavity has closed from the bottom, as premature closing of the exit will lead to a reaccumulation of pus.

Gunshot Wounds of the Face.—Wounds of the face are of frequent occurrence, but their mortality is not high, and their importance is mainly due to the deformity which sometimes results when the injury is inflicted by a shell fragment or deformed bullet, and to the grave consequences of injury to the visual organs. Still, wounds of this region are frequently of a serious nature. The unclean condition of the nasal and buccal cavities, by which infection of wounds involving them is favored, and the proximity of the brain, to which inflammation may easily extend, are usually the main factors of danger in these cases.

The *character* of wounds of the face by gunshot necessarily depends largely upon the missile by which they are inflicted, while their gravity will rest more particularly upon the location and depth of the wound, and whether or not it is badly infected.

Wounds by fragments of shell, from the large size and irregular form of these missiles, may cause extensive and disfiguring wounds, while undeformed bullets, particularly of the jacketed type now used in war, and revolver bullets of small calibre, may pass through the face and leave no disfiguring trace.

Fig. 211.—Shell Wound of the Face. Complete destruction of the upper lip and the anterior portion of the upper jaw. (Spanish-American War.)

The location of the wound is of importance, particularly in relation to injury of the visual organs, and its depth bears a distinct relation to the possibility of infection from the nasal and buccal cavities.

Flesh wounds of the face (excluding visual organs) are rarely of grave importance, for when the bones of the face escape injury the thinness of the tissues overlying them presupposes a limited injury and one which is readily repaired.

Wounds of the face with *fracture of the facial bones* are frequently serious. In 17 cases of fracture of the facial bones in the Spanish-American war there were 3 deaths, a fatality of 17.6 per cent. This high fatality is largely ascribable to infection from the unclean nasal and buccal cavities and extension of inflammation to the meninges of the brain. Also, fractures of the face by shell fragments and deformed bullets, from the extensive laceration of the soft parts and open nature of the wound, may lead to the same results by infection from without, even when the buccal or nasal cavities are not involved.

Aside from the question of infection, the character of the fracture depends largely upon the missile inflicting the injury. Shell fragments frequently produce extensive comminution of the bone and great destruction of the soft parts, which result in great disfigurement and which often require for relief extensive and careful cosmetic operations. These operations must of necessity be deferred until active inflammatory action has ceased, and must be done under careful aseptic technique.

Fractures of the bones of the upper part of the face by undeformed jacketed bullets are, as a rule, not serious injuries unless infection occurs. The bones of the upper face are spongy and fragile and a bullet passes through them readily, the destruction of osseous tissue being almost entirely confined to the track of the bullet, as the loose cancellous tissue of these bones does not transmit the vibrations set up by the bullet with sufficient force to cause solutions of continuity at a distance from the actual place of impact.

The malar bone is the most resistant of the upper facial bones, and for this reason is sometimes considerably shattered.

Many perforated wounds of the face by jacketed bullets have been recorded in which the bullets passed through the part in various directions with a minimum of immediate or remote effect. Even when the bullet is moving at high velocity no explosive effect is produced, for, as above noted, the soft bones do not transmit the energy of the bullet with sufficient force to cause destruction of the explosive type.

When the teeth of the upper jaw are struck, they are sometimes shattered, and, from their resistance, are driven forward by the bullet and act as secondary missiles, enlarging the exit wound, or are driven into the tissues.

In fractures of the lower jaw the form of the fracture is considerably influenced by the velocity of the missile and by the circumstance whether or not the teeth are struck by it. The osseous tissue of the lower jaw is more compact than that of the other bones of the face, and for this reason fragmentation at short ranges and fissuring at the mid-ranges are more apt to occur, but at long ranges the body of the bone may be perforated or guttered only. When the teeth are struck, they may, by leverage on their sockets, cause fissuring of the bone, and, when the bullet ranges along them, they may force out quite a large part of the alveolar border and cause radial fissuring of the body of the bone.

The *treatment* of fractures of the body of the inferior maxilla consists in the removal of loose bone fragments, the fixation of the bone, and the use of antiseptic mouth washes. If fragments are left, necrosis invariably follows, and their early removal before this occurs does much to further early union of the bone and healing of the wound. In the great majority of cases fixation by a four-tailed chin bandage will, in field surgery, be the only method practicable, and, fortunately, in nearly all cases excellent results are obtained in this way. But in the hospital and in civil surgery other methods of fixation may be required,

and devised according to the peculiarities of the case and the means at the disposal of the surgeon.

Fractures of the ramus of the lower jaw are of interest from the ankylosis or limitation of motion which so commonly follows. These results of gunshot injury appear to be due to the considerable amount of fragmentation which usually occurs, and to the large callus which forms about the displaced fragments, some of which are driven out into the tissues. For this reason Makins suggests that better results would be obtained in those wounds if they were habitually explored under asepsis and all small or loose fragments removed.

Gunshot Wounds of the Eye.—Gunshot wounds of the eye are divided into: (1) Contusions; (2) wound and rupture of the eye, destroying the globe more or less completely; (3) wounds of the eye by small missiles which penetrate the ball without producing much destruction of the sclerotic; and (4) injuries to the optic nerve and the vascular supply.

All of these injuries, except probably the third variety, are generally accompanied by trauma of the parts about the eye and frequently by fracture of the skull and injury to the brain.

Transverse and oblique shots injuring the eye invariably produce wounds of the soft parts and fractures of the orbit, in some cases wounding both eyes at the same time. Vertical shots may pass through the anterior part of the skull and brain; and, from the tolerance of the anterior lobes to injury by small undeformed bullets when travelling at moderate velocity, cases so wounded may eventually recover. These wounds, as well as deep transverse ones, may pass behind the globe of the eye without injuring it, and sever or damage the optic nerve, causing complete blindness, even when the nerve is barely grazed by the bullet, as the lateral transmission of energy imparted by the missile causes irreparable damage to the nerve.

In wounds of the eye in which the eyeball is more or less damaged, prompt enucleation is followed by the best results, as a clean wound is left which usually heals readily. Wounds of the eye by small missiles which penetrate the eye with but little injury to the sclerotic are rare, but in these cases, unless the missile be very small and the wound uninfected, early enucleation will be generally followed by the best results. When expectant treatment is adopted, the eye should be closely watched for intraocular inflammatory symptoms and for sympathetic inflammation in the uninjured eye. The occurrence of sympathetic inflammation is evidenced by photophobia, ciliary and conjunctival congestion, pain, and iritis.

The onset of these symptoms in the uninjured eye should be promptly followed by appropriate treatment, as their continuance will result in loss of vision. If they follow cases in which an attempt is being made to save the injured eye, such conservative treatment should be at once abandoned, and the injured eye should be enucleated, thereby removing the focus of inflammation.

Wounds of the Neck.—From the many important structures contained within this area, wounds of the neck are of serious moment. At the same time this region presents instances of remarkable escape from death. This is particularly true of individuals who have been wounded by the modern jacketed bullet, for, with this missile, the neck has been perforated in almost every direction without injury to important nerves and vessels, even where, from the location of the wound tracks, avoidance of these structures scarcely seems possible. The escape of important structures in these cases is probably due to the small size of the projectile rather than to the pushing the nerves and vessels aside without injuring them; although, with a missile travelling at low velocity, displacement without trauma may occur.

In the Spanish-American war the mortality from wounds of the neck was 18.6 per cent, while in the American Civil War it was 12.6 per cent and in the Franco-German war 13.1 per cent. This somewhat high mortality is not surprising in view of the anatomical peculiarities of the part. Wounds of the larynx and trachea may lead to septic pneumonia, trauma of the coats of the great vessels may lead to aneurisms or secondary hemorrhage, and wounds of the œsophagus and infected wounds generally may lead to deep-seated inflammation and suppuration.

The character of wounds of the neck depends (*a*) upon the structure or structures wounded and (*b*) upon the infection or non-infection of the wound.

Wounds of the neck by shell fragments are almost always infected and more or less lacerated. The treatment in these cases should be directed to the arrest of hemorrhage and the thorough cleansing of the wound, followed by drainage, while, if special organs or structures are injured, the treatment to be pursued is identical with that laid down for injury of these structures by bullets as given below.

All injected wounds of the neck, whether made by shell fragments or by bullets, or secondarily infected from the œsophagus or otherwise, should be treated by thorough antiseptic methods and drainage. The danger in these cases lies in the occurrence of suppuration and burrowing of pus into the loose connective tissue of the neck, forming deep and extensive pockets which may even extend downward into the mediastinum. To the dangers incident to inflammation and suppuration, such as extensive cellulitis, septicæmia, and pyæmia, is added the danger of secondary hemorrhage if the walls of any of the vessels have been contused or wounded by the missile, or if any of the vessels have been so injured as to require ligation. These dangers can be avoided only by the early recognition of infection and the adoption of thorough cleansing and drainage. The fact that shell wounds are generally infected, and therefore dangerous, and the necessity for early recognition of infection, if present, in other wounds, cannot be too strongly emphasized.

Wounds of the blood-vessels may in rare instances come into the hands of the

surgeon in time to allow ligation, but operative procedures on the vessels of the neck will usually be possible only in conditions which follow the injury, particularly aneurism, arterio-venous aneurism, and aneurismal varix, all of which frequently follow damage to the walls of the blood-vessels. The occurrence of aneurism in the neck, as well as in other regions containing large blood-vessels, is relatively quite common since the small-calibre bullets have been adopted, and, from the close relation of the carotid artery and internal jugular vein, arterio-venous aneurisms of these vessels, arising from simultaneous injury to their walls, are comparatively frequent. The general conditions present and the causative factors in these cases are dealt with under the head of Wounds of Blood-Vessels.

The treatment of aneurism has already been touched upon briefly on a previous page.

Of the nerves in the neck the cervical and upper parts of the brachial plexus are most frequently wounded. Wounds of these and other important nerves in this region are practically beyond help by surgical means, but where the conditions are due to contusion or concussion only, initial loss of function may gradually disappear.

Wounds of the larynx and trachea are always serious and are frequently complicated by wounds of other important structures. They are evidenced by escape of air from the wound, emphysema, cough and expectoration of blood, stridor, dyspnœa, cyanosis, impairment or loss of voice, and difficulty in deglutition. The immediate danger, aside from hemorrhage into the trachea, is inflammatory œdema of the glottis; later, septic pneumonia and other inflammatory troubles due to infection of the cervical tissues may develop.

The treatment in all cases is early tracheotomy combined with suitable attention to the wound. The introduction of the tracheal tube insures the entrance of sufficient air, enables the operator to determine the occurrence of hemorrhage into the trachea, if present, and prevents the occurrence of extensive emphysema, which may otherwise extend down into the anterior mediastinum. The surgeon should in no case delay the operation, but should do the tracheotomy as soon as possible after a diagnosis of perforation of the larynx or trachea has been made. The sooner the operation is performed, the greater will be the probability of preventing early death from the entrance of infected matter and blood into the trachea. The absence of alarming symptoms is no indication for delay, the presence of a tracheal or laryngeal wound being sufficient indication for the operation. Where the œsophagus is simultaneously wounded, the indication for tracheotomy is, if possible, more urgent than when the trachea alone is wounded, as operation is imperatively demanded to lessen the evil of the passage of infected food and mucus from the œsophagus into the trachea.

Wounds of the œsophagus, like those of the trachea, are often accompanied by injury to other important structures. The symptoms of wounds of the œsopha-

gus are pain and interference with deglutition, the escape of food or mucus from the wound, and the regurgitation of blood, together with great cervical swelling and perhaps dyspnœa. The dangers are mainly deep-seated cellulitis, inflammation, deep suppuration which may extend to the anterior mediastinum, septicæmia, and pyæmia. These dangers are always to be apprehended, whatever the nature of the missile by which the wound was made, as the wound is certain to be infected from the œsophagus, especially if alimentation be carried on by the mouth.

For this reason the *treatment* of wounds of the œsophagus is always operative. The site of injury to the œsophagus should be exposed by appropriate incision, and, if possible, the opening or openings in the œsophagus should be closed by two layers of sutures, one for the mucous membrane and one for the outer layers of the tube. The wound should then be drained with strips of iodoform gauze extending down to the place of suture. When it is impracticable or impossible to suture the œsophageal wound, careful tubular drainage, with the tube surrounded with gauze, should be made in order to provide a direct channel from the wound to the surface and so prevent infection of the surrounding tissues. The taking of food and drink by the mouth should be stopped when there is a suspicion that such an injury exists, rectal feeding should be resorted to, and, when necessary, gastrostomy should be done. The common sequelæ of wounds of the œsophagus, *i.e.*, œsophageal fistula and stricture, will require treatment later when the measures appropriate to such cases can be adopted.

Wounds of the Spine and Spinal Cord.—Wounds of the spine which involve the cord are among the most fatal and serious of gunshot traumatisms. The serious disability and grave complications and sequelæ which follow these injuries are particularly trying to both the patient and the surgeon, while the inflammatory conditions which follow infection are even more serious and fatal than those which follow infection of the intracranial structures.

Frequency and Fatality of Wounds of the Spine.—Fortunately, wounds of the spine are comparatively infrequent. This is mainly due to the position of the spine, at the back, where it is least exposed to gunshot, while the cord is further protected by the depth at which it is placed and by its surroundings of bone and overlying muscles. These factors were particularly important in protecting the cord against injury by the low-velocity missiles formerly used in war, and are still effective against low-velocity missiles from revolvers and like arms, shrapnel bullets, and fragments of shell. With high-velocity bullets the effect of these protective factors is less; and, as the frequency of wounds of the spine has been about doubled in recent wars of which statistics are available, it is probable that this increase is to be largely ascribed to the great penetrating power of the jacketed bullet.

SPINAL FRACTURES.

	No.	Died.	Frequency. Per Cent.	Fatality. Per Cent.
Civil War (Federals).....................	642	349	0.26	55.5
Spanish-American (U. S. Troops).........	9	6	0.55	66.6
Philippines, 1899–1900.................	21	14	0.82	66.6

With the older missiles the relative frequency of spinal fractures was about one-fourth of one per cent of all wounds. In the Spanish-American war and the Philippine insurrection the percentage of small fractures was raised to over one-half of one per cent, while the high mortality (about 66 per cent) was maintained. From this it appears that the use of the modern rifle has increased the number of wounds of the spine and has maintained their high fatality in spite of modern surgical methods. The high mortality which still obtains is undoubtedly due to the increased number of cases of spinal fracture which are accompanied by cord injury. The older missiles were readily arrested by resistant structures and their effect was frequently expended upon the spinal bones, while the modern missile more readily perforates the spinal column and injures its contents. With soldiers lying prone, the jacketed bullet will make long transverse, oblique, and longitudinal wounds of the back, perforating all structures in its course.

The gravity, course, treatment, and result of fractures of the spine are markedly different according to whether or not the spinal cord is directly injured or involved, and in consequence these wounds are properly considered under two heads: (a) Spinal fractures without injury to the cord, and (b) spinal fractures with cord involvement.

Fractures of the Spine without Involvement of the Cord.—These injuries are comparatively common with slow-moving lead missiles, even when the cord lies directly in the path of the bullet, as the missile is generally arrested by the bones of the spinal column, but secondary involvement of the cord and membranes by extension of infection may follow. With the modern war bullet the cord rarely escapes injury when it lies in the bullet's course, but when it lies outside of the direct course of the ball it may escape injury, especially if the velocity of the bullet is low; and, with the quite aseptic condition of most bullet wounds, secondary inflammation is rare. In uninfected wounds fractures of the vertebræ without involvement of the cord are not grave injuries unless accompanied by injury to some of the spinal vessels or nerves.

Fractures of the neural arches by bullets travelling at high velocity rarely occur without injury to the cord, but fractures of the processes and centra may occur without cord involvement if the velocity of the missile is low.

When the injury has been inflicted by a jacketed bullet the centrum or

body of the vertebra usually shows a clean-cut perforation, the cancellous tissue readily yielding to the bullet without transmitting its energy. Makins states that in all cases of bullet fractures of the centrum seen by him in the South African war they were of the character of pure perforations with no comminution beyond slight splintering at the aperture of exit. With jacketed bullets penetrations of the body in all directions occur, and perforations of several centra by the same bullet are not uncommon.

The *symptoms* of fracture of the vertebræ by the jacketed bullet, without cord lesion, vary according to the location of the lesion and whether or not it is accompanied with spinal nerve injury. Fracture of the processes is often indicated by local pain, tenderness, mobility, and crepitus. Fractures of the arches, centra, or transverse processes are evidenced more by the course of the ball than by other symptoms unless there is concomitant concussion of the spine or injury to the nerves.

The shock of impact in gunshot cases is frequently sufficient to jar severely the cord and cause more or less transient signs of spinal concussion, while injury to the nerves, as before stated, gives rise to symptoms of suspension or interference with their functions.

Deformity following fracture of the centrum of a vertebra is rare. With large bullets and deformed missiles, extensive destruction of the centrum may occur with subsequent marked deformity.

Fractures of the spine by *shell fragments* are always grave, as the wounds are infected and there is danger of extension of the infection to the cord and its membranes. The same may be said of fractures by deformed bullets and by undeformed large lead bullets, as the probability of infection by these missiles is much greater than with the undeformed jacketed bullets.

Fracture of the Spine with Involvement of the Cord.—In spinal fracture by bullets, concussion, compression, and direct destruction of cord tissue may occur. These complications are of a very serious character. Dent, in speaking of this class of injuries in the Anglo-Boer war, states that no cases in hospital seem more hopeless or more distressing. He remarks upon the astonishing rapidity of the degenerative changes which occur, deep, sloughing bed-sores forming in a day or two and cystitis setting in early. He further states that if there is any grave lesion of the cord the wound may be set down as mortal, although the wound affects but a small portion of the cord. Even when the traumatism is small, the bullet having barely grazed the cord, the area of damage may be very great. Makins is of the same opinion relative to the gravity of these injuries, and says of the wounded seen by him in South Africa that injuries implicating the spinal medulla were the most fatal of any which came under treatment, and that these cases formed one of the most painful and distressing features of the surgery of the campaign.

With bullets travelling at high velocity injury to the cord may arise either

from direct impact of the bullet or from lateral transmission of the bullet's energy. This latter factor plays a most important part in cord injury, as it appears that complete transverse lesion is the rule, even when the bullet barely grazes the cord, and in some cases where it has only passed near it. This extensive injury to the cord is undoubtedly due to the fact that it is fluid-saturated, and therefore, like other fluid-saturated organs, transmits the energy of a high-velocity missile with lateral explosive violence.

Concussion of the spinal cord by gunshot, like concussion of the brain from the same cause, is due to molecular vibrations set up by the impact of a large missile against the spinal column or to the lateral transmission of energy from a rapidly moving bullet to the cord itself. The effects of such injury vary from transitory symptoms of pain and loss of muscular control to complete paralysis and anæsthesia of all parts of the body supplied by nerves given off below the location of the spinal injury, followed by more or less persistent pain, anæsthesia, hyperæsthesia, and general neurasthenic symptoms.

A grave form of concussion is exemplified in those cases in which a rapidly moving projectile barely grazes or passes near the cord, and in which the molecular vibrations set up are so great as to lead to actual solution of continuity of cord tissue with parenchymatous hemorrhage and symptoms of complete transverse lesion. These cases are as unfavorable in their course as are the cases in which the cord substance is destroyed by direct contact of the missile.

Direct destruction of cord tissue may arise either from injury to the cord by in-driven bone fragments or from the direct impact of missiles. When it is caused by in-driven bone fragments, the symptoms of complete transverse lesion may be absent, while those of compression or irritation are present. This form of injury is comparatively common with slow-moving lead bullets, the missiles being arrested by the bone, but having sufficient energy to drive fragments of bone inward into the spinal canal. These cases are characterized by symptoms of cord irritation and partial transverse lesion. The reflexes are not completely or permanently abolished and paralysis and anæsthesia are not complete. These cases are suitable for operative relief under aseptic precautions.

Compression of the cord is generally due to hemorrhage, but may be caused by depressed bone or lodged missiles. Compression from hemorrhage is quite apt to occur in bullet wounds, as the small size and length of the track wound make escape of the blood from the external wound difficult.

Compression by depressed bone or lodged missiles is not uncommon with the larger lead bullets and may arise with any missile when its energy is so nearly exhausted that it is arrested by the bone after having partially or wholly entered the spinal canal.

The Diagnosis and Prognosis of Cord Involvement.—Shock is always a marked symptom in gunshot injury involving the cord. Paralysis and anæsthesia of the parts supplied from the cord below the injury, together with paralysis of the

bladder and rectum and loss of the patellar reflex, commonly occur at once, whether the injury is a complete transverse lesion or not. Babinski's reflex is important in this respect. In the lighter forms of concussion the paralysis and anæsthesia disappear and the reflexes are soon restored.

Differentiation between compression and the severer forms of concussion is difficult and sometimes impossible. In compression by lodged missiles or depressed bone, compression and concussion may occur together, and the initial symptoms in each may give way to improvement. Compression from hemorrhage may likewise come on early, or may be complicated with symptoms of concussion and may show improvement as the blood clot is absorbed. The diagnosis as to the extent of cord lesion must generally rest upon the extent, and particularly upon the persistence, of the symptoms of arrest of function.

The common complications and sequelæ of involvement of the cord are spinal meningitis, myelitis, disease of the kidneys, cystitis, and bed-sores. These conditions are all serious and generally sooner or later end fatally.

Meningitis is due to infection, and may be either local or general. The general form is rapidly fatal and accounts for the majority of deaths which occur within a few days after the injury. The local form gives rise to local myelitis and degenerative changes which are progressive in character and which eventually cause death from cystitis and decubitus. Where degenerative changes of the cord occur without inflammation, the cases run the usual chronic course and eventually die from the conditions incident to cystitis, disease of the kidneys, or bed-sores.

Treatment of Gunshot Fractures of the Spine.—The great majority of spinal wounds are made by bullets which strike the spine at an angle to the antero-posterior plane. The wounds are deep and small, and the exact amount of injury to the cord in many cases cannot be at once determined. These factors, together with the depth at which the cord is situated, the extent of the operation required to disclose it, and the fatal results which follow infection, make operation in these cases practically possible only in hospitals where asepsis is available and where the press of work is not so great as to prevent taking the necessary time.

In war the immediate treatment of wounds of the spine, with or without injury to the spinal cord, is expectant, with the exception of those rare cases in which there is a large wound leading directly down to the spine. For these reasons bullet wounds of the spine should be dressed with the first-aid packet, and, unless suppuration occurs, should not be interfered with until the case has reached a permanent hospital. At this hospital and in civil practice immediate operation is indicated when the symptoms of irritation or compression of the cord by bone fragments, lodged missiles, or effused blood, are present.

In all cases of injury of the cord in which the bullet is lodged, a Roentgen-ray apparatus should be used, and, if the bullet is located in the spine, where it is pre-

sumably encroaching upon the canal or compressing nerve tissue, it should be removed.

Wounds of the spine by shell fragments or other missiles in which there is manifest infection should be explored at the earliest possible moment, cleansed thoroughly, and drained. In infected wounds no good is attained by expectant treatment, but by antiseptic methods and drainage the inflammatory processes may be localized and checked.

The sequelæ of cord injury are frequently most distressing and difficult to treat. This is particularly true of bed-sores and cystitis which so frequently occur and which so commonly end fatally from the septic trouble and exhaustion which they cause.

Wounds of the Chest.—Prior to the use of modern surgical methods, wounds of the chest had a very high mortality, but, under the new conditions, and when made by small-calibre bullets, their fatality has been markedly decreased, and they are now, when uncomplicated, among the easiest to treat of all gunshot wounds.

If wounds of the chest of all description be taken, their relative regional frequency is a little over 8 per cent of all wounds. In the Civil War the mortality of all chest wounds was 27.8 per cent, while in the Spanish-American war it was about 9.5 per cent.

The character and fatality of wounds of the chest differ so widely, according to whether the parietes only are injured or the thoracic cavity is opened and its contents injured, that the wounds of this region are properly considered under two heads: (a) Non-penetrating, and (b) penetrating wounds of the chest.

Non-Penetrating Wounds of the Chest.—Under non-penetrating wounds of the chest are classified all wounds of the chest in which the pleural cavity is not invaded.

The character of non-penetrating wounds of the chest differs according to the weapon or missile by which they are inflicted.

Wounds of shell fragments are of varying size and degree of laceration, according to the size and form of the fragment. In some instances quite a large extent of surface is denuded and the underlying tissues may be badly lacerated and the ribs broken. These wounds are almost always infected and require throrough cleansing and antiseptic treatment.

Deformed bullets may cause lacerated wounds which resemble those made by shell fragments and which require similar treatment. Shrapnel bullets and slow-moving lead bullets from revolvers frequently produce contour wounds, the bullet being deflected by a rib and coursing about the chest below the skin. When such wound tracks of such great length are infected they are slow to heal and ordinarily require laying open the entire length in order to clean them thoroughly and cause them to heal throughout. If a rib is broken and the wound uninfected, the case should be treated, as in simple fracture in

civil practice, by the application of adhesive straps to immobilize the chest. Hemorrhage will rarely occur in non-penetrating wounds, but when the intercostal artery is severed the wound should be laid open and the artery secured.

Penetrating Wounds of the Chest.—Penetrating wounds of the chest include all traumatisms in which the pleural cavity is entered, with or without injury to the structures within the thorax. The frequency with which the chest is penetrated is somewhat increased with the use of the modern bullet, but the mortality from this class of injuries has been strikingly reduced.

FREQUENCY AND FATALITY OF PENETRATING WOUNDS OF THE CHEST IN THE CIVIL WAR COMPARED WITH THE SPANISH-AMERICAN WAR AND PHILIPPINE INSURRECTION.

	Number.	Per Cent.	Died.	Mortality Per Cent.
American Civil War (U. S. Troops)......	8,715	43.0	5,260	62.5
Spanish-American War (U. S. Troops)...	73	50.0	14	19.1
Philippine Insurrection (U. S. Troops)...	140	60.8	38	27.1

It will be seen from the above table that, if the mortality from this class of wounds in the American Civil War be taken as a standard for the mortality which obtained in wars with older missiles and surgical methods, the reduction in mortality under the new conditions is about 60 per cent (62.5 per cent to 27.1 per cent and 19.1 per cent).

The *character of penetrating wounds of the chest* depends mainly upon the size of the missiles by which the wounds are made. This is due to the fact that both the thoracic parietes and the contents are of such structure that they do not readily transmit the energy of projectiles, and consequently the tissue destruction is confined almost entirely to the track of the missile.

The great immediate danger in wounds of the chest is from hemorrhage; the remoter dangers are from infection and its sequelæ.

Wounds in which the pleura is opened and the contents are not injured are usually due to missiles of low velocity or to those striking the body very obliquely, because the resistance of the thoracic wall is not great and is readily overcome, especially by modern bullets.

Undeformed bullets of modern type rarely produce penetrating wounds without injury to the thoracic contents, except when they strike the chest very obliquely, in which case they may groove or fracture the ribs.

Fracture of the Ribs.—In fracture of the rib the bone trauma is confined almost entirely to the track of the missile, and the principal danger arises from hemorrhage.

Diagnosis of fracture of the ribs. In fracture by a shell fragment or a deformed bullet, the fracture will often be evident upon inspection or palpation. Pain, as a symptom in gunshot fractures of the ribs, is not always present,

particularly when due to transverse shots, the solution of continuity being so complete as to prevent the main fragments rubbing each other and so producing pain during respiration or crepitus on palpation. On the other hand, in longitudinal shots with fracture of several ribs, pain during respiration is much more common. Diagnosis is, however, in any case, assured only by palpation or by exploration of the wound in those cases in which operation is indicated. Pain on movement incident to pleuritis due to fracture also aids in the diagnosis.

Penetrating Wounds with Intrathoracic Injury.—Wounds of the heart and pericardium which come under treatment are of extreme rarity. Many cases have been reported of wounds by modern small bullets where, from the location of the apertures of entrance and exit, it appeared that the heart could not have escaped. In this connection the mobility of the overlying parts and of the heart itself should be remembered. It is easily conceivable that the pericardium may be pierced and the ventricles grazed, and the aseptic nature of the wound accounts for recovery without accident. If the wound is infected, septic pericarditis will probably result. For this reason, in treating these cases, unless the wound is manifestly infected, non-interference and occlusive sterile dressing are indicated; but when the wound is infected, antiseptic treatment is indicated.

It is now well known that patients with wounds of the heart may, in some instances, survive for several hours and even longer. In these cases the patients present symptoms of shock, collapse, weak, irregular, and intermittent heart action; under which conditions the surgeon may be justified in opening the pericardium and attempting closure of the wound. To operate thus, an osteoplastic flap is made by dividing the fourth and fifth costal cartilages at their points of attachment to the sternum and the ribs, about an inch external to the points where they are attached to the cartilages. The flap is turned upward and can be enlarged if necessary. Other methods of procedure are also practised.

Wounds of the Lung.—Lung tissue is so spongy that it offers little resistance to a missile and transmits its energy not at all; the trauma conforming to the size of the missile, and, when made by a modern undeformed bullet, the destructive effect is slight and is confined to the small wound track made by the projectile. Consequently, when no blood-vessel is wounded and the wound is uninfected, these cases show surprisingly few symptoms and recovery is uninterrupted and rapid. The danger in these cases arises entirely from hemorrhage and infection. Wounds of the lungs by fragments of shell and by deformed missiles are much graver injuries, their gravity depending upon the size of the traumatism in the chest wall and in the lung, and upon the infection which is usually present.

The *symptoms* of a wound of the lung differ markedly according to the location and amount of damage done by the missile. The main symptoms, any or all of which may be present, are shock, pain, dyspnœa, pneumothorax, hæmoptysis, and intrapleural bleeding, asymmetry of thoracic movement, and cough.

It is evident that many of these symptoms, while present in wounds of the lung, are due to the injury to the thoracic wall rather than to lung involvement. Systemic shock is frequently pronounced, especially if the injury be received at short range, and is largely attributable to the impact of the missile against the chest wall. It is more pronounced in injury by shell fragments and deformed bullets, because of the greater shock of impact from these missiles. Pain, when present, is to be ascribed to the chest injury and irritation of the intercostal or other sensory nerves and to traumatic pleuritis. As noted in discussing rib fractures, pain is often not pronounced.

Dyspnœa, when an early symptom, is, like shock, due to the concussion of the bony thorax and depends largely upon the velocity and size of the missile. Makins notes that the respiration in individuals wounded by the modern bullet, while quickened and shallow, was easy and regular. Dyspnœa occurring later is a marked and important symptom of intrapleural hemorrhage or pneumothorax.

Cough is sometimes present, but, unless accompanied by hæmoptysis, is not specially significant.

Hæmoptysis is often present in a wound of the lung, but may be entirely absent. Its occurrence depends upon the facts that a blood-vessel of sufficient size to cause hemorrhage of some quantity has been wounded, and that there has also been an injury of an air passage into which the blood may escape. Frequently the hæmoptysis is considerable immediately after the injury, the patient subsequently expectorating bloody mucus only at intervals. In regard to hæmoptysis as a sign of wound of the lung, it must be noted that the symptom sometimes follows injury to the chest wall alone and where the lung is not involved.

Asymmetry of thoracic respiratory movement is due to accompanying rib fracture and hæmothorax from intrapleural bleeding, which may be due to a hemorrhage either from a wounded lung or from an intercostal artery.

It is evident that the symptoms present in wounds of the lung are suggestive, rather than conclusive, of visceral lesion. They are of especial value as evidence of penetrating wounds of the chest with possible lung involvement. The diagnosis, however, is based mainly upon the course of the bullet as shown by the wounds of exit and entrance. When the missile is lodged, its course, together with the symptoms, and especially its localization by Roentgen-ray examination, should be conclusive.

The Complications and Sequelæ of Penetrating Wounds of the Chest.—Shock, hemorrhage, pneumothorax, and subcutaneous emphysema are the common complications of wounds of the lung. Empyema and abcess of the lung are the sequelæ which, arising from the infection of the pleura or lung, account for most of the delayed deaths from penetrating traumatism of the chest.

Hemorrhage is the most grave complication of chest wounds. It is the cause of most of the immediate deaths from wounds of the chest, and slow bleeding into

the pleural cavity accounts for many deaths occurring later. Hemorrhage from chest wounds is clinically differentiated into parietal and visceral; it may also be designated as primary or secondary, and as rapid or slow.

Parietal hemorrhage comes from an intercostal or mammary artery, and may go on to fatal termination with little or no external evidence, the blood flowing into the pleural cavity. Concealed bleeding is especially to be watched for, as it is a common complication and a sequela of chest wounds. Hæmothorax very often comes on after exertion on the part of the patient or after the disturbance incident to transportation. In fact, transportation of the patient and exertion have been particularly noted by military surgeons as causative of hæmothorax, and the necessity for their avoidance to all possible extent has been especially insisted upon. So common is this complication when patients have to undergo long and fatiguing transportation that Makins estimates that it occurred in about 90 per cent of all such cases, while Greenleaf, in 24 cases of chest wounds collected in the Spanish-American war, found this complication in 9 cases, or 37 per cent.

The symptoms of hæmothorax may come on rapidly or slowly soon after the receipt of the wound, or they may not occur until the efforts of the patient or the disturbance resulting from transportation has caused it.

Makins notes that the symptoms in severe cases were usually not fully pronounced until the third or fourth day after the injury. Rapid and feeble pulse, cough, pain, dyspnœa, inability to lie on the sound side of the body, hæmoptysis, and rise of temperature are the usual general symptoms. Locally there is dulness over the intrapleural blood, and, in incomplete cases, Skodaic resonance above, loss of vocal resonance, and fremitus; and, in some cases, fulness of the intercostal spaces, gravitation ecchymosis, and increase in girth of the injured as compared with the well side, are present.

A rise of temperature is a most important symptom, as it appears to coincide with the occurrence of the hemorrhage, although it may be due to incipient pleuritis. In well-marked cases it reaches its height (102° to 104° F.) by the third or fourth day. On the other hand, if a second hemorrhage occurs, the rise of temperature which accompanies it has to be carefully differentiated from the rise which accompanies the onset of suppurative pleuritis.

In the minority of cases signs of considerable intrapleural hemorrhage immediately follow the receipt of the wound. In other cases the bleeding is gradual and ceases if the patient is kept at rest. In still others the hemorrhage is recurrent, the recurrence commonly happening after the transportation of the patient or exercise on his part.

The general course of hæmothorax is toward spontaneous absorption. The blood slowly coagulates, the fluid serum separates and is absorbed with considerable rapidity. In some cases the amount of blood in the pleura is so great as to require its removal, the quantity being sufficient to compress the lungs, displace the heart, and produce marked dyspnœa.

The treatment of hæmothorax is, as outlined above, complete rest and immobilization of the chest. In cases of evident parietal bleeding, the wounded vessel should be sought for and ligated, or, if its location cannot be ascertained, compression should be applied to the chest. Operative treatment for visceral bleeding has not as yet met with much success. The large opening which must be made in the chest wall to gain access to the lung allows air to enter, and collapse of the lung generally occurs, which may be immediately fatal. When an opening into the pleura has to be made, the surgeon should take special precautions toward preventing collapse. Where no special apparatus is at hand the opening should be made as small as will admit proper manipulation, and if possible the lung should be stitched at least in part to the opening. If a Fell-O'Dwyer apparatus is at hand is may be used to great advantage, or, if a cabinet for intrathoracic work is available, it should be used. In desperate cases the injection of ice water into the pleural cavity has been recommended. When hemorrhage has progressed so as to cause pressure collapse of the lung, the pleural cavity may be opened, the blood clot cleaned out, and an attempt made to check the bleeding.

Pneumothorax is now fortunately not a common complication of wounds of the chest. Formerly, with large bullets making large wounds through which air could enter, it was more common. The symptoms of pneumothorax are those of marked depression, dyspnœa, and the local signs of air in the pleural cavity.

Empyema is the most common and one of the most dangerous sequelæ of penetrating wounds of the pleura. It results either directly from infection of the pleural cavity by the missile or infected material carried in, or from secondary infection of the blood clot in hæmothorax, or from infection introduced by operative procedures which open the pleura. Infection from the lung occurs but rarely, as bacteria are practically absent in the smaller bronchial tubes, and for infection of the pleura to occur from a wounded lung it is necessary that infection pass outward from one of the largest bronchi. A deep wound of the lung is, therefore, more apt to give rise to abscess of the lung than to empyema.

Treatment of the Wounds of the Chest.—The treatment of non-penetrating wounds of the chest is usually comparatively easy. Wounds by small-calibre bullets will rarely require any treatment other than the application of aseptic dressings. Long "contour wounds" by shrapnel or large lead missiles may be infected, and, in such case, if suppuration persists, the wound track may have to be laid open in whole or in part, cleaned and treated antiseptically. Similar antiseptic treatment will be required in the infected wounds made by shell fragments.

The treatment of penetrating wounds requires more careful consideration and depends entirely upon the character of the traumatism and the presence

or absence of complications and sequelæ. Penetrating wounds made by the modern small-calibre bullet, when uncomplicated by hemorrhage, primarily require simply occlusive dressing and *rest* or, if possible, confinement of the patient to the bed. The wound should in no case be probed or otherwise interfered with, except under aseptic precautions and then only for some manifest indication. From the apparently trivial nature of many of these injuries, the patients are perfectly able to walk about and object to restraint. Doubtless not a few of the sequelæ (particularly hæmothorax) observed in such cases are due to failure of the surgeon to keep the patients quiet or to the necessary movements of transportation.

If hæmothorax occurs, pyothorax from infection of the clot is apt to follow; hence the necessity for quiet in all such cases, however unimportant the symptoms may be.

The patient should be kept prone, and not be transported unless necessity requires, and, in addition, the chest wall should be discreetly immobilized by adhesive straps or a tight encircling bandage. The use of morphine internally and the application of cold to the chest wall are also indicated.

In all infected wounds, the external injury should be carefully cleaned, loose fragments of bone should be removed, and antiseptic dressings should be employed, in order, if possible, to limit the infection to the chest wall, thereby preventing infection of the pleura.

In all wounds of the chest the possibility of the occurrence of empyema should be remembered, so that it may be early detected if present.

An early diagnosis and operation, including the resection of a part of a rib and drainage, will usually prevent the occurrence of the severe pathologic processes which make necessary the more extensive operations of Estlander and Schede.

Wounds of the Abdominal Region.—Abdominal wounds, like those of the chest and head, are divided into non-penetrating and penetrating wounds.

Of these, the non-penetrating wounds are rarely of gravity. Their greatest importance arises from the difficulty with which they are sometimes differentiated from penetrating wounds. The mortality from non-penetrating wounds may be taken as a means of indicating the advance made in the treatment of flesh wounds by the adoption of modern surgical methods. In the American Civil War in 4,469 cases with 1,335 unreported results, 253 died, a mortality of 8 per cent. In the Franco-Prussian war, when antiseptic treatment was not carried out to any extent, in 4,143 cases of non-penetrating abdominal wounds 364 died, a mortality of 8.7 per cent. The figures show that for ordinary flesh wounds of the abdominal region in pre-antiseptic days the mortality was approximately 8 in 100. In the Spanish-American war and the Philippine insurrection 64 non-penetrating wounds were reported, with no deaths. While the number wounded in the Spanish-American war was small, the absence of

mortality conclusively shows how modern methods contribute to the control of the result.

A few cases of rupture of the viscera, with no external wound, have been reported as the results of gunshot. These injuries are closely allied to the " wind-age" shots, before referred to, and are due to extremely oblique contact by very slow-moving large missiles; the skin, from its elasticity, not being broken, but the force of impact being transmitted to the viscera, which may be torn or rupt-ured by it.

The treatment of non-penetrating wounds of the abdomen is similar to that of flesh wounds of other parts of the body.

Penetrating wounds of the abdomen rank with those of the head and spine in gravity. Wounds of the chest were formerly of almost equal importance, but the advance in surgery has greatly reduced the mortality of chest wounds, without so greatly affecting that from wounds of the other cavities of the body. The fact, however, that the surgeon may now freely open the abdominal cavity, under asepsis, and this combined with the advances made in surgical technique itself within the abdomen in the methods of intestinal repair, has greatly improved the prognosis and treatment of penetrating abdominal wounds. The fact re-mains, however, that penetrating wounds of the abdomen, like those of the head and spine, are among the most discouraging the surgeon is called upon to treat. A large proportion of these cases have no chance for recovery, even with the most perfect surgical intervention, because of the results of infection.

The conditions relative to penetrating gunshot wounds of the abdomen differ materially as to whether the injury is received in civil or in military life. This is due to the different conditions which obtain, especially where the wounds are made by bullets. In warfare bullet wounds of the abdomen or its contents are usually made by the small-calibre, steel-jacketed bullets, which produce very small wounds which are often uninfected. In civil life the wounds are usually made by bullets of larger calibre, impressed with low velocity; and, in addition, these bullets have no jacket and the surface is rough; hence, infection by them is much more common. The condition of the patient and his environment at the time of the injury are of particular importance, and these differ also with the civilian as well as with the soldier. In war the men wounded are usually strong, young men, in the full vigor of health, and in some instances have been fasting when the wounds are received. They are, therefore, in the best condition to combat the effects of infection, and, the alimentary canal being practically empty, the bullet may pass through the stomach and intestines, producing a minimum trauma and consequently less shock and danger of septic infection and peritonitis. In many cases in civil life quite the opposite conditions obtain. The physical condition of the persons wounded is frequently bad. They are often under the influence of alcohol, the alimentary tract is replete, the effect on the filled stomach, when wounded, is marked, and the probability of extra-

vasation of the gastric and intestinal contents, with resulting peritoneal infection, is often largely increased.

On the other hand, the facilities for treatment in civil practice are much greater, often compensating for the otherwise bad features of the injury. The civil surgeon can ordinarily operate early and with aseptic and full surgical facilities, while early operation and proper facilities are often impossible in military service.

The *frequency and fatality in gunshot wounds of the abdomen* in war are given in the following table:

PENETRATING AND PERFORATING WOUNDS OF THE ABDOMEN WITH AND WITHOUT VISCERAL LESION.

FREQUENCY AND FATALITY.

War.	Total.	Penetrating.	Died.	Frequency. Per Cent.	Fatality. Per Cent.	Authority.
Crimean-English	. . . .	120	111	. . . .	92.5	Matthew
American Civil	8,159	3,690	3,015	45.2	90.0	Otis
Prussian-Danish	. . . .	103	59	. . . .	57.2	Loeffler
Franco-Prussian	5,677	1,534	1,061	27.0	69.1	Official
China-Japan	52	47	33	. . .	70.2	Haga
Spanish-American	61	39	26	63.9	66.6	Official
Philippine Insurrection, 1899–1900.	118	76	53	64.4	68.4	Official

The above table shows that 50 per cent or more of all gunshot wounds of the abdomen received in war penetrate the abdominal cavity. In comparing the number of cases of penetrating wounds in the American Civil War, where 45 per cent were penetrating, with those of the Spanish-American war, where 63.9 per cent, and the Philippine insurrection, where 64.4 per cent were penetrating it will be seen that the number of penetrating wounds of the abdomen has probably been increased by the use of the modern small-calibre bullets. That the number of penetrating wounds is increased is to be expected from the great penetrating power of the modern missile. It will be noted also that, while the cases of penetrating wounds are increased, the fatality has markedly decreased. In the English troops in the Crimean war, 92 per cent of penetrating wounds were fatal, and in the American Cival War 90 per cent succumbed. It is stated in the "Medical and Surgical History of the War of the Rebellion" that not a single case of wound of the small intestine recovered, the 59 recoveries reported being from wounds of the large intestine. In the Spanish-American war the mortality was 66.6 per cent, and in the Philippine insurrection 66.4 per cent, a gain of a little over 20 per cent compared with the American Civil War. So far as military surgery is concerned, it appears that practically all the saving of life has occurred in cases not operated on. Colonel Whitehead reports 8 cases during the Terah campaign. Of these, 5 were operated upon and all died. The other 3 did not require

operation and recovered. In the Spanish-American war there were 44 penetrating wounds of the abdomen in the regular troops. Of these, 4 were operated upon and all died. In the 40 cases not operated upon, 25 died, a mortality of 62.5 per cent. In 1899 in the regular and volunteer troops, there were 60 cases; 10 were operated upon and 9 recovered. The statistics of the Anglo-Boer war and the Russo-Japanese war are yet unavailable, but the operative experience in these wars appears to have been about the same as that of the Spanish-American war, viz., that practically all of the cases of recovery were cases which did not come to operation.

In civil life the statistics relating to operative interference are somewhat more favorable. Oliver gives 22 cases operated upon; of these 5 recovered and 17 died, or 22.8 per cent of recoveries. Grant gives a total of 253 cases, with 48 per cent of recoveries. The *Year Book of Surgery*, 1901, gives 66 recoveries and 41 deaths in 107 cases operated upon. The difference in the mortality in the operations in military and civil practice is sufficient to show that the ability to operate early, with aseptic technique and adequate surgical appliances and assistance, in a large measure accounts for the better results obtained. In considering these results the element of time is of major importance. Coley gives a mortality, from cases operated upon in the first twelve hours, of 53.9 per cent; after twelve hours, 77.3 per cent. The relatively greater number of recoveries in the first twelve hours clearly demonstrates the importance of early operation in these cases. The sooner an operation is done after the receipt of the injury, the less likelihood there is of extravasation of intestinal and stomach contents into the peritoneal cavity, with resulting infection and fatal peritonitis.

Classification of Abdominal Injuries.—In the prognosis and treatment of penetrating wounds of the abdomen so much depends on the presence or absence and on the degree of infection, and on the circumstance whether the hollow or solid viscera or blood-vessels have been injured, that these facts must be taken into account, both in considering the treatment and in formulating the conclusions relative to the final outcome of cases. Penetrating wounds may be divided into the following:

1st. Penetrating but not injuring any viscera or blood-vessels.
2d. Penetrating, with wounds of important blood-vessels.
3d. Penetrating, with perforation of an important hollow viscus.
4th. Penetrating, with perforation of a solid viscus.
5th. Penetrating, with perforation of both hollow and solid viscera.
6th. Penetrating, with wounds of the viscera and the blood-vessels.

The prognosis depends largely on which of the above classes the wound falls under. If the wound be a simple penetrating one, with no injury to internal structures, the result will be almost entirely determined by the presence or absence of infection of the peritoneal cavity by the missile. If the peritoneal

cavity be uninfected, as is frequently the case with small-calibre bullets, the prognosis is very good.

Next in order of favorable prognosis, where the wound is uninfected, are the wounds of the solid organs, particularly when they are made by small-calibre missiles. When made by small-calibre bullets travelling at a moderate velocity, these wounds do not, as a rule, give rise to fatal hemorrhage, unless a large artery of the organ be wounded, for the wounded organ generally heals readily.

Wounds of the hollow viscera are the ones which give the highest mortality. Of these, wounds of the small intestine are the most fatal, few, if any, of which recover without operative treatment. Wounds of the stomach and the large intestine may recover spontaneously, although such cases of recovery are comparatively few. Makins, in his "Surgical Experiences in the South African War," tabulates 49 cases of penetrating wounds of the abdomen, with 34 recoveries and 15 deaths. In the analysis of these cases he states that it appears clear that wounds of the stomach may recover spontaneously; that perforating wounds of the small intestine are very fatal injuries; that every patient in whom this condition was correctly diagnosed died; that in 8 cases in which there was perforation of the large intestine 4 recoveries took place.

The symptoms of penetrating gunshot wounds of the abdomen present no special information in reference to the presence or absence of visceral injury. Where an intra-abdominal blood-vessel of appreciable size is wounded, symptoms of internal hemorrhage will occur with greater or less rapidity. Shock, even when severe, is not evidence that an intra-abdominal organ or viscus has been wounded. Shock of the most pronounced character may be present in simple non-penetrating wounds, and it may be very slight or absent when important organs are injured and even where there is multiple perforation of the intestine. A patient with a penetrating wound of the abdomen involving the viscera may walk some distance without great suffering, and when seen by the surgeon may show no important symptoms of shock or evidence of internal hemorrhage. Pain is also a most unreliable and frequently misleading symptom. It may be great in a non-penetrating wound, and may be moderate, or almost absent at first, when multiple perforations of the intestine are present. The pulse, like the symptoms of hemorrhage and shock, presents at the outset nothing characteristic of intra-abdominal injury. In fact, so far as the immediate symptoms of penetrating wounds of the abdomen are concerned, there is usually nothing definite which can lead a surgeon to a decided conclusion.

The diagnosis of penetrating wounds cannot usually be made immediately after the receipt of the injury except by exploratory incision, but a tentative diagnosis may be made by paying attention to the location and direction of the wound and the general condition of the patient. The position of the wound is not conclusive unless there is a wound of exit as well as of entrance, in which case, if the injury has been produced by a jacketed missile moving at high velocity, it is

practically certain that the bullet has passed directly through the body from one wound to the other, and even then the thickness of the abdominal wall should be taken into consideration. Where the entrance and exit wounds are made by revolver bullets of low velocity their position is no conclusive indication of the course of the bullet, since it may have struck the fascial or muscular layers of the abdominal wall and been deflected, making contour wounds instead of passing directly through.

Vomiting, pain, and shock, when persistent, indicate visceral lesion. If the stomach be wounded, the presence of vomited blood may indicate the lesion. Absence of liver dulness is an early and important indication of gastro-intestinal perforation. Blood in the stools seldom appears sufficiently early to be of diagnostic value unless the wound be of the transverse or descending colon, the sigmoid flexure, or the rectum. When shock is present and persistent, it generally indicates the occurrence and persistence of intra-abdominal hemorrhage or large extravasation of the intestinal contents. The escape of fæces or intestinal gas from the external wound is positive proof of injury in the intestines, but it is of rare occurrence and seldom takes place before twenty-four to forty-eight hours after receipt of the injury.

The *late distinctive symptoms* of intestinal perforation and intra-abdominal infection are those of septic peritonitis. The abdomen becomes distended and painful to the touch. The distention and upward displacement of intestines and the escape of gas into the peritoneal cavity cause disappearance of the normal liver dulness. Tympanites and rigidity of the abdominal walls become pronounced, and recurrent vomiting and constipation all appear as symptoms of infective peritonitis. Coincidently, the temperature rises and remains high, and the pulse becomes rapid and weak. It is needless to say, however, that to wait for these symptoms of penetrating wounds of the abdomen is to wait until there is no possibility of saving the patient.

The diagnosis by exploratory laparotomy is the patient's safeguard in all cases in which the surgeon does not absolutely know that the wound is a non-penetrating one, provided always that the exploratory operation can be done under reasonable aseptic technique. It is the lack of proper facilities and time which marks the distinction between the course to be pursued by the military and that within reach of the civilian surgeon in penetrating wounds of the abdomen.

Stephenson, in his "Wounds in War," written after the South African war, says:

"If it be admitted—and it must be admitted with regard to South Africa—that the conditions of warfare are such that operations for gunshot wounds of the abdomen are not justified on mere diagnosis of penetration, the discussion of these injuries and their treatment may be kept within comparatively restricted limits, for it was the supposed necessity of putting forward reasons for holding the opposite view that formerly made the subject a long one.

"The vast majority of surgical authority was, and—except in this country —perhaps still is, in favor of immediate operation in these cases. Sir Frederick Treves grants the theoretical correctness of this view of the subject. Sir William MacCormac held the same opinion until his South African experiences forced him to abandon it. Mr. Watson Cheyne admits that the rule in civil practice is to open the abdomen at once, but says that, as in South Africa, some cases got well without operation, and, as the conditions were so unfavorable for aseptic work, this rule would have to be considerably modified; and Mr. Makins writes: 'A wound in the intestinal area should be watched with care. In the face of numerous recoveries of such cases, habitual abdominal exploration is not justified under the conditions usually prevalent in the field.'

"While it is conceded that a certain, though comparatively small, number of cases recover where bullets have traversed the abdominal cavity, and that, therefore, in the absence of symptoms of intestinal injuries, exploratory operations are not warranted in the field because of the extra risk accompanying them, nobody will deny the occurrence of others where there is no possibility of recovery unless surgical interference is undertaken as soon as may be, although the number of successes must be few. These are cases in which penetration has occurred in the central area around the umbilicus, and when unequivocal signs of laceration of the small intestines are present. But, notwithstanding the clear indications for operative treatment in these cases, the surgeon will often find himself so surrounded by difficulties, so hand-tied by the overcrowded state of the field hospital and the want of all but the most inadequate means of even antiseptic work, that he may feel himself compelled to refrain from interfering, while he knows that under other circumstances operation might give the patient a chance for life."

Stephenson's statement quite covers the case and, so far as the military surgeon is concerned, he is generally debarred from making a diagnosis by exploratory incision. The surgeon in civil life, with aseptic control and adequate technique and assistance, can often adopt the theoretically proper course, can open the abdomen and determine the exact conditions, and, having found intra-abdominal injury, can proceed to repair it so far as surgical skill will allow.

Exploration of the wound by either the fingers or a probe, even under strict aseptic conditions, can be advocated only in exceptional cases. The use of the probe is practically always contra-indicated. With it the surgeon can rarely follow the bullet track and determine perforation, and may do injury. Exploration with the finger is uncertain, and it is much better to open the abdomen; for, with the finger or probe, even if the surgeon cannot determine penetration, he cannot be certain that penetration has not occurred. Besides, if penetration is determined, laparotomy will then have to be done, with the result that delay and possible danger have been the only outcome of the use of the finger or probe.

The location of the wound of entrance is of some diagnostic importance.

If it be near or in the umbilical region, the possibility of damage to the small intestine is great. If it be outside this region, there is more likelihood that the large intestine, bladder, or one of the solid organs is injured.

It has been determined from experience that bullets, and especially the small-calibre bullets used with the modern military rifle, may penetrate the abdomen, pass completely through the abdominal cavity, and yet no symptoms appear which indicate that any internal organ has been injured. These cases are all marked by the mildness of the symptoms; shock is not pronounced nor of long duration. The pulse, though at first fast, soon falls to one hundred or under, and the respirations are not very greatly quickened. Vomiting is occasionally severe, but not persistent, and ceases on the second day. The local abdominal signs are not pronounced and are of a limited nature; the distention is slight or absent. Movement of the abdominal wall is restricted only in the neighborhood of the wound, and the abdominal rigidity is confined to one-fourth, or, at most, one-half of the abdomen. There is little local tenderness, and, while it is usually present, is not excessive, and is limited to the neighborhood of the wound. Cases such as these generally go on to uninterrupted recovery with no bad after-effects.

Character of Gunshot Wounds of the Stomach and Intestines.—When the hollow viscera of the abdomen are wounded by gunshot, the character of the lesion depends upon the size of the missile and the angle at which it strikes the viscus, and, with the missile travelling at very high velocity, whether or not the viscus is empty or filled.

When the stomach or intestines are empty and are impinged upon by a small-calibre jacketed bullet, the character of the injury varies according to the mode of impact. The gut may be merely contused, or its outer coats may be lacerated, the lumen of the gut not being opened. Such minor injuries as these are no doubt common in penetrating wounds by small-calibre bullets. These lesions are readily healed and the patient may recover without the intestinal contents escaping.

When the missile strikes obliquely but more deeply, long, oval wounds are made, involving all the coats. These wounds are particularly dangerous, for they lay the intestinal lumen widely open and allow the ready escape of the intestinal contents.

When the missile strikes the gut at right angles and penetrates or perforates it, a circular, quite cleanly cut wound, similar to the entrance wound in the skin, is produced. Undoubtedly, the greater number of persons so wounded die from septic peritonitis. It has been shown, however, by actual observation in the South African war, that these clean-cut, small wounds may occasionally close and the patient recover.

When the intestine is empty and there is no immediate escape of the intestinal contents, the wounded intestine may press against another loop of intestine,

or the omentum may cover the wound; the apposed surfaces become agglutinated and thus the injury may be repaired.

In the stomach, small wounds are produced when this organ is empty or nearly so. When, however, the stomach or the intestine is filled and the bullet is travelling at high velocity, the wound made in the viscus is ordinarily large, and extravasation of the contents is much more apt to occur. When it is filled with fluid, the impact of a missile travelling at high velocity upon the incompressible fluid in some cases produces wounds of large size which may properly be called explosive. When a deformed bullet penetrates the stomach or intestines, it produces a large and ragged wound through which extravasation rapidly follows. Undoubtedly many of the rapidly fatal deaths from penetrating wounds of the abdomen, especially on the battle-field, are due to missiles which have been deformed by ricochet striking the abdominal viscera. This was noted by Makins, who divided the cases of injury to the small intestine into three classes:

"1. Those who died upon the field or shortly after removal from it. In these the external wounds were often large, the omentum was not rarely prolapsed, and the escape of fæces sometimes occurred early. Shock from the severity of the lesion, and hemorrhage, were no doubt important factors in the early lethal issue in this class. Many of the injuries were probably produced by bullets striking irregularly, by ricochets, by bullets of the expanding forms, or by bullets of large calibre. As being beyond the bounds of surgical aid, this class possessed the least interest.

"2. Cases brought into the field or even the stationary hospitals with symptoms of moderate severity, or even of an insignificant character, in which evidence of septic peritonitis suddenly developed and death ensued.

"3. Cases in which the position of the wounds raised the possibility of injury to the intestine, but in which the symptoms were slight or of moderate severity and which recovered spontaneously."

He calls attention to the difficulty in making a diagnosis between the cases of Class 2 and those of Class 3, and states that the advent of peritoneal septicæmia was in many instances the only determining factor. He says that, in his opinion, in civil practice an exploratory abdominal section is the only means of determining whether or not the bowel wall is injured.

In wounds of the large intestine the wound may be entirely extra-peritoneal, and even in intra-peritoneal wounds a fæcal fistula may form and recovery result. On the other hand, extra-peritoneal wounds of the large intestine may be followed by extensive infection with resulting fatal septicæmia. Makins states that extra-peritoneal wounds of the cæcum, ascending colon, and rectum are more dangerous than intra-peritoneal wounds and more likely to give rise to septicæmia.

Wounds of the viscera by large lead bullets and by fragments of shell, unless these wounds be extra-peritoneal ones of the large intestine, are, it is believed,

invariably fatal unless operated upon. The large size of the wounds makes the extravasation of the intestinal contents certain, and natural methods of repair impossible.

Treatment of Wounds of the Stomach and Intestines.—The treatment of intra-abdominal wounds is always operative whenever the operation can be done aseptically, and when the patient is not so shocked that he will succumb from the operation. In military surgery the treatment is ordinarily non-operative, and this entirely from the fact that the surgeon can neither control his aseptic technique nor has he the time and facilities for doing the required work; also, for the added cause that the military surgeon can rarely operate until it is too late. Relative to this, Makins says:

"It is true that to the civil surgeon, accustomed to surroundings replete with every modern appliance and convenience, and the possibility of exercising the most stringent precautions against the introduction of sepsis from without, abdominal operations (in South Africa) presented difficulties only faintly appreciated in advance; but this alone scarcely accounted for the want of success attending the active treatment of wounds of the intestine when occasion demanded. Failure was rather to be referred to the severity of the local injury to be dealt with or to the operations being necessarily undertaken at too late a date. Many fatalities, again, were due to the association of other injuries, a large proportion of the wound tracks involving other organs or parts beyond the boundaries of the abdominal cavity."

Operation should be done at the very earliest possible moment after the receipt of the injury. Every minute lost increases the chance of extravasation of the intestinal contents and infection. Statistics show conclusively that operations done within the first twelve hours have a much lower mortality than those done later. The surgeon should, therefore, wait only for recovery from the initial shock and for the preparation of the necessary operative appliances. The incision in the great majority of cases should be median, and always so when the stomach is involved, when the wound of entrance is located near the median line, or when a wound of the small intestine or bladder is suspected. Perforations of the cæcum and the colon call for lateral incision directly over the wounded organs, while laparotomy for the arrest of hemorrhage should always be by long median incision.

The abdomen having been opened, a search for perforations should be made systematically, otherwise a perforation may be overlooked, or, if several exist, some of these may be found and repaired and others remain undiscovered; and, unfortunately, such results may occur even after most careful and systematic search by the best operators. It is important that the search be as rapid as possible, for long-continued handling of the gastro-intestinal canal adds greatly to the shock of the operation. The ileo-cæcal junction is the best landmark for beginning the search; from here the small intestine should be traced rapidly

upward, each loop being returned as soon as examined, and the large intestine should be traced downward. Senn's method of inflating the intestines with gas may be of benefit after the abdomen has been opened.

The perforation having been found, its method of repair will depend upon its size and location.

Wounds of the intestine up to one inch and a half in length on the convex side can be closed without fear of causing intestinal obstruction; but if the wound be of the mesenteric side, it cannot be directly sutured unless very small; for, if it be large, the vascular supply to the intestines is correspondingly cut off, and also there may be produced at the seat of suture a sharp flexion which will cause intestinal obstruction. The suturing should be done with fine silk and an ordinary straight needle. Five or six Lembert's sutures to the inch will suffice.

When the wound in the intestinal wall is large, end-to-end approximation of the intestine by circular enterorrhaphy with Czerny-Lembert suture or Murphy's button should be done. Where double enterorrhaphy is required and the intervening portion of the small intestine is not more than two or three feet in length, it is best to resect it and use single rather than double union of the bowel, thereby more quickly completing the operation and decreasing the shock.

When a wound of the *stomach* is to be repaired it should be sutured in the direction of the blood-vessels—by turning the margins of the wound inward and bringing into apposition the healthy serous surfaces and uniting them by continuous or interrupted sero-muscular sutures.

Wounds of the hollow viscera having been repaired, the question of cleansing and draining has next to be considered. The use of sterile gauze sponges is to be preferred to irrigation, unless the fæcal extravasation or escape of stomach contents has taken place in quantity. Where the extravasation is localized it is better to cleanse with moist sponges, thereby avoiding the possibility of disseminating the infection, a result which too often follows irrigation. When the extravasation is so great and so widely disseminated that cleansing by sponging is impracticable, flushing the peritoneal cavity with warm normal salt solution should be done. The fluid is removed by turning the patient on his side, and then wiping the parts very carefully.

Drainage after gunshot perforation of any of the intra-abdominal organs is undoubtedly in all cases safer than to close the abdominal cavity completely. It is impossible to say, even in wounds in which there has been little apparent extravasation, whether or not dangerous infection has occurred. The aphorism of Tait, "*When in doubt, drain,*" is therefore an excellent rule to remember in the surgical treatment of penetrating abdominal wounds. It is also important to determine the probable position of the patient's body during the period of his confinement and to establish the drainage outlet at the most dependent point. For special details in regard to this matter the reader is referred to the article on Laparotomy in a later volume.

Wounds of the Solid Viscera.—Under ordinary conditions, bullets when unde-formed penetrate the solid viscera in such a manner as to produce fairly clean-cut channels. The danger usually is from hemorrhage, and, when this does not occur and the wound is not infected, traumas in these organs commonly heal readily. In fact, wounds by small-calibre missiles, except perhaps when made at extremely short range, are trivial injuries compared with those inflicted by large or deformed missiles, unless the bullet cuts one of the larger blood-vessels.

In wounds of the *liver* uncomplicated by hemorrhage, no special treatment is required. In civil practice, the abdomen having been opened and the exist-ence of a wound in the liver having been determined, a small gauze packing should be used, the end being brought out through the abdominal wall as a drain. Furthermore, when the wound is large and hemorrhage is taking place, the best means of controlling it is by plugging the wound in the liver with gauze, although in severe cases deep suturing, approximating the sides of the wound, may be indicated. When the gall bladder is wounded it may in some cases be sutured and a drain used, or the opened gall bladder may be sutured to the abdominal wall and a biliary fistula established, as in cholecystostomy. Cholecystectomy may be deemed advisable in some instances.

Wounding of the *spleen* seldom occurs without injury to other viscera, and there are no distinctive symptoms on which a diagnosis of a wound of this organ can be made, except a probable one based on the direction of the bullet track, or upon this combined with signs of hemorrhage. With small-calibre bullets, wounds of this organ may occur and no serious results follow. When a hemor-rhage from the spleen takes place it is usually severe. In some cases plugging of the wound, as is done with the liver, may check the bleeding. When, however, the wound is large and ragged and the hemorrhage excessive, splenectomy is the best method of procedure, and, if it be done early, the chance of recovery is good.

Wounds of the *kidneys*. Wounds of any part of the urinary tract are fraught with danger, particularly when any part of the urinary passages is cut, thereby giving rise to urinary extravasation. When the kidneys are wounded by small bullets without lesion to other viscera and the wound is not infected, the patient may go on to recovery with no grave symptoms. Like wounds of other solid organs, the danger is great when the trauma is made by a large or deformed missile or when the wound is infected. When the pelvis or calices of the kidney are opened, extravasation of urine into the peritoneal cavity or into the loin will occur, depending upon the position of the bullet track.

The symptoms of a wound of the kidney are usually not pronounced, though profound shock is frequently present. The direction of the bullet track and the appearance of internal hemorrhage or blood in the urine may be diagnostic. The hæmaturia may vary from mere blood-stained urine to almost pure blood. Clots may form in the ureter and bladder, blocking the former and almost filling the latter. If the wound is extra-peritoneal, urinary extravasation into the cellular

tissues will take place, giving rise to perirenal suppuration and abscess in the loin, ending, if the patient survives, in urinary fistula, which may eventually close spontaneously.

The treatment of uncomplicated wounds of the kidneys consists in the enforcement of rest, together with the administration of opium for the hæmaturia when this is pronounced. When the injury is made by a small-calibre bullet, renal hemorrhage in sufficient amount to require the removal of the kidney as a primary step will rarely occur. On the other hand, where there is evidence of internal hemorrhage, unless the surgeon is absolutely sure that the kidney only is wounded, exploratory laparotomy should be done. If, on opening the abdomen, the hemorrhage is seen to come from the kidney region, the kidney should be exposed by holding the intestines out of the way with suitable gauze sponges and the peritoneum should then be incised sufficiently to give access to the wound. If the hemorrhage is severe and the pelvic part of the kidney is injured, nephrectomy should be done at once unless the surgeon feels that the hemorrhage can be controlled by careful packing (the packing possibly being brought through a wound in the loin), or when, upon palpation, he finds the other kidney presumably diseased or absent. If nephrectomy is decided upon, the kidney should be lifted out of its fatty cushion, the pedicle ligated with strong sterile silk or kangaroo tendon, and cut at a safe distance from the ligature. Counter drainage through the lumbar region should always be made before the abdominal wound is closed. When the wound inflicted upon the organ is known to be extra-peritoneal and demands operation, the organ should be reached through the loin by an oblong incision, beginning about an inch below the lower rib and extending from the quadratus lumborum muscle downward and forward to a point above the anterior superior spine of the ilium. Also oblique and transverse incisions are employed for this purpose. Through this opening the kidney is carefully examined, the wound in it sutured if necessary, or packed, and a drain inserted. Careful packing and drainage will ordinarily control the hemorrhage, and, if the wound involve the pelvis of the kidney, a channel will be given for the escape of the urine, preventing troublesome and dangerous urinary infiltration. One of the most distressing conditions in wounds of the kidney, with hemorrhage into the pelvis, is the accumulation of blood in the bladder. This coagulates and is then most difficult to remove. For treatment a large urethral catheter should be inserted into the bladder and direct aspiration through it be made with a syringe. Should this fail, the bladder should be emptied through a perineal or suprapubic operation. When a wound of the kidney is infected, primary measures for thorough drainage should be instituted. Should suppuration of the kidney occur, nephrectomy or nephrotomy will be indicated, according to the particular conditions present.

Wounds of the Pelvic Region.—When the pelvic soft parts or bones only are injured, the conditions present and the treatment are those of ordinary flesh

wounds or compound fractures. When the pelvic bones are struck by bullets there is usually not much comminution, and this is particularly true of wounds inflicted by small-calibre missiles. With these missiles the pelvic bones may be grooved or punctured, and, if the wound is uninfected, very little ill effect may follow. When a bullet passes through the pelvic cavity, intrapelvic organs may or may not be injured. The organ injured is most commonly the urinary bladder, although wounds of the sigmoid flexure and rectum are not infrequent. Wounds of these organs, like those of other contiguous viscera, may be either intra- or extraperitoneal, and should be sought for and repaired as are wounds of other parts of the intestinal tract.

Wounds of the urinary bladder may be either extraperitoneal or intraperitoneal, or, if the bullet passes through the bladder, one wound may be extraperitoneal and the other intraperitoneal. The experience of the Anglo-Boer war appears to show that extraperitoneal wounds of the bladder are more dangerous than the intraperitoneal ones. These conclusions were based upon injuries-received from small-calibre bullets, when it appears that, if the bladder is wounded intraperitoneally, the urine escapes into the peritoneal cavity, and the contraction of the bladder will so approximate the sides of the wound that it may heal and recovery follow. If the wound be uninfected, the escape of sterile urine into the abdominal cavity does not appear to be at once of vital importance. On the other hand, extraperitoneal wounds are very frequently followed by suppuration, cellulitis, and septicæmia—in fact, by all the evil results of urinary infiltration, combined with the infection which almost invariably follows. When a small-calibre bullet passes intraperitoneally through a distended bladder, it may, when travelling at very high velocity, produce extensive ruptures of the organ. If, however, the bullet has been discharged at a moderate velocity and at long range, the wound corresponds in size to the calibre of the missile, and, when the bladder is evacuated, the contraction of its coats reduces such a wound to a very small size.

Symptoms and Diagnosis of Wounds of the Bladder.—The two symptoms that are most to be relied upon in diagnosing perforation of the bladder are hemorrhage and an empty bladder. The extraperitoneal wounds are usually characterized by the hemorrhage; the intraperitoneal wounds, by the escape of the urine into the peritoneal cavity. Where the wound is made by a small-calibre missile, such complete emptying of the bladder and loss of function may not result. In intraperitoneal wounds of the bladder, the opening may be disclosed by the leakage following injection into the bladder of a moderate amount of sterile normal saline solution, or by the escape of air if this be used instead of water. In a suspected extraperitoneal wound, injection of the test fluid, together with palpation through the rectum, may determine the existence of the injury. Definite information is obtained by suprapubic incision of the bladder, the wound being repaired through the opening so made, after which free drainage should be pro-

vided either above the pubis or through the perineum. Where operative treatment is not instituted as a diagnostic measure, the later determining symptoms will be the occurrence of septic peritonitis as a result of the intraperitoneal wound and urinary infiltration, cellulitis, or septic toxæmia as the result of the extra-peritoneal injury.

The *treatment of gunshot wounds of the bladder* depends, as it does in penetrating wounds of the abdomen, upon the facilities commanded by the surgeon. In civil practice the abdomen should be opened, to the end that the wound in the bladder be closed. Experience has clearly demonstrated the great value of early laparotomy and suturing of the vesical wound as life-saving measures in the treatment of intraperitoneal wounds of the bladder. Before opening the abdomen, the penis should be carefully cleaned and the urethra washed out with a mild antiseptic solution and a sterile catheter inserted. During the operation, if the operator has difficulty in finding the wound in the bladder wall, distention of the bladder through the catheter introduced, as above indicated, will readily locate the wound by the escape of fluid through it. The catheter is then retained in the bladder, fastened in position, and used to drain the bladder by siphonage. This is accomplished by attaching a rubber tube to the catheter and inserting its lower end beneath the surface of an antiseptic fluid placed in a receptacle two or three feet below the level of the bladder.

In suturing the wound in the bladder two rows of sutures should be used, the first preferably of catgut and the second of silk; the first should be buried, as in the Lembert stitches. If the patient's condition permits, it is advisable immediately to distend the bladder after suturing, and if leakage is found the defect should be remedied by additional stitches. The urethral siphonage should be continued for seventy-two hours after the operation, and thereafter frequent aseptic catheterization should be done.

In *military* surgery, laparotomy for a wound of the bladder is usually at first contra-indicated for the same reason as is operative treatment of intestinal injuries, the surgeon being entirely influenced by his ability to control asepsis and by the time at his disposal.

When the wound in the bladder is found to be extraperitoneal and its situation admits, it should be sutured carefully and a drain should then be inserted from the skin through the tissues down to the wound. The bladder should be siphoned in the same way as for intraperitoneal wounds. Under favorable conditions the bladder wounds will heal readily, or there will result a urinary fistula which will ordinarily close spontaneously. Where the wound cannot be sutured, thorough drainage, leading to the establishment of a urinary fistula, should be instituted. In military surgery the treatment of extraperitoneal wounds is determined by the symptoms which occur. When urinary extravasation occurs, or symptoms of cellulitis or septicæmia appear, the wound leading to the bladder

should be thoroughly explored, carefully cleansed and thorough drainage instituted.

Gunshot Wounds of the Urethra have the same significance and are to be treated in the same way as are cases of rupture of the urethra. The immediate danger from this condition is caused by extravasation and retention of urine, due to the mechanical difficulties in the way of spontaneous urination, with resulting infection and cellulitis. The over-distention of the bladder demands immediate relief, either by catheterization or by suprapubic or perineal operation. An attempt should at once be made, by enlargement and exploration of the wound, to locate the opening in the urethra and then to insert a catheter. If catheterization is accomplished, the instrument should be kept in place until perineal section can be practised, which should be done as soon as circumstances will permit. If the effort at catheterization fails, perineal section should be done at once, when possible, and every attempt should be made to find the wound in the urethra and then carry a catheter through it into the bladder. This failing, a drain should be inserted in the wound and supplemented by gauze, so that it may not interfere with drainage. If the bladder is over-distended, suprapubic aspiration should be performed, and as soon as the bladder recovers its tone the urine will usually be expelled through the drain and surrounding gauze. If the urine does not escape freely, or if there is danger of urinary extravasation, perineal section should at once be resorted to. In any case, where there is over-distention of the bladder, immediate relief may be had by suprapubic puncture.

Wounds of the testicles are of importance according to the size of the missile by which they are inflicted. With the jacketed small-calibre missile, the scrotum and testicles may be perforated and very little injury be done, the wound healing readily and producing no after-trouble. If the injury be caused by a deformed missile or by a large bullet, intense pain, with vomiting, pronounced shock, followed by hæmatocele, great swelling, and inflammation of the parts may result. The tunica vaginalis or the testicle itself may become infected and suppurative inflammation result.

The treatment of wounds of the testicle is tentative unless they be manifestly infected, when the wound should be thoroughly laid open, cleansed, and drained. Suppurative infection of the testicle proper will nearly always necessitate removal of the organ.

Wounds of the Extremities. —*Frequency and Fatality.*—Wounds of the extremities outnumber those of all other parts of the body, but their fatality is low. If the upper and lower extremities be taken together, about 70 per cent of all wounds are of these parts of the body. In the Civil War 88,793 wounds of the upper extremities and 86,413 wounds of the lower extremities were recorded, a proportion to the entire number of wounds of 70.8 per cent. In the Spanish-American war 429 wounds of the upper extremities and 504 wounds of the lower extremities were tabulated, a proportion to the entire number of 66.68 per cent.

The proportion of fractures to flesh wounds in both the upper and the lower extremities is about as one to two. In the Civil War 54,801 flesh wounds and 32,992 fractures of the upper extremities were recorded, a proportion of slightly less than two to one. In the Spanish-American war 289 flesh wounds and 140 fractures were tabulated, a proportion of almost exactly two to one. Of the lower extremities 59,139 flesh wounds and 27,274 fractures were given for the Civil War, a proportion of a little more than two to one. In the Spanish-American war 354 flesh wounds and 150 fractures were reported, a proportion of two and one-half to one. The proportion of flesh wounds to fractures is, therefore, somewhat greater in the lower than in the upper extremities, a fact which might be expected from the greater amount of soft parts about the bones in the lower limbs.

NUMBER OF CASES AND MORTALITY FROM GUNSHOT WOUNDS OF THE EXTREMITIES IN THE CIVIL WAR AND THE SPANISH-AMERICAN WAR (UNITED STATES REGULARS).

	Cases.	Died.	Mortality.
Upper Extremities :			
Civil War...	87,793	5,608	6.5
Spanish-American War.............................	429	1	.2
Lower Extremities :			
Civil War...	73,665	11,813	13.8
Spanish-American War..............................	652	9	1.6

Mortality and Results of Treatment.—It is in the wounds of the extremities that the use of the small-calibre rifle and modern surgical methods have produced the great saving of life and limb. Wounds of other regions of the body, particularly of the head and abdomen, present but moderate reduction in fatality, but wounds of the upper and lower extremities have been surprisingly less fatal in wars where the small-calibre bullet has been used and where the wounds have been treated by aseptic and antiseptic means and by the expectant and conservative treatment which is a natural concomitant of these methods.

WOUNDS OF THE EXTREMITIES TREATED BY EXCISION AND AMPUTATION, AND BY CONSERVATISM, AND THE RELATIVE MORTALITY OF EACH TREATMENT FOR TWO YEARS.

War.	WOUNDS OF EXTREMITIES.		AMPUTATIONS AND EXCISIONS.		Percentage of Operations to Wounds.	Operative Mortality.	Conservative Mortality.
	Total.	Deaths.	Total.	Deaths.			
Civil..........................	174,206	17,421	12,193	2,636	6.99	21.4	9.1
Spanish-American...............	991	10	32	6	3.20	18.7	.4

Thus, in the Civil War, while the mortality of all wounds of the extremities, upper and lower, was from 6.5 to 13.8 per cent, similar wounds in the Spanish-American war had a total mortality of but 1.8 per cent. The number of deaths in the latter war from wounds of these regions is surprisingly small, but 10 in 991 cases; and of these 10 cases, 3 died very shortly after the receipt of their injuries, probably from hemorrhage. The difference in treatment adopted in these wars is not less great than the mortality.

This table shows at once: (a) The small number of operations done or required to be done in wounds of the extremities since the adoption of the new rifle and modern surgical methods—the proportion having been reduced over one-half (6.99 to 3.20); (b) the great decrease in mortality in these cases, the mortality being reduced over twenty-two times in cases treated conservatively (9.1 to 0.4), and somewhat decreased in those treated by amputation or excision.

The high mortality in operation cases makes it probable that only the extremely serious cases were operated on. In the Spanish-American war, in the cases reported among the regulars, the deaths that occurred were all from high amputations.

RESECTIONS AND AMPUTATIONS AND DEATHS FROM THESE OPERATIONS IN THE SPANISH-AMERICAN WAR (REGULAR TROOPS).

	Resections.	Amputations.	Deaths.
Arm	1	4	1
Forearm	1	2	0
In hand	0	13	0
Hip joint	0	2	2
Thigh	1	5	2
Knee	0	1	1
Leg	0	1	0
Ankle	0	1	0
Total	3	29	6

No deaths from resection.

From this it may be formulated that the use of the small-calibre rifle and the adoption of modern surgical methods have together greatly reduced the loss of life and limb in gunshot wounds of the extremities.

The change in treatment and the results obtained in gunshot wounds of the joints have already been discussed under that head. The tables there given show the tremendous reduction in mortality in wounds of the articulations in recent wars, for, while gunshot wounds of the knee in the American Civil War gave 53.7 per cent of mortality, in the Spanish-American war these injuries gave but 5.5 per cent. Wounds of the ankle, shoulder, elbow, and wrist in the American Civil War gave from 12.9 per cent (wrist) to 31.1 per cent (shoulder) fatal-

ity, while in the Spanish-American war there were no deaths from wounds of these joints. These figures alone are sufficient to demonstrate the wonderful results obtained through modern methods.

COMPARATIVE MORTALITY OF COMPOUND FRACTURES IN THE CIVIL AND SPANISH-AMERICAN WARS, ACCORDING TO TREATMENT ADOPTED.

	CIVIL WAR.		SPANISH-AMERICAN WAR.	
	Treated Conservatively.	Treated by Amputation or Excision.	Treated Conservatively.	Treated by Amputation or Excision.
Arm	14.3	26.0	0.0	*20.0
Forearm	6.4	13.9	0.0	0.0
Thigh	49.19	62.4	0.0	*57.1
Leg	13.8	30.5	0.0	0.0

* One operation only.

The treatment in compound fracture by gunshot has been as radically changed, and for the better, as has been the treatment for gunshot wounds of the joints. This is shown in the following table, where it will be observed that there was a mortality of from 6.4 per cent to 49.19 per cent in cases of gunshot fractures treated conservatively in the Civil War, while in the Spanish-American war all cases so treated recovered. The same table shows that while there was 13.9 per cent to 62.4 per cent mortality after amputation and excision in the Civil War, the mortality from operative treatment in the Spanish-American war was from 0 to 57.1 per cent. The apparently high mortality at 57 per cent is due to the fact that there was but one operation for amputation in the thigh in the Spanish-American war and this terminated fatally.

CASES, OPERATIONS, AND DEATHS FROM COMPOUND FRACTURES OF EXTREMITIES, UNITED STATES REGULARS, SPANISH-AMERICAN WAR.

	Cases.	Died.	Resections.	Amputations.	Deaths from Amputations.
Arm	18	1	1	4	1
Forearm	26	0	1	2	0
Thigh	30	4	1	6	4
Leg	26	0	0	1	0
Total	100	5	3	13	5

	Per cent.
Mortality in all cases	5.0
Operative mortality	31.2
Conservative-treatment mortality	0.0

From this table it will be seen that, as with wounds of the joints, conservatism is made possible in gunshot fractures by the aseptic nature of the wounds made by the small-calibre bullet, and that, aided by aseptic methods, conservatism has reduced the mortality in these cases to an extent almost beyond belief. The

gravity of compound fractures depends mainly upon the presence or absence of infection; and where this can be excluded or prevented, traumatisms of the bones heal as well as do traumatisms of other tissues. In the Spanish-American war 100 gunshot fractures of the extremities, exclusive of the foot and hand, were reported among the United States regulars. In these 100 cases there were but 5 deaths, and these only in cases operated on.

It is to be noticed that the deaths all occurred after high amputations, 2 being amputations at the hip joint, of which both died; 2 amputations in the middle third of the thigh, with 1 death; and 2 amputations in the lower third, with 1 death. The death from amputation of the arm was in a case operated on at a dressing station, death occurring eighteen days later, probably the result of infection due to operation in septic surroundings. The results tabulated in the tables given show most emphatically that in military surgery conservatism should be practised in all cases possible.

When operative measures have to be adopted, the question of excision or amputation will arise.

Excision in the shaft of the long bones has been unfavorably considered by military surgeons in the past. The mortality from this operation has been greater than that from amputation, and the functional use of the part has, as a rule, not been good. It is to be noted, however, that the extensive statistics now available are from wars in which aseptic and antiseptic methods were unknown, and that in recent wars operations have been too few to warrant conclusions. It would seem that, with the resources of antisepis and asepsis, limbs could be saved in many cases by recourse to excision and without greater danger than is entailed by amputation.

The reduced, though still high, mortality from amputations shown above, like the high mortality from amputations for wounds of joints, is undoubtedly due to these operations being done only in the worst cases. Amputations and excisions will, of course, still be necessary in gunshot fractures when destruction of the soft parts is great, when the main vessels of the part are severed, and when infection, if present, cannot be controlled. Conservatism, however, is the rule, in these cases. In military surgery the results from this line of treatment and the decreased mortality in gunshot wounds of the bones of the extremities are such that it may be said that the use of the small-calibre rifle and modern surgical methods have together greatly reduced the mortality in gunshot fractures of the extremities.

Gunshot Wounds of the Upper Extremities.

All possible conservatism should be practised in wounds involving the upper limb. The loss of a part of a lower extremity can be quite well remedied by a properly applied artificial limb, but in the upper extremity no adequate mechani-

cal limb has ever been devised, or one which is a good substitute even for a hand and arm whose function has been greatly reduced. Fortunately, the upper extremity, from the free anastomosis of the blood-vessels and the comparatively large blood supply, is quite favorable for conservative treatment. In general, it may be stated that it is only in cases of extensive destruction of the soft parts, involving the main arteries or the nerves, or where dangerous inflammatory action is present, that radical measures, especially amputation, are required.

Wounds of the Shoulder.—In the Spanish-American war 29.6 per cent of all wounds were of the upper extremities, and of all the joint wounds 12 per cent were of the shoulder. In wounds involving the shoulder joint all varieties of injuries may be seen, from mere wounds of the articular capsule to those in which the head of the bone is greatly fragmented or even pulverized. With the modern small-calibre rifle bullet and the small revolver bullet, the capsule of the bone may be injured and the bone escape. Delorme has pointed out that wounds of the capsule of the shoulder joint, unaccompanied by injury to the bone, may be caused by the bullet passing from before backward, or in the reverse direction, between the acromion process and the head of the humerus. In the Civil War 72 such cases were reported, with a death rate of about 8 per cent. All these were treated conservatively and indicate the propriety of such treatment in these cases. When the head of the humerus is struck by a projectile, the amount of comminution will depend largely upon the size of the missile, and, to a less degree, upon its velocity. Fragments of shell and deformed bullets will produce extensive fragmentation of the bone. Undeformed bullets of small calibre which strike the head of the humerus above the anatomical neck will usually groove or perforate the bone, sometimes without solution of continuity. More frequently, however, radiating fissures will extend outward, making a complete fracture. When the bullet strikes on or just below the anatomical neck, there is generally some fragmentation of the bone, and the head may be broken into two or three pieces. When the bullet strikes the surgical neck, the amount of fragmentation, owing to the density of the bone, is usually considerable, but the character of the injury is generally different from that of wounds of the head, for, the injury being largely below the joint cavity, it may in most cases be considered and treated as a fracture of the shaft of the bone. On the other hand, fractures through the anatomical neck and of the head of the bone, being within the joint cavity, may produce decided functional impairment, through the formation of large callus within the joint or by the presence of the loose head or its fragments.

Treatment.—Wounds of the capsule of the joint, unless infected, are to be treated conservatively by surgical dressing and immobilization of the limb. Where the bones are involved, or the wound infected, three lines of treatment —(*a*) conservative, (*b*) amputation, and (*c*) excision—have to be considered. Conservative treatment, as before stated, gives particularly favorable results in

wounds of the upper limb. The limb can be immobilized, and in military surgery the patient can be moved with much less danger than is possible in a fracture of the lower extremity. In non-infected wounds the amount of fragmentation of the bone, provided the great vessels and nerves remain intact, is no indication for operative treatment. Displacement of bone fragments, with accompanying pressure upon the nerves or blood-vessels, requires the conservative operation of removing the fragments or wiring them in place. So great is the need for preserving the upper limb that the surgeon is warranted in running some risk in order to save the part. This extra risk is the slightly increased mortality which follows the secondary operation of amputation or excision rendered necessary by the failure of conservative treatment.

When conservative treatment fails, secondary excision may be successfully performed, and, though the humerus is shortened or the shoulder joint stiff, these conditions are nothing as compared to the loss of the forearm and hand by amputation. It must be pointed out, however, that conservatism in these cases does not necessarily mean non-interference. In fact, in all cases of wounds involving the cavity of the joint, with fragmentation of bone, the surgeon should, unless there be a contra-indication, open and explore the joint under aseptic technique. In this way he will learn the condition of the fracture as regards comminution and displacement of the fragments, the presence of loose splinters, or the detachment of the head of the humerus if such has occurred. Following such exploration, the removal of all entirely detached fragments and the replacement of the main portions of the bone may be done. Large fragments seldom require removal, and no fragment, unless quite detached, should be removed unless it cannot be returned to its original position. When the wound is aseptic, replaced fragments may be expected to unite, although usually with the formation of a large amount of callus. Immobilization of the joint may be effected by means of suitable splints placed on the outer and back side of the arm and extending from the elbow to the point of the shoulder. Careful padding of the axilla and inner side of the arm with cotton or other suitable material should always be done. Stromeyer's cushion is excellent for the purpose of fixing the arm and shoulder joint in the case of gunshot fracture. It is a very useful immobilization apparatus, either when the patient is kept in bed or when he has to sit up or be moved about, at which time the cushioned arm should be supported in a sling.

The results following conservative treatment of the shoulder will necessarily vary according to the amount of damage done by the bullet. In some few cases perfect movement may be preserved in the joint. In the larger proportion there will be considerable limitation to the motion. The remaining cases will end in ankylosis, partial or complete. The great tendency to ankylosis is a strong indication for the early employment of passive motion. The joint does not readily admit of the effective use of this procedure, in consequence of the

mobility of the scapula, and for this reason care should be taken to fix the scapula as much as possible when moving the arm. If possible, slight passive motion should be begun as soon as ten days after the receipt of the injury.

Excision.—Formal excision of the upper end of the humerus is now rarely indicated, except as a secondary operation to overcome ankylosis. The primary excisions are usually informal and consist in the removal of fragments of bone at the time of the exploration of the wound. Even in infected cases thorough exploration of the wound, with removal of the loose fragments and drainage, should be first instituted, and later, if healing does not occur or the injury heals with ankylosis, secondary excision in order to restore motion may be practised.

Amputation.—At the shoulder joint amputation is rarely necessary except where there is a large amount of destruction of the soft parts, or especially where the main vessels and nerves of the limb are implicated. Extensive comminution of the bone does not call for primary amputation, but rather for the removal of the loose fragments and conservative treatment, as has been indicated; but when, together with the fracture, the main vessels are injured, and there is a probability of gangrene resulting through lack of nutrition, early and prompt amputation is required.

Where the main nerves are not entirely destroyed, and it is possible to save the limb, this should be done, for even a partially paralyzed arm and hand are better than a mechanical substitute. When the paralysis is complete and the limb is in the patient's way, it can be removed later by secondary amputation if required. Secondary amputation at the shoulder may be rendered necessary by the occurrence of secondary hemorrhage which is not amenable to other treatment, or by suppurative and inflammatory processes of long duration which destroy the function of the limb and endanger the life of the patient.

Gunshot fractures of the humerus will rarely require other than conservative treatment, except under the conditions already given, the same conditions by which excision or amputation at the shoulder joint is necessitated. The fact that no joint is involved makes these cases usually easy to treat, and the probability of good functional results is correspondingly increased. If formal or informal excision has to be done, a very useful limb may be obtained, even though the humerus be considerably shortened.

Gunshot wounds of the elbow joint are eminently suited for conservative treatment, and this is particularly true of those resulting from rifle bullets. Even though all the bones entering into the formation of the joint are fractured, an attempt should be made to save the limb, unless there is accompanying extensive destruction of the soft parts and laceration of the main vessels and nerves. The aim of conservative treatment should be not only to save the limb, but to obtain a movable joint. Unfortunately, this ideal result cannot always be obtained. Ankylosis is almost sure to occur in cases in which the opposing bones of a joint

are fractured, but some motion of pronation and supination may be retained when the head of the radius has escaped injury. Unfortunately, the cases in which movable joints are obtained are rare, but, unless the amount of comminution of the bones is extensive or the wound infected, the surgeon should exhaust every means to prevent ankylosis, as by the early use of passive motion and

Fig. 212.—Fracture of Arm from a Revolver Bullet (.45 Calibre). Skiagraph showing much comminution of the bone and involvement of the joint, with lodgment of pieces of missile. Conservative treatment. Recovery with movable joint. (Spanish-American war case.)

massage. Even in infected wounds, our modern methods of antisepsis may be depended upon to limit or reduce the inflammatory processes. The conservative treatment of wounds of the elbow joint, like those of the shoulder, consists in exploration of the wound, whenever necessary, together with the removal of all loose bone fragments and the replacing of those not entirely detached. Having in mind the probability of ankylosis, the surgeon should flex the forearm at a right angle with the arm and place the hand in a position midway between

pronation and supination, so that, if ankylosis does occur, the elbow will be fixed in its most serviceable position. Where the wound is not infected, passive motion should be instituted at as early a date as would be done in an ordinary simple fracture. In infected wounds, thorough irrigation with a solution of bichloride of mercury, removal of all fragments, with good drainage, should be resorted to. The best result that can be hoped for in these cases is the healing of the wound with ankylosis.

Excision of the elbow was not highly esteemed in pre-antiseptic days. Now, however, with modern aseptic and antiseptic methods this operation is done with the assurance that the patient will secure a serviceable limb. Experience has shown that anklyosis almost invariably follows partial operation on the elbow joint. In view of this fact, the possibility of producing a movable joint by more extensive removal of the fragments of the bones which enter into the formation of the joint should be considered. Elbow excision is indicated in cases of continuous suppuration and in those cases where ankylosis has occurred with malposition of the limb or where the patient is extremely desirous of having some motion in the part, and careful excision of the elbow joint will usually result in some degree of motion and, in some cases, in almost as much flexion and extension as could be desired. In doing this operation, however, the surgeon must bear in mind that, if he does not remove more of the bone than simply the articular ends, immobility will follow. After the operation electricity, massage, passive movements, etc., should be employed carefully and persistently.

Fibrous ankylosis the result of gunshot injury is less amenable to treatment by forcible flexion and extension under anæsthesia than is the similar condition which results from ordinary fracture of the joint. Usually repeated breaking up of the adhesion under anæsthesia, together with persistent use of passive motion and massage, will have to be employed to obtain motion in the joint.

Primary *amputation* is rarely required in a gunshot wound of the elbow, unless the injury be by shell fragments of such size that the soft parts have been greatly damaged, the bones of the articulation exceptionally shattered, and the main vessels and nerves severed.

Gunshot Fractures of the Forearm.—The bones of the forearm are very hard and brittle, consequently the amount of comminution at the point of impact of the projectile is generally considerable. When the injury has been inflicted by a shell fragment both bones are usually broken, but in bullet injuries one bone frequently escapes. Hemorrhage from the large vessels is a common complication in gunshot injury of the forearm, but is readily treated by ligation of the vessel in the wound.

Treatment of gunshot injuries of the forearm, except in rare cases, should be directed toward the preservation of the limb. The free anastomosis of the blood-vessels particularly favors this treatment and it is usually followed with success unless there is extensive disorganization of the soft parts.

Conservative treatment is particularly indicated where there is but one bone broken; and fracture of both bones, unless the destruction of the soft parts is so great as to render the occurrence of gangrene certain, should also be treated conservatively. The treatment of fractures of the forearm where but one bone is involved is comparatively simple. Where both bones are fractured, the possibility of the formation of an osseous union between them, with resulting loss of rotation of the radius, should be remembered and prevented if possible. To this end the surgeon should explore the wound and remove all bone fragments which invade the interosseous space, and put up the arm, if practicable, with interosseous pads and splints and sufficient wadding to prevent the contact of the retaining bandages with the arm. During convalescence, passive motion of the elbow, wrist, and fingers should be persistently employed.

Primary resection of the bones of the forearm is rarely indicated and should be resorted to only when it is a choice between this operation and amputation.

Gunshot Wound of the Wrist.—On account of the size of the wrist bones relatively to that of the missile, it is impossible for a bullet to traverse this joint without fragmentation of the bones to a considerable degree. As a result, bony ankylosis is almost sure to follow such injury. Conservative treatment is to be adopted in all cases of bullet injuries of the wrist and carpus. It is only in large wounds of the part, with extensive destruction of tissue, that amputation is ever justifiable. Where the wound is infected, exploration, with the removal of all loose fragments, drainage, and repeated daily irrigation, should be practised, the result being invariably a firm ankylosis. When the bullet has traversed the part and produced an uninfected wound, early and persistent massage and passive motion afford the only means by which complete loss of motion may be prevented. Having in mind the impaired function which almost invariably follows the receipt of gunshot of the wrist, the surgeon who has an x-ray apparatus available and can operate aseptically should carefully examine these cases, and, if there be displaced bone, he should explore the wound and remove the loose fragments. It is perhaps justifiable under aseptic technique to explore all of these wounds and remove or replace the fragments. Without such exploration ankylosis almost invariably occurs, while by operating the surgeon may put the parts in a more favorable condition. This method of treatment should certainly be practised in all cases of comparatively large wounds and where the bones are considerably shattered. Following such injury there is always obliteration of the synovial sacs and binding together of the numerous tendons which are in such close relation with the wrist joint. The small size of the bones of the wrist and the hand cause them to be greatly fragmented when struck by a bullet, and, from the close proximity of the tendons and the tendon sheaths, bone fragments are driven into or against the latter and a large callus involving the tendons or interfering with their free movement is produced. Only by early operation and thorough removal of these fragments can such result be obviated.

Fig. 213.—Pistol (.38 Calibre) Wound of the Hand. Skiagraph showing characteristic destruction of the shaft and shortening of the metacarpal bones, with lodgments of fragments of bullet.

Excision of the wrist is rarely performed as an early operation. The result of such operation has usually been no better than that obtained through conservatism.

Late excision may be practised where there is necrosis of the bones with continued suppuration, or where there is ankylosis of the wrist bones with little involvement of the tendons. In such cases operation by the Lister method may be followed by an excellent result. In suppurative cases firm union at the wrist and the mobility of the thumb and finger joints may be obtained. In uninfected cases where the injury is entirely confined to the wrist articulation, a clean excision may give a partially movable wrist, provided passive motion and massage are early instituted and persistently carried out.

Gunshot Wounds of the Lower Extremities.

Wounds of the Hip Joint.—Wounds of the hip joint are the most serious joint wounds made by gunshot. The large size of the joint cavity favors extensive and dangerous inflammatory action when the wound is infected, and the depth of the joint makes operative treatment difficult. When infection occurs in the hip joint the mortality is exceptionally high; and, when the injury is so severe that extensive operation is required, the probability of a fatal outcome is very great.

Both the diagnosis and the treatment of wounds of the hip joint are surrounded with difficulties. When the capsule alone is injured there will be no immediate symptoms, and, unless the wound is infected, the case may recover with little trouble. When the wound is infected, the great depth of the infection delays early detection of the inflammatory processes, and the pathological changes, therefore, may have progressed so far as to make the treatment both difficult and uncertain. The difficulty in making a correct diagnosis in cases of gunshot wound involving the hip is found in the anatomical conditions present in that joint. The joint is so deeply placed that the ordinary signs of fracture are often extremely difficult to make out. The bullet track passes through deep masses of tissue, and, from after-movement, the wounds of entrance and exit may not coincide with the position which they occupied when the trauma was received. Also, in gunshot wounds of the upper end of the femur the ordinary physical signs of fracture may be absent. There may be neither shortening of the limb nor eversion of the foot nor discernible crepitus. In some cases the fracture may not be complete, especially when the injury is made by a small-calibre bullet travelling at low velocity. The large size of the head of the femur and its spongy texture favor grooving or perforation without complete separation of fragments. In these cases, and even in cases where the fracture is complete, the patient may be able not only to move the limb, but to walk. Many cases of incomplete fracture have been made complete by the wounded person

walking after receipt of the injury. One case of this sort came under the observation of the writer during the Spanish-American war. In this instance the bullet, as shown by the x-rays, passed through the bone at the junction of the upper portion of the great trochanter with the neck. The wounded man walked some distance, then increased disability occurred, the trouble being found to be a fracture extending inward from the place where the bullet had guttered the bone. Even where the fracture is complete, well-authenticated cases are recorded of the patient's walking some distance after the receipt of the injury. The small amount of immediate disability observed in some cases, together with the absence of shortening and eversion of the foot, is probably due to the fact that the small-calibre bullet may even completely fracture the upper end of the femur and the lines of fracture may extend into the hip-joint, and at the same time there will be little or no displacement of the fragments. The firm fibrous tissue about the bone, especially where the capsule is attached to it, might hold the fragments in place until they are forced apart by considerable strain. Difficulties in the diagnosis of these cases are therefore met with, and, in obscure cases, the surgeon has to determine whether he shall treat such cases conservatively or whether he shall enlarge one of the wounds and determine by actual examination whether or not the bones entering into the formation of the joint are fractured. Even should he elect the latter course, the difficulty of discovering the fracture by exploration of the wound may be great. The depth of the joint renders it extremely difficult, and in some cases impossible, thoroughly to explore it with the finger unless the incision be made very large and the joint cavity freely opened. Instrumental exploration through the wound is practically valueless. When the x-rays are available, all difficulty of determining the presence of fracture, its amount, and kind, is quite overcome. In doubtful cases in military practice the best procedure is to treat the case tentatively until an x-ray examination can be made, or otherwise to persevere in tentative treatment until it becomes plainly evident that fracture has occurred. Possibly in civil practice, where the conditions are favorable for aseptic operation, the surgeon might be justified in laying one of the wounds freely open and thoroughly examining the joint. Under these conditions, if the joint be found intact, the operation wound is a comparatively trivial matter, for primary healing with no subsequent injury to the patient may be expected. On the other hand, should the surgeon find a fracture, he will be able to determine its extent and institute the proper procedures for its treatment. Then, besides, if the wound contains foreign material which would infect it, the operation gives opportunity for its removal. In military surgery, tentative treatment by immobilization of the joint and the application of occlusive dressings is to be instituted in all cases, except those in which the surgeon is sure that the wound is infected, or where there is extensive injury to the soft parts by a shell fragment with involvement of the bone. In military surgery this conserva-

tive treatment of wounds of the hip joint has been as successful as the same treatment applied to wounds of the knee joint.

In determining whether or not a bullet which has traversed the upper portion of the thigh has injured the joint, careful observation of the probable track of the missile is of importance. The surgeon should be familiar with the areas through which a bullet must pass if it is likely to impinge upon the bone. Stevenson gives as a dangerous region "a triangle the angles of which are at the spine of the pubes, the anterior inferior spine of the ilium, and the outermost point of the great trochanter." A bullet wound of this region should be regarded as highly indicative of involvement of the joint.

Treatment of Gunshot Wounds of the Hip.—Expectant treatment of these wounds is particularly to be recommended in military surgery, unless the wound is large and manifestly infected. In ordinary bullet cases, such expectant treatment, combined with the necessary immobilization, will give a high percentage of good results. It is necessary to state that all cases treated on the expectant plan should be most carefully watched for beginning signs of inflammation, in order that, should such appear, the surgeon may at once explore the wound, remove the infectious material, institute drainage, or proceed to other more radical operative measures when necessary.

Conservative treatment of hip-joint cases, especially in military surgery, may be considered as combining expectant with such later operative measures as may be indicated. In pre-antiseptic days, conservative treatment of wounds of the hip joint, as shown by Otis in the "Surgical History of the War of the Rebellion," was followed by extremely disastrous results. He reports 252 authenticated cases of gunshot wounds of the hip treated conservatively, and in these there were but 3 recoveries—a mortality of 98.8 per cent. In considering these results it is to be borne in mind that the conservative treatment of pre-antiseptic days was entirely different from the conservative treatment of to-day. Then conservative treatment meant simply non-operative treatment, the wound itself being in each case explored by dirty fingers and probes and treated with wet dressings which were in no wise clean. Under such conditions the patient could not escape secondary infection of the wound even when the wound was primarily sterile. The condition is identical both in treatment and in results with the pre-antiseptic treatment of wounds of the knee and other joints, except that in knee cases amputation was always recommended whenever the joint was wounded, in order to give the patient some chance of recovery by removing the large joint, inflammation of which was almost always disastrous, while amputation at the hip joint, from the high mortality of the operation itself, could not be as unqualifiedly advocated.

Modern methods of antisepsis and asepsis have so entirely changed the conditions relative to, and the results of, gunshot wounds that but little inference can be drawn from the results obtained in pre-antiseptic days.

In summary, when the method of treatment to be adopted in gunshot wounds of the hip is considered, it appears that tentative treatment is to be instituted in all bullet wounds which involve, or are suspected to involve, the joint when aseptic control is not available and where the wound is not manifestly infected; that conservative treatment, including incision and exploration of the joint cavity, is to be practised when aseptic control is available, and especially in cases in which infection is suspected or the amount of the fragmentation of the upper portion of the femur is great; and, finally, that excision and amputation are to be practised only in the gravest cases.

When infection is not present, tentative treatment will often give the most excellent results so far as the life of the patient is concerned, but secondary operative measures may be required to relieve pain, ankylosis, or other troubles of the joint. When conservative treatment is determined upon and aseptic control is available, the procedure should be, *first*, exploration of the joint; *second*, the removal of loose bone fragments; and, *third*, immobilization and ex- tension of the limb. Exploration can frequently be done by enlarging the wound of exit or that of entrance, according to its location. Often, however, the wound is so situated that access to the joint is much more readily effected through an incision such as is made for excision of the head of the femur, and, unless the wounds of entrance and of exit are very conveniently situated, the ordinary operative incision should be made, as it allows more complete exploration and command of the joint if extensive operation or exploration should be required. The removal of bone fragments in these cases is frequently quite difficult, often more difficult and tedious than a formal excision of the head of the bone. Care should be taken to remove only those fragments which are entirely loose and to replace others. When the wound is infected, the surgeon has to choose between removal of fragments with drainage, or formal excision with drainage and amputation. If the head of the femur is very badly shattered and the wound infected, even if drainage be instituted, there will supervene inflamma- tory conditions of the bone which will be extremely difficult, if not impossible, to arrest. Under such conditions the surgeon is justified in making a clean exci- sion of the head of the femur and instituting thorough drainage after suitable cleansing and the washing out of the infected wound with an antiseptic solution. Such treatment under modern methods may result in a condition similar to that usually obtained in formal excision of the head of the bone, or, if inflamma- tory conditions and suppuration continue, amputation may be later resorted to.

In all cases, whether treated conservatively or tentatively, the necessity for immobilization and extension of the limb is great. Temporary immo- bilization may be effected by bandaging the injured limb to the sound one, the inequalities between the two limbs being well padded with some material. Such immobilization will, in ordinary cases, answer the purpose of protecting the parts from further injury during the patient's transportation to a hospital.

When he is actually in hospital, any suitable immobilizing apparatus may be applied, but the apparatus must not cover the wound so as to interfere with inspection and dressing. The value of extension cannot be overstated. By means of it the pressure upon the bone fragments within the joint cavity is removed, their liability to displacement is lessened, and pain is relieved.

Excision of the Hip.—In former days excision of the hip following gunshot wounds, whether in military surgery or in civil practice, was not encouraged. Before the Civil War the operation had been done 16 times with but 1 recovery. In the Civil War primary excision of the hip gave a mortality of over 93 per cent. In the Franco-German war the death rate was 83.8 per cent. With modern surgical methods and the surgeon's ability to control infective processes, the results in such operations in the future should be very much better, and it is the writer's opinion that excision of the hip joint should be unhesitatingly done whenever the surgeon considers that the conditions warrant it.

Intermediary Excision.—Intermediary excision may be required in some cases where tentative or conservative treatment has not been followed by the proper results. Such operation is, however, not usually recommended, for the mortality heretofore has been very great. Cases will arise in which it is a choice between this excision and amputation, and the surgeon should be guided in his election of an operation by the conditions that are present in each particular case.

Secondary excision may be required when fragmentation is present and when suppuration follows conservative treatment. In such cases the suppuration will continue indefinitely unless the diseased bone fragments are removed. In these cases the surgeon has to pay particular attention to the condition of the bone left in place; he should render the wound as aseptic as possible by curetting or by cutting away all infected tissue, and he should remember that long fissures may extend into the neck or even into the shaft of the bone, and that along these infection may progress. In choosing an incision for secondary excision, the surgeon should be guided by the fact that drainage is much better carried out through a posterior than through an anterior opening. The posterior incision is also especially useful where there is fragmentation of the great trochanter or the bone near it. The anterior incision is particularly suitable in cases in which the head and neck alone are fractured and where the wound is not infected, as it gives ready access to the joint and allows careful exploration and removal of fragments. Even if the operation is performed through an anterior incision, it is usually best in each case to make a counter opening behind through which drainage can be carried out. When the surgeon has opened the joint, if he finds the amount of damage to the bone extensive, he may at once choose between a rather extensive excision and an amputation. Authorities are divided in opinion as to which course is the best to pursue. Delorme advocates that amputation be immediately done. Langenbeck advises excision first, and the removal

of the limb later should it be necessary. The procedure best adapted to each case can usually be determined by the condition of the bone and the condition of the patient. Amputation is a much more severe operation than excision, particularly on account of the greater amount of shock which it entails, and the surgeon is not warranted in attempting a complete removal of the limb unless the patient's condition is such that he can withstand the shock. The operation of excision in gunshot fractures of the neck and head is made somewhat difficult by the fact that the upper end of the bone is broken off and the femur cannot be used as a lever for throwing it out previous to removal. It is necessary, therefore, to make a free excision through the capsule and remove the head by pulling it out with powerful forceps.

The treatment of patients after an excision of the hip is identical with that adopted when conservative treatment is practised. Immobilization, extension, and counter-extension, with careful attention to the position of the foot, which should be one of slight eversion, are necessary.

Disarticulation at the Hip.—Amputation at the hip joint as an immediate operation will be required only in cases where there is extensive destruction of soft parts about the joint, particularly where, in connection with such destruction, there is injury to the great vessels and nerves. On account of the severity of such wounds, the cases rarely reach the field hospital, most of them dying on the field. The presence of other wounds below the hip joint, such as wounds of the knee and leg, complicate such cases, and were formerly thought in military practice to necessitate disarticulation. Under modern conditions such rules no longer hold, the condition of each wound being considered in relation to the amount of tissue destruction, and cnosequently in relation to the necessity for amputation. The mortality of disarticulations of the hip is very great. In 254 cases of disarticulation of the hip joint in the Civil War there was a death rate of 88.9 per cent. In primary amputations, of which there were 82, there was a mortality of 91.4 per cent. In the Spanish-American war there were 3 disarticulation operations with 1 death, and in the Boer war Stevenson records 4 with 1 death, a percentage much lower than that which obtained in pre-antiseptic days, for Otis gives 40 secondary amputations, with 82.5 per cent mortality. The immediate cause of death after amputation at the hip joint is primarily shock, and secondarily the hemorrhage which intensifies the prostration of the patient. The bleeding is not so much from the large arteries, which can be quickly controlled, as from the many small blood-vessels in the large flaps. The control of hemorrhage in these cases is of great importance. Numerous methods have been devised, many of which are excellent, and most of which require some special appliance which the surgeon too often has not at hand when the operation should be done. In military surgery, a method which is adaptable to the circumstances has been devised by Senn. The writer has twice practised this method and has been par-

ticularly impressed with its adaptability to military surgery. There are others, however, who believe that Wyeth's method of controlling hemorrhage by the employment of long needles or skewers is equally well adapted to the needs of the military surgeon. As both of these methods will be fully considered in the article on Amputations, in Vol. IV, it will not be necessary for me to enter into any further details in the present place.

Wounds of the Diaphysis of the Femur.—Before the days of antiseptic and aseptic surgery, gunshot fractures of the femur ranked nearly with gunshot wounds of the hip joint and knee in gravity. In 6,576 cases of gunshot fractures of the shaft of the femur recorded in the " Surgical History of the War of the Rebellion " the mortality was 42.8 per cent in the lower, 46.1 per cent in the middle, and 49.7 per cent in fractures of the upper third. In recent wars the mortality has been greatly reduced, especially in those cases which are not treated by amputation. In 132 cases of gunshot fracture of the femur in the Spanish-American war, the mortality was 7.6 per cent in the lower, 17.9 per cent in the middle, and 16.6 per cent in fractures of the upper third—an average mortality of 14.3 per cent for that war as against 46.2 per cent in the Civil War. For the Boer war, Stevenson reports 43 cases, with an average mortality of but 9.3 per cent, a most marked improvement over the figures for pre-antiseptic days. When the injury is so severe that amputation has to be resorted to, the mortality is greatly increased. Thus, in the Spanish-American war, in 31 cases operated upon, 13 died, a mortality of 41.9 per cent. Stevenson reports 7 cases in the Boer war, of which 4 died, a mortality of 57.1 per cent.

Probably no bone in the body presents more typical fractures as a result of gunshot injury than does the femur. The bone is very hard and resistant, and consequently, when it is struck by a missile, especially when the latter is travelling at high velocity, the amount of fragmentation is great. Deformation of the missile also has a marked effect, deformed bullets producing great comminution, especially when they have sufficient velocity to pass through the bone. With shell fragments and bullets travelling at very low velocity, it is not uncommon to see long oblique fractures with little comminution. Also, in some few cases, an undeformed bullet travelling at low speed may produce fairly clean-cut perforations of the bone on the side of the entrance wound, the exit, however, being as a rule considerably fragmented.

The probability of injury to the large vessels of the femur, whether directly struck by the missile or indirectly by misplaced bone fragments, is considerable. This is particularly true when the exit wound is on the inner side of the thigh, for not only in such a case is there great probability of the bullet itself injuring the vessels, but the bone fragments will be more greatly displaced along the line of the missile's flight and may impinge upon and lacerate the great vessels or nerves.

Treatment.—The treatment of gunshot fractures of the femur is mainly to be

considered under three heads: Expectant treatment, conservation, and amputation.

In military surgery, *expectant treatment* will be indicated in all cases of bullet wounds where the main vessels are not involved and where the wound is not infected. The amount of comminution of the bone in itself is no indication for operative treatment in military surgery. Very extensive fragmentation of the femur may occur, but if the limb be immobilized and extension and counter-extension be employed, although large callus may form, a serviceable limb will result. The writer has seen typical cases of this sort; one case, in particular, being that of an officer wounded at Santiago. In this case the missile passed with high velocity from before backward through the femur, producing great fragmentation of the shaft. The treatment was as above given, and, although there was a shortening of the limb that amounted to nearly three inches, the foot was in an excellent position, and the officer was able to do duty without difficulty by wearing a shoe with a high sole. In civil practice, gunshot fractures of the femur, like the same injuries to the hip joint, may well be explored when the surgeon is able to control his asepsis. Under such conditions, if no contra-indications exist, there is no objection to cutting down upon the bone immediately after the receipt of the injury, for the purpose of determining the extent and kind of fracture, of removing all loose fragments, and of wiring displaced fragments in place. The previous use of the x-rays will be of great assistance to the surgeon in determining the advisability of the operation, and particularly in ascertaining the position of the fragments. When tentative treatment is adopted, the patient should be carefully watched for signs of infection and inflammation, and, should these appear, proper exploration of the wound, with complete clearing out of infectious material and loose bone fragments, with subsequent thorough drainage and irrigation, should be instituted.

Excision in the continuity of the femur has not been recommended by writers on military surgery. In wars occurring in pre-antiseptic days, the mortality was equal to or exceeded that from amputation. Nowadays, with aseptic control, there is no reason why the surgeon should not adopt excision as a proper mode of treatment when the particular conditions of the case indicate it. Extensive excision, with recovery, necessarily means considerable shortening of the limb, and it is believed that this, rather than the possibility of high mortality, should be the guide for the surgeon in determining between an excision and an amputation. Prosthetic skill is now far advanced and hence the efficiency of the artificial limbs manufactured should be well considered before a decision to amputate is reached.

Conservative treatment, covering all methods by which conservation of the limb is attempted, is essentially a modern method of treatment of fractures of the femur. Formerly, all authorities condemned it and were unanimous in recommending amputation. From this extreme, surgical opinion is now swerv-

ing to the opposite, and amputation is now advocated only when there is such
extensive destruction of the soft parts that nature will not be able to restore
function, and particularly where the vessels of the limb are injured to such an
extent that gangrene of the limb is likely to occur. Modern methods of surgery
have decreased but little the death rate in amputations of the thigh which are
done within a day or two after the receipt of the original injury. The loss of
blood and the shock are so great that a large percentage of these cases succumb.
This fact itself is an argument for conservative treatment and an indication
that amputation should be done only in those cases where the life of the patient
is otherwise to be despaired of. The procedures to be adopted in carrying out
conservative treatment will necessarily vary according to the character of the
injury. Where the wound is made by a shell fragment, thorough exploration
of the wound, with removal of all foreign material, loose fragments of bone, and
ragged tissue, followed by proper drainage, should be done.

When tentative treatment is adopted as the first step in conservation, the
application of suitable dressings and immobilization of the limb are to be insti-
tuted. In ordinary cases extension by means of a weight and pulley and counter-
extension may be employed. In cases where the wound is large and there is
considerable destruction of the soft parts, such apparatus may not well be borne,
and when this is the case the surgeon may have to resort to Esmarch's double
inclined plane or some form of suspension support. Where there is considerable
bone fragmentation, with loss of bone substance, care should be taken not to
employ extension, as non-union may result.

Amputation for Gunshot Injury of the Femur.—Most of the indications for
amputation, such as extensive injury to the soft parts, vessels, and nerves, have
been referred to above, and when they are present, operation should be done
at the earliest possible moment. Secondary amputations are most frequently
required when tentative or conservative treatment has been attempted and
healing has not occurred through the persistence of inflammation incident to
infection. In gunshot injury of a large bone, such as the femur, with an
infected wound, conservative treatment can be too long persisted in. Modern
aseptic methods enable a surgeon to control inflammatory action to a certain ex-
tent, but, where a large bone is involved, ostitis and osteomyelitis may super-
vene and may persist for a long time, entirely incapacitating the patient by pro-
ducing great general disability. Such cases may linger for weeks and months,
with practically no change except a gradual sapping of the patient's strength.
In other cases, acute osteomyelitis occurs, producing infective conditions which
immediately endanger the patient's life. Under such circumstances, the surgeon
should not continue conservative treatment for too long a period, but should
proceed to amputation.

The particular method of amputation to be done in gunshot injury of the
femur will depend upon the condition of the patient and the part. The shock

is always very severe, and the operation should not be attempted until the shock from the injury is recovered from. Rapidity of operation is always to be commended in amputations of the large extremities. So true is this that, where the patient is greatly prostrated, rapidity of operation rather than neatness is required, for rapid operation may save a patient's life, even though the stump be not quite as good as one obtained by a slower method. There are undoubtedly a certain number of cases in which amputation of the thigh is best done by transfixion, on account of the rapidity with which this operation can be accomplished. When time and the condition of the patient allow, operation by the method which calls for a long anterior and a short posterior flap gives excellent results in any part of the thigh. In the lower third of the thigh, in fleshy limbs, the circular or modified circular operation gives an excellent stump. The surgeon should remember that there is great retraction of the muscles in strong and healthy men, especially such as are found in military service, and that consequently the flaps are very liable to prove short and inadequate. (See also article on Amputations in Vol. IV.)

Gunshot Wounds of the Knee Joint.—Formerly gunshot wounds of this joint ranked next to those of the hip in gravity. The size of the joint cavity and the excellent conditions there present for favoring inflammatory processes made these injuries, when infected, so serious that life was despaired of and early amputation of the thigh was almost universally practised. Amputation as a routine treatment in military, and even in civil, surgery for gunshot wounds of the knee joint was the rule up to the time of the epoch-making experiment of von Bergmann in the Russo-Turkish war of 1887. Von Bergmann, dissatisfied with the extremely high mortality of cases of gunshot wounds of the knee treated either by amputation or by ordinary wet dressings, selected from the number of cases of gunshot injury to the knee joint received in the battle of Gorne Dubnik fifteen of those who had received the most serious wounds—not only wounds of the joint, but also wounds in which there was extensive comminution of the bone. He treated these cases by disinfecting the skin in the region of the wound, applying aseptic occlusive dressing, and then immobilizing the limb with plaster of Paris. With one exception all of these cases recovered, although they were exposed to extremely bad weather and had to be transported across the plains over bad roads. The difference in result was so great as to determine at once the necessity for a change from operation and surgical intervention in these cases to treatment by simple occlusive dressing and immobilization of the limb.

The nature of the bone injury in wounds of the knee joint is such as might be expected from the character of its osseous tissues. With ordinary bullets the amount of fragmentation is not great, for the cancellous tissue does not readily transmit the energy of missiles. Generally a bullet gutters or cuts clean holes through the lower end of the femur or the upper end of the tibia,

and these traumas may or may not be connected with the joint cavity by lines of fracture. When the injury is by a shell fragment or greatly deformed bullet, great fragmentation takes place, the amount of comminution varying with the size of the missile.

The *treatment* of wounds of the knee joint is so like that of the hip joint that practically the same remarks will cover both forms of injury. In military surgery, when the wound is inflicted by a bullet, the rule is to treat the case expectantly by applying occlusive dressings and immobilization apparatus. When the wound is infected, or the joint widely laid open, the joint should be thoroughly cleansed with strong bichloride solution, all foreign material removed, and drainage instituted, especially of the upper synovial pouch, the hope being entertained that by thorough irrigation and continued drainage inflammation may be limited and the limb saved. In such cases ankylosis almost invariably results, although in some very favorable cases, in which the joint can be thoroughly cleansed and no extensive inflammation occurs, a partly movable joint may be obtained. If, in addition to the infection, there is extensive laceration of the soft parts, amputation above the joint may be required.

If the missile is not lodged within the joint, and there is little fragmentation or displacement of bone, the surgeon may elect to practise tentative treatment, and not operate unless symptoms of inflammation appear. If such tentative treatment be practised, symptoms of inflammation should be carefully watched for, so that operation can be done as soon as the first symptoms of infection are manifested. In fact, the result of such tentative and conservative treatment has been so good, both in military and in civil practice, that a surgeon is probably justified, in cases where there is no extensive displacement of bone fragments or lodgment of a bullet, in treating the case tentatively and being ready to operate should any untoward symptoms occur. Ordinarily there is much greater probability that a good joint movement will be obtained after non-operative treatment than after operative interference. The removal of any amount of opposing joint surface or joint cartilage results, as a rule, in a defective and painful knee. In general, the patient's chances for a good joint are best when no operation is required, even though there be considerable fragmentation of the bones. Displacement of the bone fragments in the joint is greater cause for operation than is fragmentation alone.

Excision of the knee joint may be practised in those cases where there is such extensive fragmentation of the bone ends, coupled with inflammation, that the surgeon has to decide between this operation and that of amputation, and where also he believes that excision may be practised with comparative safety; but an ankylosed knee and a shortened limb give poor function, and it is only in exceptional cases that excision is probably warranted rather than amputation. Primary amputation is indicated for the same reasons as is amputation of the thigh. If the lower end of the femur is not injured, and if sufficient

soft parts remain to cover the stump, the operation may be done through the joint. If the patella can be saved, the Gritti-Stokes amputation gives a very perfect stump.

Gunshot Fractures of the Leg.—The bones of the leg are very hard, the tibia being especially strong and resistant, in this respect ranking second only to the femur of all the bones in the body. The fibula is very compact and brittle and its size is such that when struck by even a small missile the amount of comminution is generally considerable, and, when the bullet is travelling at high velocity, considerable loss of substance may occur. In the shaft of the tibia all varieties of fracture may be seen, from the simple oblique fracture to fractures of the explosive variety. In the ends of the bone more or less clean perforations may occur when an undeformed bullet strikes the bone at moderate or low velocity.

The *treatment* of gunshot fractures of the leg, like that of gunshot fractures of other parts of the upper and lower extremities, has been greatly modified and the results have been greatly improved through the adoption of modern methods. In the Civil War the mortality following gunshot fractures of the leg was 26.4 per cent. In the Spanish-American war, in 146 cases reported, 6 died, a death rate of but 4.1 per cent. Of these, 15 cases were amputated, with 2 deaths, a mortality of about 13 per cent. As has been before pointed out, the high mortality which still obtains in amputation is due to the severity of the cases in which such procedure has to be done.

Excision in the continuity of the bones of the leg is not to be recommended. Conservatism or amputation is the line of treatment which should be adopted in these cases.

Amputation of the limb is indicated in all cases where there is, in addition to the injury to the bone, extensive destruction of the soft parts, and particularly of the blood-vessels. Fortunately, this operation is one which can be readily advised, for the reason that so satisfactory an artificial limb can now be given. In doing amputation of the leg, certain facts relative to the application of an artificial limb are particularly to be remembered. A stump not less than four inches in length is necessary if an artificial limb is to be worn; and when this length of tibia cannot be preserved, the surgeon will have to choose between two courses, viz., whether the patient is to wear a peg-leg or whether he shall have an artificial leg fitted to the thigh, for a peg-leg amputation may be done just below the tuberosity of the tibia, but otherwise amputation must be done through the knee joint, or, preferably in some instances, just above it. Also, the leg should preferably not be amputated below the junction of the lower with the middle third. Amputation at any spot between the junction of the middle and lower thirds and a point four inches below the knee joint will give a stump with which an artificial limb may be comfortably worn.

Gunshot Wounds of the Ankle Joint.—Gunshot wounds of this joint inflicted

by a bullet are now rarely fatal, but, like wounds of the wrist joint, they very frequently result in complete or partial loss of function of the articulation. The close proximity of the tendons causes them frequently to be injured; and, even when they escape the bullet, adhesions between them and their sheaths are very liable to form. When the wound is infected, prolonged suppuration often leads to the necessity for amputation through the leg.

The treatment in uninfected cases is usually conservative—immobilization of the limb and treatment of the conditions as they may arise. Where extensive suppuration supervenes, or there is much destruction of the soft parts, producing loss of function of the joint or threatening the life of the patient, amputation through the leg should be resorted to. A stiff and painful ankle joint is such a source of discomfort to the patient that an amputation, with the after-application of a suitable artificial foot, affords, as a rule, more comfort and a greater ability to get about than if the disturbing part should be retained.

Wounds of the Foot.—Gunshot wounds of the foot, like those of the hand, are very frequently followed by stiffness of the articulations and consequent disability and pain in walking. This is particularly the case when the bullet passes from side to side through the foot, breaking more than one of the metatarsal bones, for in such cases the bone fragments are disturbed along the line of the missile's flight, and, when callus forms, the different bones may be firmly bound together by interosseous bridges. When the anterior portion of the foot is greatly damaged by gunshot, either by deformed missiles or by shell fragments, the question of amputation has to be considered. In choosing an amputation operation, the surgeon will have the choice of many classical methods, but, in general, he should remember that unless the patient is so poor that he cannot afford an artificial limb, amputation posterior to the tarso-metatarsal articulations does not afford a satisfactory lower extremity upon which to walk. It is true that some operations about the ankle joint, like that of Pirogoff, give fairly excellent results, the Pirogoff method particularly giving a stump which enables the patient to walk about and follow his occupation without any mechanical apparatus, a matter of much importance to indigent patients or those belonging to the working classes. When, however, the patient's position in life is such that an artificial limb can be procured and worn, amputation through the place of election in the leg is to be preferred, particularly in those cases in which the ankle joint itself, or the bones in its immediate neighborhood, are injured.

In all cases of injury to the foot and ankle, conservative methods should be practised when possible, the x-rays should be used, the wound explored, loose fragments of bone removed, and every attempt made to save the part and prevent ankylosis. In most cases such conservative measures can be at first adopted with little danger to the patient's life or limb, the surgeon later doing amputation should it become necessary.

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