Remote consequences of injuries of nerves, and their treatment : an examination of the present condition of wounds received 1863-65, with additional illustrative cases / by John K. Mitchell.

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REMOTE CONSEQUENCES

OF

INJURIES OF NERVES

AND THEIR

TREATMENT.

AN EXAMINATION OF THE PRESENT CONDITION OF WOUNDS RECEIVED 1863-65, WITH ADDITIONAL ILLUSTRATIVE CASES.

BY

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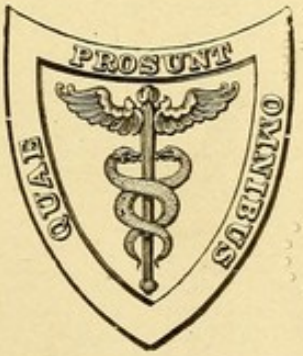

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DEDICATED TO

S. WEIR MITCHELL,

SEVEREST OF CRITICS AND KINDEST OF FATHERS,

IN THE HOPE THAT IT MAY PLEASE HIM

IN BOTH CHARACTERS.

CONTENTS.

ERRATA.

Page 22, 5th line, XLV. should be XLIV.
" " 3d line from bottom, XLIV. should be XLIII.
" 23, 2d paragraph, XLIV. should be XLIII.
" 24, 1st and 2d lines from bottom, XLIV. and XLV. should be XLIII. and XLIV.
" 25, Note, XLIV. should be XLIII.
" 31, 24th line, XXII. should be XV.
" 49, XLV., in both instances, should be XLIV.
" 71, 6th line from bottom, II. should be XXXII.
" 98, 21st line, insert before "hurt," "slightly."
" 109, 13th line from bottom, XLV. should be XLIV.

INJURIES OF NERVES.

INTRODUCTION.

In 1864 Drs. Weir Mitchell, Morehouse, and Keen published a small book[1] upon the effects of gunshot and other injuries of nerves, as observed by them in the wards for diseases of the nervous system of the United States Army Hospital, Turner's Lane, Philadelphia. A number of cases were reported, and many new and original observations made. In 1872 Dr. Mitchell published a larger work,[2] of more extended character, on similar subjects.

The present little volume is the result of a desire to examine into the very late consequences of such wounds and injuries as were dealt with in the books above mentioned. It happened sometimes in the course of service at the Orthopedic Hospital and Infirmary for Nervous Diseases that men who had been in the charge of Drs. Mitchell, Morehouse, and Keen during the Civil War applied for treatment of conditions resulting from their former wounds, and this suggested the study of as many as could be reached of the old cases.

Assistance in tracing those of the soldiers who were on its list of beneficiaries was very kindly afforded by the

[1] Gunshot Wounds and Other Injuries of Nerves. J. B. Lippincott & Co.
[2] Injuries of Nerves and Their Consequences. J. B. Lippincott & Co.

Bureau of Pensions, upon the kind recommendation of the Hon. J. W. Noble, Secretary of the Interior. I feel it incumbent upon me to acknowledge especially the active interest of Dr. Ingram, then an officer of the Bureau, who sent me notes of a number of cases of great interest, several of which have been used in this book. It did not at first seem that it would be difficult to secure medical histories of patients whose names and addresses were known, but it proved an exceedingly long and troublesome affair. Many of the addresses were imperfect, and letter after letter was returned undelivered; many more remained unanswered or were buried in the oblivion of country post-offices. Every device to insure safe arrival of letters was tried, but a number even of those which presumedly reached their addresses brought no reply. I believe one cause of these troubles to have been the impossibility of convincing the men that my questions were not a device of the Pension Examiners, and that my anxiety to know various minute details of their condition was not prompted by a desire to reduce or take away their pay.

Of course, in the lapse of so long a period of years, many men had passed entirely out of reach; death had claimed some, and no inquiry could reach others, who, it was believed, were still alive. But by diligent search through the medium of postmasters, many of them old soldiers themselves, by advertisement through Grand Army posts and meetings, a number of men were found who remembered gratefully their treatment in the Christian Street and Turner's Lane United States Army Hospitals, and from among these the twenty cases reported are selected. Of the others who replied, some presented no feature of interest; from the accounts offered by some no clear statement could be made; and a few (I am glad to

say, a very few) were obviously somewhat factitious. When from the letters it was judged that the case might prove valuable, the soldier was asked to submit the circular of questions to a physician, and request assistance in giving a medically correct and detailed history of his present condition. I cannot too heartily thank the gentlemen, almost all of them personally unknown to me, to whose painstaking help I am so much indebted. Other individuals, not too far distant, I examined myself, and a number were brought to Philadelphia, and there studied with care. All this involved an unexpected amount of labor and some hundreds of letters. It is only to be hoped that the result will be considered commensurate with the pains taken.

Besides the cases reported in *Gunshot Wounds* and in *Injuries of Nerves* from the hospital records, I have added accounts of the results of a number of other cases of wounds received during the war, some, acknowledged in their places, from the Pension Bureau records, some from the unpublished notes of the United States Army Hospital, and a few seen in private practice or in the course of service as assistant physician to the Orthopedic Hospital and Infirmary for Nervous Diseases.

Eighteen cases of injuries occurring in civil life are used to illustrate different phases of the subjects discussed. Two of these are from the publications of others, but are given for their peculiar interest.

Most of the soldiers received their wounds during 1863–1864. The late examinations were spread, by the difficulties already detailed, through a period of more than two years, beginning in the spring of 1890, so that the interval is about twenty-seven or twenty-eight years. An abstract, as brief as may be, of the history of the wound, its early

consequences and treatment, precedes the statement of the later results and present condition.

While some of the cases will necessarily be found incomplete, owing to the lack of uniform methods of examination among so many observers, every endeavor has been made to give the fullest clinical details, in order that the reader may draw his own conclusions. The sum of cases is not large enough, and the variety of injuries too great to permit of drawing many general conclusions; so that even where this has been done I have, at the risk of some repetition, discussed the individual aspects of the several cases in the *Remarks* appended to each. Nor has it been thought desirable in work of a character as purely clinical as this to attempt any statement of neural physiology, so much of which is still rather probable than sure.

Certain general causes affected all the "war cases" for good or for evil. The occasional privations and forced exertion of military service preceding wounds, the exposure and neglect which too often followed them, the haste with which surgeons at the front and under pressure of over-work had to examine and dress cases, must have been factors of ill in many patients. Where these causes entered largely into cases the fact, if known, has been stated. On the other hand, the youth of most of the patients was in their favor. Accustomed to-day to see the gray-headed veterans of the war about us, it is amazing to find that only a very few of the men whose injuries are here described were over twenty years of age at the time of their reception. Judging both from physiological experiment and from clinical observation, neural injuries have a much more successful issue in the young than in even the healthy adult. Besides, those who had not suffered from disease or exhausting effort before being wounded

must have been in a far more favorable condition for the healing of wounds than the ordinary individual in civil life. It is within the knowledge of everyone who has had experience in the "cattle countries" of the West, that hurts which elsewhere if not fatal would certainly require months of prolonged care to bring about healing, are there repaired with an astonishing rapidity; the life of the soldier in active service, and not undergoing unusual hardship, may very well be compared with that of the cowboy and plainsman.

It remains only to be said that it is probable that the general result of treatment was somewhat better than would here appear, not only because the worst cases were the ones most likely to be reported, but because I have not cared to give room to the details of the cases of recovery reported to me, except where the original injury or the present condition presented some features of interest.

In an Appendix are printed the brief circular of questions which was sent out, two letters of interest, and the names and regiments of those cases of importance which I have not been able to trace are added, in the hope that some of the physicians into whose hands this book may come may chance to be able to help me to reach at least a few of them.

CHAPTER I.

CONTUSIONS AND COMMOTIONS OF NERVES.

WIDELY differing degrees of injury must come under one title when instances of contusion or commotion of nerves are to be considered. A slight blow over a nerve-trunk produces a tingling pain of brief duration, such as every one is familiar with from a blow on the ulnar where it turns about the olecranon. Where the nerve has suffered a heavier blow, a more severe pain of like character is the early result, and late changes are apt to take place out of all proportion to the apparent original damage.

This blow may be delivered upon the surface of the body by a weapon or a missile, or the missile may pass through the tissues and touch the nerve nearly enough to bruise without dividing any of its fibres. This may readily occur where the nerve is not closely confined by adjacent bone.

When the nerve is tied down as it emerges from a bony foramen, or lies along a bone, it is less easily pushed out of the direct path of the weapon, and may be violently bruised. Such accidents are the second degree of contusions; from these the cases of concussion, as of the spinal cord by a ball passing alongside the column or fracturing a vertebral process, are separated rather by their greater severity than by any known difference in the character of the resulting lesion.

The first symptoms of contusions are a sharp, stinging pain, an area of numbness, and a passing paralysis. The

slight character of these indications should not deceive the observer into too confident a prognosis. Bruised nerves recover less readily than those which have received slight direct injury, and are more inclined to suffer inflammation.

Injuries which should perhaps be considered with contusions are those like Cases VII. and VIII.,[1] where a strain or wrench so hurts the spine or some of the spinal nerves at their exit from the canal that, although the patient recovers and seems to be perfectly well, his complaints are apt to be disregarded or to cause suspicion of simulation, the slow process goes on, and suddenly he develops paraplegia or myelitis, or some symptom of sclerotic alteration in the cord. In VII. there was probably a rapid compression of the cord by hemorrhage. The curious state of VIII. can hardly be classed with this, and, indeed, the history is too imperfect to leave us sure that the destructive results are consequent upon the hurt, and not merely after it in point of time.

As various trophic effects follow contusions as follow severer injuries. G.'s wound (Case I.) could scarcely have been more than a contusion of the left sciatic nerve, as he was able to walk some miles after the reception of the hurt. The case is complicated, as military cases must often be, by the effects of long exposure upon the battle-field, and, in this instance, by an imprisonment of nine weeks in Libby. "The ulcers proved very unmanageable," says the report, but the case is quoted as a "fair type of partial wound or commotion of a nerve." But the recovery has been imperfect in nearly all respects—touch and pain-sense are perverted, and fatigue or a

[1] Roman numerals refer to the case-numbers. The full case-histories are given at the end of each chapter.

change of weather suffices to bring about ulceration of the nail-edges, and on the left side, upon which the sciatic was thought to have suffered, the nails grow less rapidly than upon the other foot.

Case II. was an injury of the arm-nerves, not any greater in degree than G.'s (I.) of the leg; but the median nerve is still congested and over-sensitive, and the nutritive change has affected hair- and nail-growth in a contradictory fashion. Generally hair-growth is greater upon the parts supplied by a wounded nerve, and nail-formation is interfered with. Here both hair and nails have grown more rapidly and strongly upon the hurt than upon the well side. Dr. Savage also says that there is no secretion of sweat upon the face or neck; this suppression would seem not to be limited to one side.

An unusual form of partial recovery is illustrated by Miss N. A. (III.), in whom sensation has been completely restored, while burning pain and ache continue. The hysterical element in the case makes it unwise to draw any general conclusions, but usually where sensation becomes perfectly natural in the one form it is soon healthy in the others.

The persistence of motor disability is partly the result of disuse in many cases, and this adds a factor hard to estimate accurately. To judge how large a portion of the palsy, of the atrophy, and of the general degeneration is due primarily to non-use of the part, and secondarily to the defects of nutrition brought about by this lack of use, we may compare the results of these cases of injuries not originally grave with one (IX.) where no nerve was wounded, but where the long splint-rest consequent upon a bullet wound of the wrist produced results as serious, as lasting, and as difficult of repair as could have been caused

by nerve laceration. The case is sufficiently commented upon in its place. It may be added that the tenderness of the whole nerve track all the way to the spine might result from a low grade of neuritis set up by pressure from the callus, as has happened in VI.; but, even supposing this, the symptoms are yet highly contradictory.

A nerve recovers readily, so far as its conductivity is concerned, from pressure even of considerable force if the pressure be gradually applied and not too long continued. In Dr. Mitchell's experiments[1] the weight of twenty inches of mercury, brought to bear little by little upon the exposed sciatic nerve of a rabbit, was needed to abolish conduction of a galvanic impulse, and it was not until the compression had lasted ten or twelve seconds that this effect was produced. The power of transmission returned in about the same time after the mercury was removed. Upon examination of the nerves a disturbance of the contents of the tubes was found, "the tissues looking much as they do seven or eight days after section," which is just about the period at which a cut nerve ceases to respond to electric stimulation.

An experiment carried to the extent of thus disorganizing the neural elements cannot be essayed upon man,[2] so that we are ignorant of the subjective sensations accompanying this condition; but in Waller's experiences, with a less degree of compression continued for a longer time, sensation in a perverted form returned first, motion more slowly, and last of all the thermal perception. After forty-five minutes' compression of his left radial nerve Waller found eleven days necessary to restore the sense of motion perfectly. The course of cases is modified by so

[1] Injuries of Nerves, p. 111.

[2] But for an accidental one see Case XIII.

many things that it does not always follow closely the lines of experimental pathology, but in the present instances the histories strengthen the conclusions drawn from the experiment.

Mr. K. (XLV.) offers a curious confirmation of the slow return of thermal sense, although it must at the same time be said that Mr. K. was suffering from more than mere compression of a nerve trunk, for he had not only endured a bruise, a violent stretching, and a slow compression of the brachial plexus, but the sharp and sudden pressure and laceration of a tightly applied ligature, so that perhaps the example is not perfect. Sensation had begun to make a faint reappearance in the arm, when, in the effort to determine his perception of heat and cold, the hand was placed in water of a temperature probably not exceeding 108° to 110° F., with the astonishing result of scalding the member as though the water had been at almost boiling-point. Even this hurt was only felt as a decided heat. Another curious observation may be made upon this: whatever the loss of trophic control which caused the skin to be so easily affected by heat, it had very little influence upon the subsequent healing processes, which are as rapid and thorough as in a perfectly healthy limb;[1] those who observed the patient inclined to think that the return of sensibility proceeded somewhat more swiftly after the scalding, as though the irritation had favorably influenced the nerves.

Similar undue effects of moderate heat were observed in XLIV., where water only felt as agreeably hot in the median territory, nevertheless scalded in the area supplied by an ulnar nerve inflamed from a puncture.

[1] It is common enough to find such injuries healing tediously and unkindly, but in X. a like easy recovery followed scalding.

How slight a compression may bring about a lasting palsy was shown in a case under my care several years ago. During an ovariotomy the patient's arms were crossed upon her breast, the sleeves pinned to her gown to keep them in place. It chanced that the right arm rested upon the edge of the narrow operating-table, thus pressing with what must have been but a small part of its weight upon the inside of the arm above the elbow. The patient was thin, and this fact no doubt exposed the nerve more readily to injury, and she had been long ill, so that her resistance was feeble and her recuperative power poor. A day or two later she called my attention to the feebleness of her hand, and soon, in spite of every care, the muscles of the hand, and especially those of the thumb, wasted rapidly, and have never been restored to their original health. The length of time which the compression had lasted could not have been above an hour.

Cases of cicatrix-pressure causing pain are rarer than might be supposed, and to the after-history of the one case (V.), detailed in *Gunshot Wounds*, I am able to add only two—VI. and XLIV. In the first pressure is exercised by both osseous and cicatricial tissue, and even if it is too late to hope for restoration of nerve function, it is probable that some relief from pain would follow were the nerve released from these sources of compression and irritation. In the latter instance, upon operation for examination in the endeavor to discover a reason for the persistent pain, the nerve was found crossed and compressed by a bridle of tough scar-tissue. Its division gave instant relief.

With such histories as these should be compared the unusual cause of pain in XXV., where a minute, sharp-

pointed exostosis in the scar of an old bone-injury kept up great tenderness in and about the cicatrix. Such causes are readily removable; in a recent case at the Orthopedic Hospital Dr. W. W. Keen removed a similar tiny, sharp bone-growth, with a point like a needle, from the exterior surface of the coccyx. This was a spontaneous growth, the patient having received no injury; it had caused agonies of pain, spreading all about the lower lumbar region, into the perineum, and over the buttocks, and its removal afforded complete relief.

Pinching of a nerve in the callus formed about a fracture is another rare form of injury. Fortunately, the symptoms can be recognized early, and may be easily and quickly relieved. When this has not happened, and the pressure has continued, and, as it usually must, has increased, an inflammation of a chronic form results with all the attendant pains and difficulties; joint-lesions may appear, neuralgia occur at any time, becoming agonizing upon change in the weather, with causalgia, and, finally, atrophy and a high degree of disability.

A partially successful case of surgical interference with callus-pressure is reported in X, which is published here by the kind permission of Dr. Thomas G. Morton, of Philadelphia, in whose care the patient was at the Orthopedic Hospital. The brachial plexus and artery were both much pressed upon by the callus and also by the misplaced fragment of the clavicle, and the lad was rapidly recovering the use and proper nutrition of his arm when the notes were made.[1] As in XLIV. and XLV., there was an unusual susceptibility of the skin

[1] But later the fragment was again displaced with a bad result. (See Notes of Case.)

to the effects of heat, so that water of moderate warmth scalded him, a peculiarity lacking an evident explanation. It would be easy to attribute it to a lack of proper nutritive control, but this is only begging the question. If the fault lies in the trophic fibres, how is it that such a hurt is so readily and naturally repaired?

Bullæ, ulcers, and various forms of disease of the skin and superficial tissues occur frequently enough following neural wounds, and we commonly attribute them to the disturbed innervation of the part; but it is characteristic of these that they heal tardily and are apt to return.[1] The only suggestions which can be offered may perhaps be charged with being generalizations on too small a basis of knowledge: obstinate ulcers, blisters, and eczemas are usually present in cases where the nerve is more or less inflamed; and although the two patients had no signs of acute neuritis, their nerves were undoubtedly in a condition of degeneration. Or, it is not impossible that there may be a difference in the course of skin affections resulting from external injury and those caused by some internal condition.

Although no hesitation should be felt in operating upon patients when it is thought that a nerve is implicated in callus or cicatricial tissue, the desire to afford prompt relief should not lessen the activity of the search for symptoms other than pain alone before the diagnosis is held to be certain. Prickling and tingling, or other forms of paræsthesia, neuralgia, and burning pains should some or all

[1] Hilton's often quoted case, where a wrist fracture pressed upon the median during its course, and ulcers on the hand resulted, is a case in point. When the hand was so bent that the exuberant callus did not press on the nerve, the ulcers healed. When the wrist was allowed to straighten, the ulcers returned.

Compare the remarks upon the ulcers in XLIV. and the discussion of the possibility of a special toxic cause.

of them be present to make very great the probability of a nerve being pinched in the new tissue. Even then, when rest and other proper means have been tried, enforced activity may suddenly or rapidly remove the trouble, as happened originally in V.

But the physician in civil life does not enjoy the privilege of ordering to the guard-house patients who refuse to walk or take active exercise, so that in such matters he may be less successful than his military colleague. Sometimes, too, pain from an obscure cause at first leads to the supposition that a nerve is injured, when with a brief period of patience the pain will disappear. A very good sample of such an occurrence is described by Dr. J. H. Pooley, of Columbus.[1] After a simple fracture of both bones of the leg acute pain began at the seat of injury and lasted for some weeks with such violence that opiates were constantly needed, and a consultation was held upon the question of cutting down upon the fracture to release the nerve supposed to be caught either in the cællus or between the fragments of bone. Action was postponed, and from the moment the man started to move about upon crutches the pain gradually subsided.

Paralysis from crutch-pressure is a form of neural injury in which, although at first the disability is sometimes very complete, the recovery is generally perfect. Two reasons for this suggest themselves: one has been already mentioned, namely, that the compression is not continuous, but intermittent, the weight being removed from the axilla as the crutch is thrust forward at each step; the other is that the most important indication for treatment in pressure-troubles—the removal of the cause—

[1] Ohio Medical Recorder.

is early heeded, as the sufferer becomes unable to use a crutch from the weakness of the hand.

A case is reported as an example of crutch-palsy in *Gunshot Wounds* which has since proceeded less favorably than is usual (XII.). At the time of his discharge from the United States Hospital he was considered in a fair way to regain the perfect use of the arm, but he states that a considerable degree of disability still persists. It is likely that in this and in other cases hereafter detailed, where the result has been less good than was anticipated at the time of discharge, both the condition of a soldier worn with the fatigues of severe service and perhaps, too, some neglect to keep up thorough treatment when the wholesome discipline of a military hospital was withdrawn, may have operated to hinder entire success.

The fourteen case-histories which follow illustrate the conditions discussed in the preceding pages.

CASE I. *Contusion or slight laceration of left sciatic and right popliteal nerves; paralysis, burning pain, eczema; nail edges ulcerated; alteration of pain and touch-sense; continued slight burning pain; recurring ulcers on nail edges; partial recovery.* (Case 20, *Gunshot Wounds.*)—Killian G., Company B, 121st Pennsylvania, was wounded at the age of twenty, at Fredericksburg, December, 1862, by a ball which passed diagonally downward through the lower third of the left thigh, from without inward, and, passing behind the bone, entered the right leg below and behind the knee. Here its course traversed the calf obliquely downward, and emerged on the outer side of the leg without injuring any large nerve. He was able to walk several miles after the hurt, but finally lay three days on the battlefield without, he says, passing water; was captured and spent nine weeks in Libby Prison, where he was very ill.

In July, 1863, he was examined at the hospital. The sciatic had evidently been slightly injured on the left side, and there was severe, not excessive, burning pain on top of the left foot, eczema and congestion of the skin, and ulceration at the edges of the toe-nails. Similar ulcers existed in the right foot, and its sensibility was also slightly defective. There was complete paralysis of the flexors of the foot, and partial of the flexor communis digitorum and of the calf-muscles on the left side. There was no marked atrophy. The ulcers proved exceedingly obstinate, but the other symptoms improved, and he was discharged, greatly improved, after five months' treatment.

Examined at the Infirmary for Nervous Diseases, March, 1890 :

Nutrition. Muscular development good. He says the right leg is weaker than the left. The growth of the hair and its appearance are not changed on either side. He thinks that the nails grow more slowly on the left foot.

Sensibility—touch. On the right side the sense of touch is lost in part of the distribution of the internal saphenous and in part of that of the musculo-cutaneous. On the left side it is lost in the region supplied by the external popliteal. As to the anterior aspect of the great toe the answers are contradictory.

Pain. As regards the sense of pain in the left leg, in general a pin-prick causes a burning sensation. This is especially marked under the knee, on its inner side, and on the anterior aspect of the foot, but is irregular in distribution and variable in intensity, in some places causing great suffering, in others only discomfort. It is now absent on the sole of the foot.

Re-examined January 2, 1891 :

Sensibility. Right side : Touch imperfect in the distribution of internal saphenous ; pain diminished in same area. Pain-sense is slight. Touch is almost lost in internal popliteal around and below the scar. Burning about the same as last year. It is worse on exercise. Burning

on the left foot was lessened after the war; but now, if tired, or if the weather changes, ulcers form on the nail-edges. These lasted over a year at the time he was in the hospital.

Motion. He cannot stand on either leg alone. He cannot extend nor flex the toes of the right foot. The other leg-movements are present. In the left leg he can lift the toes a little from the ground, but can scarcely flex or extend the ankle. Both movements are present. Knee-jerk diminished on both sides.

Electrical examination. There is great reduction of faradic contractility in the tibialis anticus and peronei, and a similar quantitative loss to galvanism, but there is no qualitative change.

Remarks. The late persistence of the hyperæsthesia to touch and slight pain is a rare event. The imperfect restoration of nutritive control is shown by the trifles which will cause return of the ulcers about the nails. A case in which callus-pressure upon a nerve caused ulceration of the supplied region is reported by Sir James Paget from the practice of Mr. Hilton.[1]

CASE II. *Gunshot-wound of ulnar and median nerves; late contraction of forearm on arm; partial recovery of motion; increased rapidity of nail- and hair-growth.* (Sanitary Com. Report, p. 144.)—J. M. S., Company B, 1st New York Artillery. The soldier was admitted to the United States Hospital in February, 1864, for an injury of the ulnar nerve received at Gettysburg in July, 1863, in the patient's twentieth year.

He was carrying a shell with his right arm bent at a right angle and a little out from his side. The ball entered two inches below the inferior angle of the right scapula, two and one-half inches to the right of the spine, and emerged over the seventh rib below the anterior border of the axilla, breaking the rib. Thence it entered the arm six inches above the internal condyle of the humerus.

[1] Surgical Pathology, vol. i., quoted in Injuries of Nerves, p. 118.

It was cut out above the internal border of the supinator longus three and one-half inches below the bend of the elbow. The bullet passed close to the artery on its entrance into the arm, but did not injure it. He felt the pain characteristic of a blow on the ulnar nerve at the elbow, and fell unconscious. During the month following he had several hemorrhages from the wound.

On admission the report was as follows:

Nutrition. Capillary circulation bad. Nails curved, especially in ulnar distribution. No well-marked atrophy, but some wasting of interossei. No contractions. Measurements: biceps, right (injured side), $9\frac{5}{8}$ inches; left, $10\frac{1}{4}$; forearm, right $9\frac{3}{8}$; left, $10\frac{3}{4}$ inches.

Sensibility. Touch lessened in ulnar territory. Pressure on median nerve below the wound caused numbness in the median distribution.

Motion. Fingers half-flexed; palmar arch lost (weakness of palmaris brevis). General weakness in thumb and in muscles of fourth finger. Lessening of faradic contractility in interossei and thumb and fourth finger muscles.

Examined by Dr. J. M. P. Savage, Sioux City, Iowa, 1890:

When the right arm is touched above the middle third an acute pain is transmitted to and through the arm and forearm to the ends of the fingers. He cannot stand cold, but heat is acceptable. The forearm cannot be straightened, *i. e.*, it is flexed upon the arm to an angle of about twenty degrees. There is no other impairment of motion, except that he has not at all times the ability to flex fingers upon the palm of the hand, and consequently grasps principally with the thumb and index-finger. The arm is one-half inch, and the forearm one inch, smaller in circumference than the left.

The hair in axilla and upon the arm, forearm, and hand is a little longer and coarser than upon the left. The nails grow faster and thicker upon the wounded side. He does not sweat upon the neck or face.

The cicatrix of entrance is about the size of a five-cent

piece, slightly pitted, not adherent, not inflamed, contracted at the upper margin, slightly depressed, not tender, surface glazed. The cicatrix of exit is the same size, slightly pitted, not adherent or inflamed, slightly contracted and depressed, very tender and surface glazed. Some loss of bone of the seventh rib.

In the gunshot-wound of the arm the missile entered on the inner side about the middle of the middle third of the arm, passing downward and outward, and made exit, or was extracted about the middle of the middle third of the forearm on the palmar surface. The cicatrix of entrance is the size of a silver half-dollar, slightly pitted, adherent at upper margin, not inflamed or depressed, slightly contracted and tender, and the surface glazed. The skin of both arm and forearm is mottled from poor circulation.

Remarks. The original notes of this case are imperfect in their description of the muscles as to motion.

The contraction which is now present seems to have come on late, and then, later still, to have improved. The ulnar nerve was not very seriously injured, and the median appears to have been involved slightly in the first arm wound, and has never recovered.

It is noted here, as in XXII. and XXXII., that the nails grow *faster* on the wounded side.

It is not stated that the arm does not sweat (as is seen in some cases, *e. g.*, XI.), but it is mentioned that there is no sweating of neck or face; whether this is limited to the right side is not reported. It is hard to see how, in view of its situation, this could have resulted from the body wound.

CASE III. *Bruise of ulnar nerve at elbow; burning pain; œdema; recovery of sensibility with persistence of pain; final recovery.*—N. A., aged twenty-three years, born in New York, was sent by Dr. George Jacoby to Dr. S. Weir Mitchell in November, 1892. She had been previously seen when a child by Dr. Mitchell for an hysterical affection of the knee-joint. In July, 1892, she was thrown from a

carriage, and a wheel passed over her right elbow. A fracture was the result, which, though set at the time, did badly, and had later to be reset. She was not rendered unconscious at the time of the injury, and, although somewhat bruised and shaken, had no other hurt of moment than the fractured elbow. There was pain at once in the arm, running down into the two ulnar fingers, which became rigid and slightly flexed, while there was an entire loss of sensation throughout the same distribution. After three weeks the sensibility gradually returned, and she now thinks that it is perfect. During the five weeks that the arm was upon the splint, the angle of the splint was altered from extreme flexion to extreme extension in the endeavor to ease by position the burning pain from which she suffered. It was generally more comfortable in extreme flexion. The burning began very soon after the application of the splint, in the ulnar distribution in the hand and above the hand in the whole arm up to the ear. She described it as "like a hot thread from the shoulder to the ear." Pain in the arm, at first steady but not intense, has now become very bad at times, and it aches always below the elbow. The worst point is in the elbow, along the groove for the ulnar nerve. There is constantly some discomfort in the whole hand; when very severe, it is felt in the mid-dorsum and in the right chest, and is especially sharp in the interspaces on the ulnar side of the hand. It is worse at night, from the fall of twilight, and is always made worse by voluntary motion.

The hand swells when the pain is bad; the enlargement is chiefly in the ulnar distribution, although there is some throughout the whole hand. After swelling has once taken place the pain becomes somewhat less, and the tumefaction is apparently a true œdema. There is no noticeable atrophy in the hand. Passive movement is not limited; active movement is good at the elbow and wrist, but is performed slowly, and the arm is weak. All muscles of the fingers move well; the ulnar muscles slightly less well. There is a very slight impairment of

touch, two points being fairly well distinguished everywhere on the hand at a natural distance.

The patient states that she sweats more upon the right side than upon the left.

An enormous variety of treatments had been applied to this case, including all kinds of massage and Swedish movements and hot and cold baths; ointments, stimulants, and electricity.

Remarks. The indication would seem to be in such a case to explore the condition of the nerve at the elbow by an operation, releasing it from any possible pressure of bone formed after the fracture, and then to put it in a splint and apply ice or stimulating treatment, as might be found most desirable.

The curious features of the case were the complete return of touch and motion, while yet some cause for pain remained, and the real œdema accompanying the pain, and seeming to help it. Secretion of sweat was increased, a matter which appears to follow no rules.

Dr. Jacoby writes (1894) that under massage and cold douches the patient made a perfect recovery in about two months, and that he now thinks the trouble was rather a traumatic neurosis than a neuritis.

CASE IV. *Gunshot-wound of arm; slight contusion or laceration of median nerve; burning pain; loss of motion; complete recovery.* (MS. notes.)—E. R. H., Company F, 126th New York, received a wound of the right forearm, May, 1864, by a ball which entered three and one-half inches below the external condyle, and made its exit on the inside of the elbow above the inner condyle. There was some injury of the bone, fragments of osseous tissue discharging from the wound, and there were great swelling, pain, and loss of motion. There were burning and pain in the hand, chiefly in the median distribution. He was only a short time in hospital, and was discharged improving.

He writes, May 30, 1894, from Los Angeles, as follows:

"The sensation of touch is not quite so good in the crippled hand as it is in the other, but on the arm it is

perfect. I think the hand is more sensitive to cold than the other. I have full movement of the hand and arm, and am writing this with the wounded hand. It is not so strong as the other, and sometimes gets somewhat lame and tired. My work is mill-wrighting, and some of the work is hard on it. It is but a trifle smaller than the other. I think that I have a very good hand and arm."

There is no change in the hair, nails, or secretion.

Remarks. This is one of the cases of a slight degree of injury, probably only a contusion, with rapid and very nearly complete recovery. Although there was decided burning pain it did not indicate a serious damage of the nerve.

CASE V. *Gunshot-wound of right thigh affecting internal and middle cutaneous nerves by pressure in the cicatrix; constant burning pain, cramps, and weakness.* (Case 14, *Gunshot Wounds.*)—William McI., Company B, 77th Pennsylvania, was shot through the right thigh in his twenty-seventh year, June, 1862. The ball entered the limb five inches below Poupart's ligament, just external to the artery, and emerged three inches below the tuber ischii, one-quarter of an inch external to it. He suffered no loss of motion, but numbness of the knee with prickling pains, worse just above and inside the knee. The distress at first increased, afterward grew better, but at the end of two months, when the wound had fully cicatrized and the scar had begun to contract, the pain grew much sharper and altered to a "shooting and darting" character, made much worse by motion or by any cause of excitement.

Two years after the wound the soldier was still suffering pain enough to be unfit for duty. Every means of relief, other than constant hypodermics of morphia, failed to relieve him, and the division of the crural nerves was contemplated. Before this was done the man was put upon guard duty, and grew so much better after a few days that the operation was postponed. He continued to improve satisfactorily up to the time of his discharge, August 30, 1864.

Examined, 1891. This patient, whose trade is boiler-making, is now working at wool-sorting, not being able to keep all day on his feet, as his former trade required. Long standing causes swelling of the injured leg and increases the constant burning pain in it, so that it is difficult to keep it cool enough for comfort, even in the coldest weather, and he usually sleeps with it outside of his bed-clothing.

There is no difference in the size of the two legs, but the wounded (right) leg seems to tire more readily than the good one. After exertion has lasted for some time, he feels what he calls a "click" in the groin—not a pain; he rests a little; presently whatever has gone wrong "slips back," and he is able to continue his exertion. There does not seen to be any hurt at this time, but it weakens the leg for progression.

He frequently has cramps in the calf, and very often severe neuralgic pains, which have sometimes been almost continuous for a month, extending up even into the spine. There is a small area in which there is a feeling of numbness above the knee over a space between two and three inches long and two inches wide; but no loss of sense of pain or touch—indeed, tact seems to be rather more acute than normal.

The weather influences the pain very greatly, damp almost incapacitating him. There is no knee-jerk on the right (wounded) side. The reinforcement is slight. The knee-jerk is less than normal on the left side, with good reinforcement.

As the patient stands the wounded leg is as strong as the other one; but the moment the knee is bent the muscles do not act so well, and there is great loss of power. It is especially hard for him to get up stairs, and he is entirely unfit for any severe labor.

Remarks. It would seem that the original cause of pain and weakness has continued in operation up to the final examination. The persistence of burning pain from the wound of superficial nerves is unusual, and it is probable that division of these cutaneous nerves, as was at one time proposed, would have saved much suffering.

Case VI. *Shell-wound of right elbow; ankylosis; paralysis of little finger; glossy skin; altered nail-growth; continued irritability of ulnar nerve from cicatricial pressure.* (From Pension Office Reports.)—J. P. R., Lieutenant Company G, 19th Massachusetts. Lieutenant R. received a wound of the right arm from a fragment of shell at Antietam on the 17th day of September, 1862. The inner condyle of the humerus was fractured.

The first examination, made December 3, 1863, notes:

"Fragment of shell struck right elbow near inner condyle; now complete bony ankylosis by which also power of rotation in forearm is wholly lost; fore and upper arm fixed at right angle; whole arm and hand considerably atrophied; can close fingers on palm only slowly and feebly, and this attended with pain along the dorsum of hand. Excessive sensitiveness at seat of wound; a blow there sends a burning pain into the fingers. Whole limb weak. Unequal to any protracted service." (David Choate, M.D., Salem, Mass.)

Next examination, October 11, 1864, *by same surgeon:*

"The ankylosis is bony and has completely destroyed the rotation of the hand, as well as flexion and extension of forearm. The fingers can be brought to touch palm, but only after strong effort, and the attempt to grasp and retain an object causes pain along the line of extensor tendons. If kept flexed they can with difficulty be extended. He can hold and use a pen, but only for a short time, and cannot rest elbow on desk from excessive sensitiveness at seat of wound. Slight blow at elbow causes scalding sensation down to outer fingers. No improvement since the examination of one year ago from wound. The hand is useless for manual labor."

Examination at the Pension Office, January 26, 1891:

"An irregular scar the size of a half-dollar over the internal condyle of the right humerus, is slightly adherent, and the tissues about it are very tender. There is complete ankylosis of the elbow-joint, which is fixed at an angle a little greater than a right-angle. The ulnar and radius are joined together with complete loss of rotary

motion. The little finger is completely paralyzed. There is loss of sensation throughout the little finger and the outer side of the ring-finger. The right little finger is smaller than the left one and cooler, skin somewhat adherent and shiny. The nail-growth is horny. The ring-finger is slightly cooler and somewhat smaller than the one on the opposite hand. Motion at wrist-joint is perfect; the grasp of the hand is limited to the thumb, fore and middle fingers, and is very weak in these—not more than one-quarter. Slight irritation over the injured ulnar nerve at seat of wound produces trembling, fibrillary movements in the muscles to which it is distributed. Besides the ankylosis at the elbow-joint and ankylosis between the two bones of the forearm, there has been evident injury to the ulnar nerve, the tissues to which it is distributed, as shown above, being atrophied and their movements greatly impaired. The soldier says he suffers from neuralgic pains in the arm both above and below the elbow."

Remarks. This is one of the few cases of pressure from callus causing impairment of nerve-function of which any record has been found. A wound apparently injuring the ulnar at the elbow had, as a consequence of the bone destruction, large bony deposit about the elbow-joint, which included and pressed upon the hurt nerve. Neuritis and sclerotic changes in the nerve followed and have destroyed the usefulness of the arm. Early surgical interference might have been of service and have given the patient a more serviceable member. Indeed, it seems even now not too late to free the nerve from its cicatricial attachments and the pressure of these and the osseous growth, and thus probably relieve the neuritis which is still present in some degree.

Case VII. *Sprain of back muscles; constant pain in back; polyuria; sudden paraplegia twenty-five years after accident, probably from hemorrhage into the cord.* (From Pension Office Reports.)—J. S., Company B, 1st Mississippi Marine Brigade. The soldier received a sprain of the

back while carrying a small cannon, which was dropped by the two men who were assisting him, so that he wrenched the muscles of the back, and was crushed to the deck of the vessel. He continually complained of pain and weakness in his back thereafter, sometimes of very severe character.

He was examined for pension February 8, 1888. He was five feet eight inches in height; weight, 170 pounds; age, forty-four years; respiration, 18; temperature, 98$\frac{2}{5}$°; pulse-rate, 112 sitting, 120 standing, 150 after exercise. The patient stated that he suffered from severe pain in the small of the back; that he was obliged to pass water frequently, and passed large quantities, clear in color. He claimed palpitation of heart and shortness of breath on exercise. The Board say that his general appearance is plethoric, robust, and strong. Physical examination of lungs and abdominal organs negative; apex-beat in normal position; heart-muscles very weak; area of dulness diminished; no abnormal murmurs; pulse very weak, rapid, and irregular, generally very rapid after exercise, and there are at this time marked nervousness and dyspnœa. No structural changes in or about any of the muscles, tendons, or joints indicating rheumatism. No paralysis in sensation or motion, or atrophy of any of the muscles. All muscles large and firm. Hands soft. Measurements of biceps and forearms, 10$\frac{1}{2}$; thighs, 20$\frac{1}{2}$ inches. Analysis of urine negative. Co-ordination perfect. No cicatrices or other evidence of injury to back. Special senses normal. No ankle-clonus. Patellar reflex normal. Board rates him $\frac{4}{18}$ for disease of heart.

He was examined again on May 16, 1888, by another Board. Height, five feet eight inches; weight, 165 pounds; forty-four years of age; respiration, 20; pulse-rate, 80; temperature, 99°. The man alleges that he is passing large quantities of urine; has to get up once or twice at night to urinate; urine generally very clear. Passage of urine generally not painful; sometimes gives pain. Suffers greatly at times in rising from a sitting position; and back gives out soon in lifting. Never had rheumatism. The

Board state: "We find applicant of erect and symmetrical figure; well nourished, with sufficient fat to give rotundity of trunk and extremities. Has no appearance of œdema or anasarca. We have examined his spine specially in the lumbar region, and find it normal in form and color, and with no appearance of the skin to indicate that it has ever been scarred from any cause. Sacrum and hips alike normal; no wasting or atrophy. His statements to us, if entirely correct, would suggest lumbago, and not disease of any part of urinary apparatus. On examination of anus and rectum, both were found normal. An index-finger in rectum feels prostate of normal size, and not hardened, and he made no complaint of tenderness within sphincter ani. His physiognomy is not suggestive of suffering from wasting or harassing painful disease. Resonance and the respiratory sounds are normal throughout both lungs; no cough or expectoration. Heart's action is regular, a little excited, possibly somewhat influenced by the examination. No valvular murmur is heard, but there is a metallic sound with impulse; area of impulse extending to epigastrium. Giving him the benefit of any doubt, we will rate him $\frac{2}{18}$ for heart affection. Affection of heart is probably in part, if not wholly, functional. No appearance of rheumatism, past or present. No disease of kidneys."

He was examined by another Board October 2, 1889. Age, forty-six years; respiration, 18; pulse-rate, 100–120; temperature, $98\frac{1}{2}°$. He claimed that he was suffering with frequent micturition and passing excessive quantities of water, at times with pain. Claimed that he suffers from pain in small of back, as if from rheumatism, and at times in left shoulder; that he has shortness of breath and palpitation. His general appearance, the Board stated, is good. Lungs and abdominal organs negative; apex-beat in epigastrium. Impulse strong, jarring chest somewhat; no murmurs; area slightly increased. Pulse slightly irregular, but not intermittent, and very fast. No structural changes in or about any of the muscles, tendons, or joints indicating rheumatism; no cicatrices of injury; no

curvature of spine. Applicant claims pain on pressure over small of back, which we think due to lumbago. Urine analysis negative. Muscles enlarged and firm; hands calloused.

Measurements: Arms, 10 inches; thighs, 19 inches; calves, 13½ inches. Co-ordination perfect. No paralysis; no atrophy. We are only able to find irritable heart, which may be due to rheumatism (or tobacco) or the effect of injury to spine, although there is no other evidence of that injury, or to lumbago.

On the 8th day of August, 1890, the soldier was suddenly stricken down, with loss of consciousness and paraplegia, while occupied in very light labor. Consciousness was restored in a very short time, but he had some difficulty with his speech for a few days. The paraplegia has continued since that time. Bowels and bladder have not been affected. Before the attack of paraplegia he had been suffering from a severe pain and weakness in small of back, and extending down into his hip-joints. He had been unable to rise from a sitting position without taking hold of something to aid him, and during the afternoon of the day on which the paralysis occurred he felt something like a stroke or blow on his spine just between the shoulders, followed by a severe pain, which continued during the remainder of the afternoon; and while walking he perceived a sharp, darting pain in the small of his back, as though a knife had been driven into his spine just above the hips. He had had similar, but less severe, attacks of pain on several previous occasions.

An examination made September 22, 1890, found anterior spinal curvature, extending from the eleventh dorsal to the fifth lumbar vertebra. The deflection forward at point of greatest curvature was about one and a half inches. There was no tenderness on percussion in lumbar region. Paralysis in both legs was complete as to motion, and almost complete as to sensation. Loss of sensation began at third lumbar vertebra. Muscles of rectum and bladder not paralyzed. He passed from three to three and a half pints of urine a day; specific gravity,

1020; no albumin. "I think whatever trouble he may have with kidneys at times is nervous in origin. Except the spinal curvature and resultant paralysis of legs, I find claimant free from disease. He is unable to turn in bed, or assist himself when kidneys or bowels move, and requires the constant attention of a nurse. I find no evidence which would indicate that claimant ever had syphilis."

The opinion of all the examining physicians was that the pains and other symptoms, as well as the somewhat obscure troubles with the urinary organs, attended with increased flow of urine, were a result of the injury, and that all the symptoms which this claimant has suffered from, culminating finally in sudden paraplegia, were caused by the injury or pain in the back which occurred in the service.

Remarks. This is an instructive and valuable history. Such a result as this late hemorrhage in the cord is not uncommon in civil life from similar accidents, or severe spraining in lifting. There is then, as happened in this case, a largely increased flow of pale urine; sometimes it is slightly tinged with blood. The pain may last for years with no further symptoms, and then suddenly a hemorrhage occurs, or softening begins gradually in the cord.

Such cases, while not rare, require a life's experience to recognize them, and no doubt some are branded as simulation where there is really latent disease. The army surgeon not unnaturally distrusted the "back cases"—and many of them were malingerers. Here there may have been an accident, and later an independent, unrelated lesion of the cord; but all other causes of disease seem to have been carefully excluded, and the conclusion that the injury caused the paraplegia is probably the true explanation.

CASE VIII. *Ball-wound of thigh; injury or commotion of sciatic nerve; increasing disability; dry gangrene of toes twenty-six years after injury.* (From Pension Office Reports.)

—B. F. R., Spencer, Tioga Co., N. Y., Company D, New York Volunteers. The patient received a severe gunshot-wound of right thigh in battle near Dallas, Ga., May 25, 1864. Was treated in hospital and furloughed September 30, 1864; returned to duty February 2, 1865. A slight wound of the back was received at the battle of Antietam.

Examination in 1873: "Soldier five feet nine inches in height; weight, 153 pounds; age, forty-four years; respiration, 14; pulse, 72. The ball entered on the inner aspect of the leg, about eight inches above the knee, and passed behind the bone; at present it disables him somewhat when much on his feet or in walking."

An examination made in 1877 describes the wound, and notes "the bone slightly injured. The cicatrix of entrance is quite deep and adherent."

Next examination, made May 21, 1884, describes the course of the ball, and notes: "The wound of entrance is three-quarters of an inch in diameter, one-quarter of an inch deep, not adherent, and quite tender. Scales of bone, he states, worked out through the anterior aspect of the same thigh at a distance from the wound. Measurements of thighs are alike. There is some enlargement of veins of internal thigh and whole leg, which we believe to be caused by the gunshot-wound. The internal muscles of right thigh are sore under palpation. There is soreness along the sacro-iliac articulations on both sides. Heart is normal."

He was next examined February 16, 1887: "He is now fifty-seven years old. Pulse-rate, 120: respiration, 20; temperature normal; weight, 148 pounds. Fairly nourished. Course of ball described as before. Cicatrices the size of a cent, depressed and tender. Thigh corresponds with fellow in size. Much tenderness in lumbar region at exit of sciatic nerve; anæsthesia of right thigh. Tendon-reflex normal. Fine, slight varicose veins in popliteal region of right leg, not ulcerated or inflamed. Area of cardiac dulness increased; apex in normal place; impulse increased. Aortic systolic murmur. Lungs normal."

Last examination, made May 14, 1890: "He states that

last February the toes of the right foot became gangrenous. On examination, pulse-rate 108; respiration, 24; temperature normal; weight, 135 pounds; age, sixty years. Tongue coated and skin sallow. At scar of entrance there is loss of tissue, sensitive and adherent. Right thigh at point of injury one and a half inches smaller than left; right calf two inches smaller. No varicose veins at present. Dry gangrene of three toes of right foot; line of demarcation forming at junction with metatarsal bones. Heart's action increased; apex-beat in fifth interspace; impulse feeble; no murmurs; lungs healthy. Gluteal muscles right side atrophied. Tenderness over hip-joint. The gangrene is probably the result of injury to the thigh."

Medical evidence furnished in the claim in 1885 by Dr. William H. Fisher, Spencer, N. Y., is as follows:

"He has been suffering during eight years with neuralgia in right leg and back, extending at times the entire length of the spinal column. He has also varicose veins of the right leg below the knee, which are on the point of developing into ulcers, except treatment is maintained in the way of elastic stockings or horizontal position of the limb for a considerable portion of the time. The circulation of blood in the limb is very much impaired below the knee, which occasions very troublesome coldness of the part, except during the warmest weather. The limb is considerably shrunken, weak, and flabby from imperfect nutrition. The above conditions are, in my opinion, entirely the result of a gunshot-wound in the lower third of right thigh."

Other physicians treated him for varicose veins and for neuralgia in lumbar and sciatic region, which they believe resulted from gunshot-wound of right leg.

An examination of the soldier at the Pension Office was made January 21, 1891, at which he stated that when he received the wound the leg was completely paralyzed, and that he suffered then and ever since from prickling sensations and numbness in the limb. Besides neuralgic pains the flesh of the leg has always been sore and sensitive when

manipulated. Examination shows the scars of gunshot-wound of right thigh about or below the middle of middle third, entering behind the rectus and sartorius muscles, passing outward and backward through the limb behind the bone, leaving a scar on the posterior surface at about the level of entrance. The course of the ball was evidently near to the great vessels and the great sciatic nerve. The thigh at this time is greatly wasted, as is also the leg below the knee. The muscles are soft and flabby. The foot is at present red, the skin somewhat tense, shining, and adherent; there is no marked enlargement of superficial veins. The great toe and the second are entirely gone. The third toe partially remains, dry and dead, about to fall off at the metatarso-phalangeal articulation. The cicatrix is thin and tender-looking, but completely covers the metatarsal bones.

The soldier is sixty-one years old. He has marked atheroma of the radial vessels. Temporal vessels tortuous, not rough; there is no arcus senilis. Action of heart is not strong. There are no murmurs.

Remarks. In this case there was probably a commotion, if not a wound of the sciatic nerve; but the early report of the case fails to note the conditions of sensation, or other indications of a nerve-wound. The remote gangrene, if the result of this injury, is interesting, although not unique; but the case-notes are here imperfect, inasmuch as no examination of the urine appears to have been made, and it is of course possible that there was some other cause—diabetes for instance. In some other instances of sciatic wound the additional impairment caused by enlarged veins has been found to add enough nutritive disability to make even slight sequent injuries of grave moment. The general capacity of the limb to resist injury is lowered in all such cases.

Case IX. *Splint-rest palsy.* (Case 52, *Injuries of Nerves.*)—P. M., 121st Pa. The patient was wounded July 1, 1863, in his seventeenth year, by a ball which entered the right wrist three and a half inches above the

styloid process of the radius, and made exit one inch above the styloid process of the ulna. Both bones were smashed, but no important vessel was injured. *The arm was on a splint motionless for six weeks*, during which time many fragments of bone escaped.

On admission to the U. S. Hospital the wrist was much thickened by callus, the extensor tendons tied fast by adhesions, the fingers rigid, the thumb level with the palm and everted, and the wound of entry still open.

Sensation was unchanged.

Motion of the fingers was limited to slight flexion. In the thumb flexion was very feeble; the other motions fairly good. Pronation, supination, and the wrist-movements entirely impossible. Every effort at motion caused tremor.

Faradization promoted a rapid cure of the weakened muscles.

Examined by Dr. G. L. Gates, Winona, Minn., March, 1890:

In the right arm there is hyperæsthesia on pressure at the lower end of the ulna, the seat of injury, extending along the ulnar nerve, brachial and cervical plexus, and the right side of the spine, from the fourth cervical to the first dorsal vertebra. The thumb is numb, cold and clammy below the injury; also the entire arm, but more especially the outer side. The arm is not so sensitive to the prick of a needle as the left, or as are other parts of the body, where sensation is apparently normal. The right hand and arm are very sensitive to cold, but not to heat. He cannot locate a touch with any accuracy in the right hand or arm, but can do so perfectly elsewhere.

Measurements around the biceps: Right arm, 10; left, $10\frac{1}{2}$ inches. Around the largest part of the forearm: Right, 8; left, 10 inches.

There is ankylosis of wrist. Contraction of finger and thumb impaired one-half.

The parts are hyperæsthetic to touch, and motion or pressure causes a short, stinging pain at the seat of the injury and on the inner side of the elbow-joint in the muscles leading to the wound at the wrist.

The wrist is pulseless, and growing weaker; he can grasp or raise but little. The limb is shrunken one-half.

The nails do not grow so fast upon the injured side as upon the other.

The original injury is just above the wrist, but pain is felt in the shoulder and in the spinal column when tired.

Remarks. As sensation was normal after the injury, and as on faradization all the muscles responded well, it was considered that there was no neural wound. The result of treatment is described as "a rapid cure," and all the difficulties were laid to too prolonged and too absolute rest upon the splint. The remote results, wasting, paræsthesia, imperfect localizing-sense, would seem to indicate that recovery had been less complete than was supposed at the time, and that a mild degree of neuritis, possibly ascending through the brachial, had followed. The symptoms described as present in 1890 are somewhat contradictory: hyperæsthesia, paræsthesia, imperfect localization, pain on touching do not belong together in any one condition of a nerve, and in spite of the evident gross changes cause a suspicion of hysteria or of malingering.

Case X. *Comminuted fracture of clavicle; pressure by callus and fragments on brachial plexus and artery; fracture of humerus, radius, and ulna; paralysis of motion and sensation in arm, hand, and forearm; pressure removed by operation; recovery of motion and sensation; undue effect of heat on paralyzed hand.* (From Ward-book, Orthopedic Hospital.)—L. C., seventeen years of age, male, born in United States, applied at the clinic of the Orthopedic Hospital, October 27, 1892, for treatment, when the following notes were made: Family history negative. The boy was well until his fourth year, when suddenly, with no known cause, he had a convulsive seizure which left his speech much impaired, though there was no paralysis.

In July, 1892, his left arm was caught in a carpet-roller, and he sustained fractures of the left clavicle at junction of outer and mid-third of the middle of the

left humerus, and of both bones of the forearm. He was eight weeks in charge of Dr. Richard Harte, at the Episcopal Hospital, during which the fractures mended, but when discharged there was partial paralysis of the arm. He was referred to the Orthopedic Hospital for treatment of this condition, and eleven weeks after the injury the notes of the following examinations were taken there:

Motion. He has slight use of the deltoid, but cannot move arm forward or back, nor extend forearm, although there is no elbow ankylosis. The fingers cannot be flexed or extended. Passive pronation and supination are much confined, with some pain. Attempts at passive movement of fingers cause pain in the joints. There is slight contracture of the fingers. He can flex the elbow when the arm is held at the shoulder-level.

Nutrition. Some general wasting, no glossiness; the limb is cold and blue, the palm soft and red, a small ulcer on the ring-finger.

Growth of finger-nails cannot be judged, as the patient persistently bites them short. There is a considerable growth of short hair on the whole arm and shoulder, and scarcely any on the sound side.

The broken ends of the clavicle overlap, and there is a large bony deposit in the middle of the bone. The callus in the forearm is still more excessive. No radial or brachial pulse to be felt.

Pain. Hyperæsthesia in hand, none in forearm above fracture.

Temperature of the right palm is 94° F.; of the left, 85.5° F.

Measurements. Middle of left arm, 7½ inches; middle of right arm, 8½ inches. From middle of supra-sternal notch to tip of left acromion, 6 inches; to tip of right acromion, 6½ inches.

Electrical condition. All muscles of the shoulder, arm, and forearm show marked degenerative changes. Brachial plexus gives no faradic reaction. Nerves from brachial plexus show the same changes of degeneration. After

several days' galvanism the biceps and deltoid showed slight reactions.

An operation to relieve the probable pressure on the nerves by callus or fragments of bone was determined upon, and on December 9th Dr. Morton made an incision along the line of the clavicle. He found three fragments. The inner end of the outer fragment overlapped the outer end of the inner fragment, pressing it down upon the plexus and vessels, and forming an angle of about 150°, with the apex up. The base of a triangle was formed by the third bit of bone, a piece of about an inch long. The first two portions were solidly joined ; the third had only a fibrous union. The middle third of the clavicle was excised, leaving the periosteum.

Three hours after the operation pulsation could be detected in both brachial and radial arteries.

No improvement of sensation or motion could be found on the seventh day after operation, but the temperature of the injured hand had risen to 88°.

On the eleventh day the experiment was tried of placing a finger of the injured hand in hot water in which the physician could hold his hand with no evil result. The patient's finger was, however, promptly blistered by it, and so severely that three days later the nail came off with the skin.

Three weeks after operation there had been decided improvement. A touch was felt quickly on arm and forearm, and motion was increased in the deltoid, and beginning to appear in the triceps.

Six weeks after operation all the muscles of the forearm and arm showed response to galvanism, and sensation was still improving.

As before remarked, the final results of operation were not such as had been hoped for. It was thought that no apparatus would be needed to prevent the shoulder falling forward, and none was used. After a time, however, the distance between the shoulder and the centre of the sternum became less than normal, and again a huge mass of callus formed, probably so as to compress anew the

plexus. The artery, however, could still be felt, but either from return of callus or from insufficiency of blood-supply, the limb has now for some months ceased to show any improvement.

Remarks. The evil effects of the fractures in this case were due not only to the compression of the brachial plexus by the callus and the misplaced bit of bone, but to their pressing upon the artery as well, thus impairing the nutrition of the arm by greatly lessening the blood-supply as well as by interfering with the trophic usefulness of the nerve. There were no signs of neuritis, contrary to what might have been expected, except the slight and vaguely distributed hyperæsthesia, and this was largely a mental symptom, more a fear of being touched or handled, arising from the suffering the poor lad had gone through and the shock of lesions so severe and extensive, than actual supersensitiveness to pain. The condition compares curiously with that of XLV., where, too, there was pressure upon the plexus, in the first place by a dislocation, in the second by a misapplied ligature, and where, too, there was the same undue sensitiveness to mild degrees of heat. The experiment of applying hot water to the skin of C.'s hand was suggested by the unusual effect it had on XLV. It was thought there to have done some little good, though rather a severe measure of counter-irritation, but not so severe as it seems, when one remembers that the hand was without sensation to touch, except in a very small area.

CASE XI. *Gunshot-wound of right forearm; partial loss of sensation; ankylosis of fingers and wrist; recovery; late degeneration of nerve.* (*Sanitary Commission Memoirs* [*Medical*], Case I.)—J. A., aged nineteen years, Company G, 83d Pennsylvania, was shot through the forearm at the battle of Chancellorsville, May, 1863. The ball passed between the bones of the right forearm, entering on the inner side of the arm at the junction of the middle and lower thirds, and emerging two inches lower upon the

posterior aspect. No account of the immediate symptoms is given.

The wound healed in six weeks, but with the fingers a good deal contracted and a stiff wrist. On June 23, 1863, the patient was admitted to the Turner's Lane Hospital, Philadelphia. The index and second fingers were then insensitive, especially upon their posterior faces.

During four months' treatment by electricity, movement, douches, and stimulating applications sensibility gradually improved, and on November 1, 1863, he was ordered to return to duty, with "movements and sensation nearly normal."

March 31, 1890. But little sensation is felt from a touch below the elbow, except on the inside of the arm. Pressure on the tendons on the inside of the arm sends a numb, prickling sensation to the ends of the fingers and to the elbow. Heat does not affect hand or arm, but cold is almost unendurable. Grip very feeble, and after opening and shutting the hand several times in succession all power of grasping is lost for the time being; in this particular it is becoming worse. The shrinkage of the arm is half an inch. The muscles of the palm are completely wasted; nothing but skin over the bones. No odor is observable; no moisture at any time is found on the surface of the arm or hand. There is no difference in the color of the hair; below the wound the hair is coarser, and contact with the clothing wears it off.

The nails grow nearly as fast as upon the other hand, but are very brittle; the growth is described as corrugated.

The eyes are easily affected by sunlight, and at times have a numb sensation. Cannot read by lamplight, nor at any time more than a few minutes.

Remarks. Hair and nails are brittle. There is, as usual, some permanent altered sensory relation to temperature, which here appears as sensitiveness to cold. The absence of any sweat secretion shows in another form the trophic disturbance. Muscular power of movement, as well as of endurance, is greatly lessened, and we may conclude that

the nerve which gave at first no very decided signs of having been injured must have received some contusion, with the result of setting up a late and slow degenerative change.

CASE XII. *Crutch-palsy; partial paralysis of deltoid, biceps, and flexors of hand and fingers; recovery; partial relapse.* (*Injuries of Nerves*, p. 133.)—G. C. M., Company B, 1st Massachusetts Cavalry. The patient had a fracture of both bones of the right leg, which united slowly, keeping him a long time on crutches. While using two crutches he had no trouble, but after three weeks' use of one crutch under the right arm he found one day that the third and fourth fingers of the right hand were numb, and the same night lost power in the arm partially.

Examination eleven days after loss of power, July 21, 1863:

Motion. Deltoid weak; other shoulder-muscles normal. The biceps had somewhat strengthened, but was still weak; flexion and extension of the wrist were much impaired, and the finger-movements excessively weak.

Sensibility was lost in the ulnar side of the palm, wrist, and forearm, and nearly absent in the forefinger.

The note on his discharge after four months' treatment is "full use of the weakened muscles," with "some slight numbness of the fourth finger and ulnar palm."

Examination by Dr. H. A. Sibley, Chelsea, Mass., March, 1890:

Sensation of pain in the right arm and of touch in the fingers of the right hand are both considerably impaired. A touch is not felt as a prick or a pinch. The right arm is more sensitive to cold than the left. Movement of the right arm is not so good as that of the left; it has never completely regained its normal movement. The nails do not grow so fast as those on the left hand. On close inspection they *seem* a little thicker and some of them slightly congested.

Remarks. A partial relapse has taken place in this

case, both in ability of motion and in perfection of sensibility, an unusual result, as crutch-palsy commonly recovers rapidly and completely with the removal of the cause; more rapidly and more completely, indeed, than is the case with other pressure-palsies, which are too often lasting. The most unfavorable outlook seems to be not in cases where there is pressure exerted for some time, as in crutch-palsy, but in those where the force is of briefer duration and more intense, as in the arm-palsies caused during the heavy sleep of the drunkard.

Case XIII. *Pure pressure-palsy from railroad accident; general weakness of forearm muscles; no signs of neuritis.* (Infirmary for Nervous Diseases, December 7, 1893.)—J. H. W., aged twenty-two years; single; born in the United States. *Family history* negative. *Personal history:* Never ill before present trouble. Worked as a blacksmith's apprentice for four years previous to autumn of 1893; then, as he could not get work at his trade, became a freight brakeman. On October 5, 1893, while coupling a car to the engine, was caught by the left arm between the bumpers. The arm was lying on one of the bumpers and slipped between them, in a semi-prone position and at right angles to the body. The middle and lower thirds were held on the ulnar side only, leaving the radial side untouched. He could not get the arm loose till the cars were separated. The skin was peeled off superficially, but not so deeply as to draw blood. The tissues were bruised, "black and blue," but not torn, and no bones were broken. The little and ring-fingers were flexed, numb, and anæsthetic immediately after the accident. Could not lift a shovel.

Local applications were made and a splint put on for one week. These relieved the pain, and in about eight days he went to work. He states that two days after the splint was removed the numb sensation returned somewhat, and the fingers became flexed again. He worked steadily for three days, though the numbness and contraction increased, and continued at his duties off and on till

November 5, 1893, when he had some vaguely described "chest trouble," which put him to bed till November 25th. He was very weak on his recovery from this, and the arm grew worse till he came to the surgical dispensary at the hospital on December 4th.

He was referred by Dr. Goodman to Dr. Mitchell, who ordered alternate hot and cold douching and faradism to the muscles.

Examination December 5, 1893. All organs, etc., are perfectly healthy except the injured member. He has diminished power in the left forearm and hand; dynamometer, R., 150; L., 70; can flex fingers so that they touch the palm of the hand, but feebly; cannot fully extend the two end-phalanges of little and ring-fingers on account of the contraction (?) of the opposing flexor muscle (flexor sublimis digitorum); cannot abduct or adduct little or ring-finger. There is no pain or tenderness in any part, and no sensations of tingling or numbness at present.

Sensation is diminished over the whole of the forearm and hand below the seat of injury, but most markedly over the outer side of the little and the adjoining aspects of the little and ring-fingers on both dorsal and palmar sides. Contact is here felt, but the patient is unable to distinguish dull from sharp. There is an area of total anæsthesia about the size of a half-dollar between the metacarpal bones of the thumb and index-finger. Heat and cold are perceived normally, except that very slight differences are not well appreciated.

The hypothenar group of muscles are wasted. All the muscles moving the hand at the wrist are in good condition.

Electrical examination. *Faradic* reaction lost in hypothenar muscles, adductor proprius pollicis and interossei; normal in thenar and forearm extensors.

Galvanism. In hypothenar and interossei KCC = AnCC. Marked quantitative change and beginning DeR.

12*th.* Decided improvement; sensation much better; stronger; dynamometer, R., 165; L., 120. Can extend fingers much better.

30*th*. Still improving. Sensation practically normal. Extension power still better. Dynamometer, R., 160; L., 130. Insisted on going home, and was accordingly discharged.

January 20, 1894 Returned to dispensary complaining that the arm was worse again and the contraction returning. A surgeon at home had told him the arm would never recover, and should be amputated. Treatment had been neglected in consequence. Splint was replaced, and he was ordered to keep up passive movements and faradism. Improvement promptly began again, which was stopped on a second cessation of treatment.

He returned to the dispensary after this more regularly, and continued to make excellent progress when last seen.

Remarks. The absence of all signs of the neuritis which might reasonably be expected to follow so severe a squeeze is to be remarked, and the several improvements and relapses, according as the treatment was properly carried on or neglected, are the interesting features of the case.

CASE XIV. *Fracture of internal condyle at elbow; immediate loss of sensibility in the forearm and hand; unusual susceptibility to heat; great clubbing of finger-tips and other trophic changes.*—H. S., aged six years, orphan child, sent by Dr. William J. Taylor from St. Agnes' Hospital. Nothing in the previous or family history can be elicited of any interest in connection with the present condition.

On December 18, 1893, the child fell down some eight steps. The woman with whom the child lives reported that the right arm was bent back at the elbow, that there was much pain, and a great deal of prompt swelling.

The physician who saw her said that there was a break at the elbow, and it is also stated that there was a loss of sensation to touch and pain from the elbow down. There was no skin abrasion.

The arm was at first put in a posterior angular splint for twelve hours, and afterward on a tin splint from the elbow to the finger-tips, and for a week was re-dressed

every day. Sensation began to return in the forearm about four weeks after the injury, at which time the forearm could be flexed and extended somewhat; but there were no motion and no sensation below the wrist.

Fomentation of warm vinegar, with salt in solution, was used daily for two weeks. The splint was removed one week after the injury, and passive motion advised, with the result of much pain in the elbow, but none below this point. The arm was carried in a sling for a few days more, but from that time on no dressing has been worn, the arm hanging limp by the side.

It was stated that about one week after the fracture the child's hand was placed in hot vinegar, with the result of causing a severe burn of all the fingers except the thumb, although the vinegar was not hot enough to scald an uninjured hand. The patient made no complaint of this injury, but it was very slow in healing.

Electric treatment was commenced at the end of a month, and was used every day for one week. About the same time sensation began to return. In four or five weeks the child could flex and extend the right elbow herself, and since then the power of flexion and extension of the fingers has returned in a very slight degree.

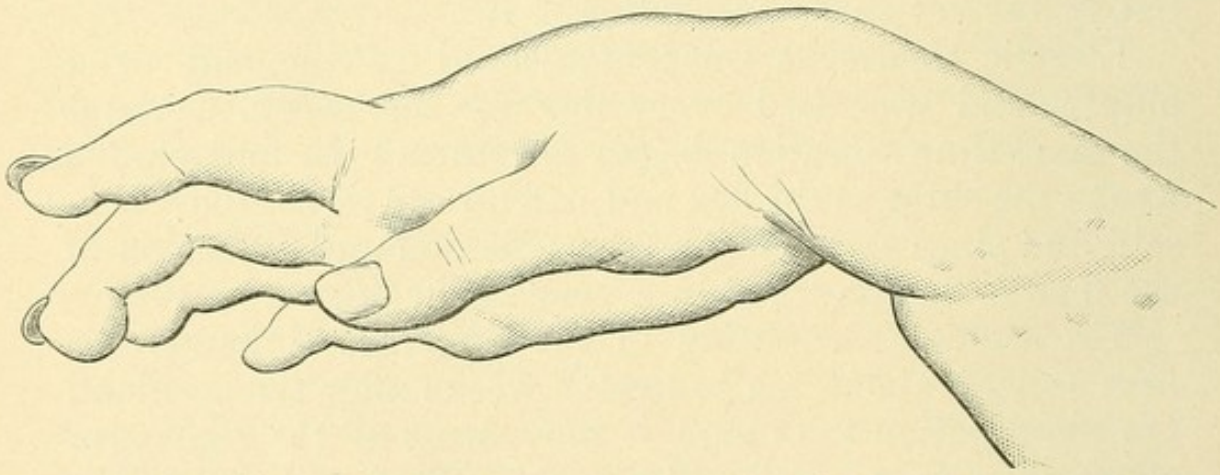
The return of sensation in the fingers and hands was first noticed about ten to twelve weeks after the accident. On examination the range of movement of the right arm above the elbow was found normal. The condition of the elbow seems to be good. The external condyle, the olecranon, and the internal condyle are in normal line with the arm extended, but there seems to be a ligamentous union of the external condyle with the humerus. The ulna is slightly bowed back. The sensation has returned completely in the right arm, even to the finger-tips, and the child localizes well. The fingers of the injured hand are partially flexed. The flexors in the forearm are contracted, so that the wrist is constantly somewhat flexed, and there is very little mobility of the joint. The fingers are clubbed to a very remarkable degree, the tip of the middle finger most markedly so. Some redness of the

skin of the finger still remains from the old burn. Thermal sense is now perfect.

The right forearm is somewhat atrophic, the skin hard, with a slightly glazed appearance below the middle third. The sensation is normal to touch, pain, and temperature over all the cutaneous nerve distributions. It is possible from the child's answers that the touch-sense is somewhat lessened over the thumb, index, middle, and median half of the ring-finger.

The muscle-jerks in the extensors are good, less good in the flexors. Faradic reaction is lost in the flexors of the forearm and in the intrinsic hand-muscles supplied by the median. The musculo-spiral and ulnar supplies are normal, with great reduction to faradism.

FIG. 1.



H. S. Case XIV. Finger-tips clubbed, especially middle and ring-fingers; nails curved and ridged; operation-scar on wrist.

On examination upon admission to the hospital in May, 1894, Dr. Keen gave it as his opinion that there had been a fracture of the internal condyle. Under treatment the red and glazed area disappeared somewhat, remaining well marked only on the fingers, and more especially at their tips.

Dr. Keen operated October 19, 1894, making an incision three inches long across the wrist from the ulnar side upward and toward the radial side. The superficial and deep tendons thus exposed, nine in all, were split with the

knife and lengthened about one inch; two stitches were then inserted in each tendon, the dressings applied, and the hand placed upon a straight palmar splint. The wrist could readily be completely extended after the operation, showing that muscular contraction was the sole source of the flexed position. The wound healed rapidly; the splint was reapplied daily, but no contraction appeared until, after perfect healing, the splint was removed No-

FIG. 2.

H. S. Case XIV. Sketch showing deformity of nails and peculiar shape of finger-tips; thumb normal.

vember 10th. Within two days the wrist had begun to contract again, and in a few days was as bad as ever; but upon reapplying the splint the flexed joint was readily straightened with little pain, and the apparatus was therefore ordered to be kept on, removing it daily for massage, and reapplying.

Remarks. The elbow injury must have brought about some pressure upon the nerves about the joint, which remains operative in spite of the healing of the fracture. Unless speedy improvement takes place under the use of

the splint, with passive movements and massage, it will probably become necessary to explore the neighborhood of the elbow, examine the nerves, and remove the cause of pressure or irritation.

The hand-condition is so remarkable that drawings are inserted to show it. The finger-tips are clubbed, and not only this, but the pulp on the palmar aspect is so enlarged that in profile the middle finger, which exhibits this peculiarity most, has an appearance almost as though there were a localized abscess in its tip. This swelling is not hard or tender, and seems to be a real hypertrophy of the tissues. The nails on all the fingers except the thumb are greatly distorted, ridged, and thickened; but this is probably due in part to the scalding mentioned, not wholly to the nerve injury higher up.

CHAPTER II.

SECTIONS OF NERVES—COMPLETE OR INCOMPLETE.

From the symptoms immediately following the reception of a nerve wound no absolute opinion can be formed of the extent of damage to the trunk, of the exact character of the injury, nor any just estimate of the probable final result. A severe blow, a concussion, a laceration, a complete division of a nerve may—any of them—cause symptoms at first nearly identical. The pain at the moment is seldom great; when a nerve is severed there is usually little pain felt, except sometimes a single flash as the wound is received, then communication is interrupted, and until inflammation begins there is but small suffering. In only two cases out of fifty-six examined as to this point was the pain at the instant of wounding described as acute. Tingling and formication may be present, but more important signs of the amount of harm done are paralysis and loss of sensibility. In slight blows and trifling lacerations these may for a few hours, or a day or two, be quite complete, and then be rapidly restored, which of course does not happen where section has been made. In that event the paralysis is followed by a loss of tone in the muscles, which makes them at once distinctly less firm to the touch, and within twenty-four hours a diminution of faradic contractility will be found; these conditions increase, the muscles become more and more flabby, the normal electric irritability lessens until this form of stim-

ulation does not affect them at all (from the fourth to the eighth day), though even with quite advanced atrophy the responsiveness to galvanism continues, changing after some weeks from the normal formula KCC > AnCC to the reaction of degeneration AnCC = KCC or AnCC > KCC.

In injuries from missiles of war there was some shock in the larger number of cases, the amount of constitutional disturbance having some relation to the extent of the neural wound, but rather more perhaps to the size and vital importance of the affected nerve. Most shock was consequent in the cases analyzed [1] upon hurts of the nerves of the neck and axillary regions. In civil practice this is an element of not very great importance; shock, after simple nerve wounds, unless complicated with extensive lesion of neighboring parts, is not common.

Of the other primary symptoms the chief and the most difficult to make sure of or to draw just conclusions from is the change in sensibility. Complete anæsthesia may be an immediate result of trifling injury, but in that case sensation is soon partially restored. Before a diagnosis can be reached with certainty, touch, pain, temperature, and localization senses must be minutely studied. It is sometimes confusing to find, when all other symptoms agree in pointing to a nerve section, that the patient has touch-sense where no touch-sense should be; but if any decided amount of sensation be preserved, there is a likelihood that the nerve has sustained a laceration or commotion, rather than that it has been divided. Besides, especially in wounds of the upper extremity, the interrelation and numerous recurring and communicating

[1] Injuries of Nerves, Chapter VI.

branches of the nerves of the arm and hand must be remembered. That mistakes are frequently made from forgetfulness of this is shown in the manner in which "successful" cases of nerve-suture are reported.[1]

These remarks upon the difficulties of diagnosis apply especially to gunshot injuries, or those where the surface lesion is not extensive enough to allow of direct search for the nerve, or where it may be undesirable to enlarge the wound for exploration. Where this can be done the obstacles to correct diagnosis are lessened, especially if the electric battery be judiciously used; should cut nerve-ends be found, it would be well to make careful study with the battery before suturing, in order to ascertain the exact area involved.

So much for the primary symptoms which ordinarily follow a neural wound in its first few days. The later course of injuries involving the division or destruction of continuity of a nerve may now be considered. It interests us to know what symptoms are time-cured, what persist, growing worse or better, what new conditions may arise, and what influence age, disease, etc., have to make matters better or worse.

Generally, it may be said that complete sections of nerves by shell or bullet (no instances of sword-wounds happen to be among the cases) resulted even less well than do the similar injuries from the accidents of civil life. The reasons for this are not far to seek; they have been referred to in the Introduction, and may be stated here once for all, though they should be remembered in judging of all the United States Army Hospital cases reported in other parts of this study. First, a nerve divided by a bullet has sus-

[1] See Chapter VI.

tained a far more extensive damage than one similarly cut by glass or a sharp instrument. The neighboring parts are sure to be much bruised and cut as well. Then the condition of the person at the moment has much to do with the course of the case, and in the army cases this was often very bad.

The special wards of the Christian Street United States Army Hospital for Injuries and Diseases of the Nervous System were put to use first in the spring of 1863; the succeeding two years were filled with the hardest fighting which the Civil War saw. From Chancellorsville, in the spring of 1863, to the Wilderness campaign, in May, 1864, the Army of the Potomac, from which the patients of the Philadelphia hospitals mostly came, was never without fighting on its hands. It was during this period that most of the cases reported in *Gunshot Wounds* came under observation. The stories of the patients are told in brief phrases in the hospital notes—"had had little food and bad for three days before injury;" "laid two days on the battlefield without water or any attention to wound;" "captured after wounding and spent nine months in Libby Prison." These tell of influences which must have injuriously affected the repair of wounds. Scurvy, camp-diarrhœa, fever and ague, complete physical exhaustion, all had their share in preparing men for the worst effects from injuries. On the other hand, the youth of most of the sufferers was in their favor, clinical experience agreeing with the evidence of experiments upon animals that regeneration and restoration of function are more rapid, and perhaps more complete, in the young than in the mature.

Another consideration hinders the drawing of general conclusions unfavorable to the means of treatment used

from some of the bad results here reported; it is reasonable to suppose that a man who at the late date after the war (1890), when the circular of questions was sent out, was still suffering from his old wound, was much more likely to answer than one who was perfectly well. Some hope of help or relief might prompt the former; the latter would have nothing to gain.

Regeneration of cut nerves is a process which is certainly slow, and, judging from such testimony as we possess, may occasionally need years for its completion.

Not less than a year or two years of active treatment should therefore elapse after a nerve-section before the physician need begin to despair of improvement. Even at a longer interval than this improvement sometimes occurs. In the chapter on "Treatment" the time occupied in repair and the methods employed to aid it will be more fully considered.

The later symptoms depend in part upon the character of the original injury, in still greater measure upon the early treatment. The results described—atrophy, anæsthesia, or various perversions of sensation, may persist or increase; then, in unfavorable cases, there appear neuritis and its accompanying horrible pains—causalgia or neuralgia, the joints may become swollen and tender, the hair fall off or increase its growth, the nails grow too slowly and become curved and ridged, eczema, bullæ, or ulcers may develop. The neuritis ascends or descends, or both, or becomes chronic. Alterations in the natural secretions take place—the skin may be glossy or harsh and dry, may sweat excessively with an acid and offensive smell, or this secretion cease altogether.

All these symptoms have been very elaborately and minutely described and considered by Drs. Mitchell,

Morehouse, and Keen in *Gunshot Wounds*, and more fully by Dr. Mitchell in *Injuries of Nerves*. What is said about them here is only intended as a brief *résumé*, to make more clear the discussion of cases of which they were or still are part.

The consideration of the cases is taken up at the point in their histories when they were discharged from the United States Army Hospital.

Extreme atrophy of muscles is not by itself a basis for unfavorable prognosis, although accompanied by impaired sensation. Even contraction, if limited to a wounded muscle or to the group supplied by a cut nerve, need not add to the bad prospects of the case. Case XVI. is an example of good recovery from such a result. The worst form, as already said, is where unopposed muscles with unbroken neural communication contract and produce strange and irremediable deformities, because then we cannot, by calling their natural opponents to our aid, overcome the malposition. In the former case we may bring about relaxation of the hurt or overstimulated muscle by manipulation, by mechanical appliances, perhaps by tenotomy, and by injections of atropia, and with massage and electricity may strengthen its opponents. Motion sometimes improves even after many years; in XV. it grew remarkably better more than twenty years after the injury.

But where the nerve has not regenerated and the contractions have once well started little can be done. The wounds of the brachial plexus, in which the whole arm was paralyzed, had especially bad results, probably because there was so little material to work upon. XVII. and XVIII. were both originally very bad cases, and, except for lessening of pain as time passed, had changed

but little for the better in twenty-seven years. The extraordinary degree of deformity which may be reached by the action of a group of unopposed muscles is shown in the picture of XVIII. at page 81. A lesser grade of the same trouble is illustrated by the photographs of XVII. XIX. sustained also a ball-wound of the plexus, no doubt more completely destroying the nerves, either by the impact of the ball or by the fragments of bone carried with it, for, while he had less pain than the others, he also made even less improvement, and his arm remained to the day of his death practically useless and insensible.

Of less long-standing, and therefore impossible to speak with certainty about, is XXI. Still, the promise here is better, for he was early and carefully treated ; treatment is still kept up, and his youth is on his side. In him, more exactly than in the others, the precise course of the bullet could be made out, and it could be determined that only one of the lower cords of the plexus was cut.

Contraction of muscles takes strange forms in occasional cases, and has in some an amazing power of continuance. In XX., as may be seen in the very thorough and careful account quoted from the notes of Dr. N. C. Reed, a "spring-trap" contraction is mentioned, which had lasted for twenty-three years. How is it that no ankylosis has taken place? In another patient (C. T., XXII.), unluckily early lost sight of, a rigid contraction followed a punctured wound of the median nerves, much like a hysterical rigidity, and probably partly of this character. There were pain and tenderness with it, but no wasting.

Destruction of nerves in the leg is less often followed by muscular contractions or by joint-stiffening. Capt. L.

(XXIX.) has a leg which is not only a useless but a very troublesome appendage. The nerves of the lower leg were first injured by a shell, and their destruction completed later and all possibility of regeneration destroyed by large abscesses in the same region; but no ankylosis followed, nor any contraction. Some of the symptoms seem always to have been less severe in the lower limbs; when neuritis occurred the eczema, glossy skin, and violent pain did not so commonly accompany it. As to the comparative infrequency of ankylosis, this was in part due to its being more easy to make a patient use a disabled leg than a lame arm. The inconvenience of a useless leg is so great that, even when to walk causes pain, a man will try to get about a little, so that there is less chance for disuse to become an important element. The good result of such enforced movement has already been illustrated by one case (V.).

Neuritis promptly followed an injury of doubtful extent to the sciatic in Krieger (XXVIII.). Touch and pain-sense both disappeared for a time; but if the nerve was wholly divided, which seems improbable, regeneration and union had taken place when he was admitted to the United States Army Hospital. At present sensation and motion both remain impaired, the power of extension of the foot and toes having never been regained.

Most interesting questions in the physiology of nerve-supply and as to the regeneration of nerves are suggested by the cases where there was a total destruction of the nerve. Where a small missile cut a nerve it is easy to conceive that spontaneous regeneration might take place. Where a larger wound was made, or where the nerve was crushed and lacerated by fragments of bone scattered and smashed into the tissues by the ball, the results were nat-

urally worse. In XXIX. there is no pain-sense below the site of nerve-section, because there is no nerve to carry sensation. But in Dyer, where the facial was totally destroyed in the canal, though there has been no improvement of motion and scarcely any in sensibility, the patient suffers increasing pain. The facial nerve being purely a nerve of motion, of course this pain is a referred and sympathetic one, and it is difficult, besides, to gauge correctly the extent of an injury deep in the bone, as this one was. Nor is there any evidence here that a reflected neuritis has been the cause of pain. A neuritis could scarcely occur in such a situation without the most serious results immediately showing themselves. Fatal meningitis would probably develop upon any deep inflammation of this nerve. The sole point in which this soldier is better is that by practice his speech has grown clearer. Where a part of a plexus of nerves was destroyed continued pain is the rule, as shown in many cases—for example, XVII., XVIII., and XIX.

The differing completeness of recovery of motion, as compared with the return of sensation, is of the utmost interest. It was stated in *Injuries of Nerves*, and has been corroborated by numerous authors since, that sensation returns sooner than motion. This return may be imperfect, may be perverted in part, so that, for instance, a touch is perceived but wrongly localized, or is felt as pain, or no distinction is made between touch with a blunt and touch with a sharp instrument, or unusual sensations are produced, as of "thrill" or "purring," as some of the patients call it. As in Waller's experiments already cited, thermal sense was found to remain long disturbed, either lessened in delicacy or exaggerated, so that moderate heat and cold are distressing.

The mis-references of the locality of a touch are most curious, but the cases which I can cite are too few to warrant any very definite deduction, the perversions being somewhat contradictory. One of these is to mis-refer a touch upward, the peripheral sensation being interpreted as nearer the centre than is true. The mis-placing is inconstant in some cases, but quite regular in others. Another form, far less commonly seen, is mis-reference downward, as in XXVI. It is not difficult to frame a theory which will account for one of these forms, but how explain the occurrence of both in one limb, as in XVII., or the still more curious condition found in the sufferer from a spinal injury, who referred all touch upon the trunk to the head? (XXXVIII.).

This condition of false reference of touch is no doubt incidental to a nerve's undergoing repair; that is, it is a natural part of the process of regeneration, and where the recovery was perfect this state would gradually pass away, and finally localization would be accurately performed. I shall discuss this more fully later in speaking of the clinical aspects of regeneration.

In a few cases it will be observed that motion has been partly or wholly regained, while sensibility has remained impaired. In some of these it is only special forms of sensibility that are bad; for instance, separation of two points or general localization is not well done, although ordinary touch-sense may be good. XVI. has preserved ordinary touch well enough to pick up small objects without difficulty, yet cannot perceive the compass-points as two until they are quite widely separated.

Where opportunity has occurred the course of return of sensation and motion has been observed, as will be seen in the notes of several of the cases. In XLV. a pecu-

liarly favorable case was presented. The patient was well educated, intelligent, and interested, and made a good witness Return of sensibility was from above downward, and motion was following, much more slowly, a like path, when the young man was last seen. In X. return of motion was in the same way first noted in the deltoid, then in the triceps, and progressed down the arm; but the testimony was not so clear in his case, as the lad was incompetent in speech and quite ignorant. The other and peculiar phenomena of the return of touch and pain senses in XLV. will be found more fully considered in the remarks on the case, which is an unparalleled one.

The men who suffered the agonizing burning pains accompanying nerve-inflammation, of which so many terrible examples were seen in the United States Army Hospital, seem uniformly to have retained an exaggerated sensibility to heat or cold, or both, to this day. It will be remembered that most of them suffered excessively from heat originally, and this continues to be a cause of trouble with some. XV. and XVI., both otherwise much improved, still suffer from extremes of cold and heat, and the latter has even now some burning. V. enjoys cold, but heat is distressing to his wounded limb. XVII., XVIII., and XXVIII., all originally among the worst cases of causalgic pains reported in *Injuries of Nerves*, have none of them pain of that character at present, though they all suffer greatly from changes of temperature, and still more from warmth. XX. was not a causalgic case, but hot weather or the application of local heat gives him great pain. Both XX. and XVIII. have a curious symptom in common, although in other respects the cases are little alike. Both still present a

higher local temperature upon the affected than upon the sound side, and this in spite of the atrophy of the tissues of the limbs affected, an atrophy which in the latter has reached a very high degree. (See Remarks on the cases.)

It might be said of these, as of those instances quoted in the previous chapter, that the recovery of thermal sense lags behind; for although there is sensibility—and too great sensibility—to heat and cold, it is in perverted or exaggerated forms, just as we say touch-sense is imperfectly restored if it has returned in some abnormal way, as when light contact is felt as pain.

This abnormal thermal sensitiveness was exhibited by some patients in whom common sensation was fairly good.

The course and progress of the trophic changes resultant upon nerve-section must be reserved for consideration in a separate chapter.

The following thirteen cases have some of them been discussed in this chapter, and others are illustrative of various conditions incident to complete sections of nerves. The special symptoms of each case have been fully considered in the remarks attached to each one, at the expense of some pardonable repetition.

Case XV. *Gunshot-wound of brachial plexus; loss of motion; late improvement of motion; increased rapidity of nail-growth.* (MS. notes.)—S. G., Bremen, Ohio, Company I, 26th Ohio. The patient received, in his thirty-second year, a musket-ball through the upper chest and shoulder-blade, in the Wilderness, May, 1864, while standing a few yards from the enemy's lines. He fell, feeling stunned, and lost consciousness, but presently recovering, crawled into our lines, and was carried to the rear. He was kept under morphine, but in the overcrowded hospital nothing more was done for him until

the third day, when the wound was dressed at Fredericksburg. Previous to this time he has no recollection of the condition of the arm, but remembers at the time of dressing he could move his elbow and fingers a little. The arm was numb and cold, but sensible of a touch. Sensation improved under treatment, but motion was very little bettered.

Patient's statement, 1890. "Sensation of touch is not so acute as it should be. I cannot stand the hot rays of the sun, and a little cold paralyzes my arm. The prick of a pin produces an aching sensation; not the acute pain that it should. There is no movement in the shoulder; just enough in the fingers to hold a fork. There is a difference in the circumference of the arms at the shoulder of two and one-half inches and one and one-half inches above the elbow. The muscles are atrophied. At first there was no motion in any part of the arm or forearm, but for the last five or six years the forearm could be moved a little. There is nothing noticeable concerning the secretions. The nails on the injured hand seem to grow a little more rapidly than those on the other hand; they are inclined to curve and are a little tough. For a long time the muscles of the face and neck would twitch and jerk with a sort of spasmodic motion; but of late years this does not occur. The arm is still similarly affected."

Remarks. The report of the case is a very imperfect one, and it is difficult to ascertain what nerves were injured, further than that some branches of the brachial plexus evidently suffered. The very late improvement in motion is curious. In this soldier, as in most of the other cases, an extreme susceptibility to change of temperature has remained, though more to heat than is usually found, and in his case, as in XXIII. and II., the nails are said to grow *more* rapidly on the injured side.

No mention is made in the original notes of the twitching of the arm to which G. refers in his statement, nor of the movements of the face and neck. They are insufficiently described to pronounce an opinion upon.

Case XVI. *Gunshot-wound through biceps muscle; tenderness in median distribution; contraction of the elbow; nearly complete recovery of motion, with impaired sensibility and persistent burning pain.* (MS. notes.)—J. M., Company D, 59th Massachusetts, was wounded in his nineteenth year by a bullet which traversed the middle of the belly of the biceps flexor of the right arm, passed upward, backward, and out of the back of the arm two inches below the posterior axillary junction. Tenderness throughout the median nerve resulted with a special point of pain in the middle of the palm of the right hand. The tenderness continued, and a burning pain was added, and later contraction of the elbow from contraction of the wounded muscle. The arm was treated by extension, and the median tract was dry-cupped.

The contraction persisted after the pain and tenderness had subsided, and it was a year after his discharge before it had disappeared.

February, 1890, the patient wrote that the arm was useful for all sorts of light work, but that burning continued from the armpit to the palm.

Dr. Samuel N. Nelson, of the Soldiers' Home, Chelsea, Mass., examined the patient, and reported as follows, March, 1890: "He distinguishes two points on the anterior surface of the left forearm at three inches; on right, six and one-half inches. On the back of the left hand the two points are distinguished at one inch, but on the right they are not perceived as two at two and one-half inches. Palms: left, two points separated at one inch; right, one and three-eighths inches. He picks up small and light articles, even pins, equally well with both hands, but heavy objects soon tire the right arm. The right hand is very sensitive to heat and cold."

All motions are restored, it is not shrunken, there is no change in the secretions, and the nails and hair are in no way different on the wounded from those on the sound side.

Remarks. This case requires no comment except to note the disproportion of the recovery of sensation as compared with the restoration of movement. All move-

ments are perfect, he reports, though not so strong as normal; but sensation remains a good deal impaired in delicacy, and the peculiar burning pain of a nerve-wound lasts up to the present time. It may be added that localization-perception is far below the normal upon the unwounded arm and hand.

CASE XVII. *Gunshot-wound of left brachial plexus; causalgia; contraction; atrophy; continued pain; curious mis-reference of touch.* (Case 44, *Gunshot Wounds.*)—Sergeant A. D. M., Company E, 3d Maryland. The patient received two wounds at Chancellorsville, May, 1863, one ball passing through the margin of the great pectoral muscle at the anterior border of the left axilla, while the arm was raised, glancing on the neck of the humerus, and making exit anteriorly to the coracoid process. As he was leaving the field a second ball entered his back, to the right of the eighth dorsal vertebra, and crossed behind the spine into the left side of the chest. Paralysis of motion and sensation resulted from the first wound. The second brought him to the ground and caused his capture, and while a prisoner he was much exposed, suffered from pleurisy, and ultimately had consolidation of the lower half of the left lung. Before this there had been a cough, hæmoptysis, and dysphagia. He was exchanged at the end of a month. He states that for a week he had no pain in the paralyzed arm, but then a very sharp pain began from the wound "down the inside of the limb and also on its front, and on the ulnar side halfway to the wrist." A tingling and burning accompanied this, and when this sensation reached the hand, with it returned some sense of touch.

Examination, United States Hospital, July 5, 1863:

Nutrition. Left arm cold, mottled, and swollen; skin thin and dark red, without eruption.

Sensibility. Touch-sense, while nowhere lost, is dull on the back of the hand and fingers, and in these parts localizing-sense is poor. Causalgia is severe, except on the dorsum of the hand, much increased by warmth or depen-

dence of the limb, and eased by cold or moisture. It is subject to exacerbations daily about mid-day.

Motion. Deltoid feeble and much wasted; other shoulder-muscles good. No motion below the elbow. Fingers half-flexed; their joints swollen, congested, and sore.

Two days after admission erysipelas attacked the arm and the treatment by hypodermatic injections of morphia was suspended. After the disappearance of the inflammation injections of atropia, $\frac{1}{25}$ gr., repeated to the point of producing severe constitutional symptoms, caused relaxation of the contracted finger flexors, but did not help the other symptoms. Electro-muscular contractility was absent in the whole forearm when the swelling was sufficiently reduced to permit examination with the battery, but its use was extremely painful.

Every effort was made to relieve the distressing burning, but, though it diminished somewhat in area, its intensity did not lessen until, after three months, a series of blisters bettered it slightly. A continuance of the vesication for *two months* was necessary before complete relief came. In December an attempt was made to apply electricity, but an immediate return of the pain resulted, and it was stopped, while daily massage and passive motion were ordered.

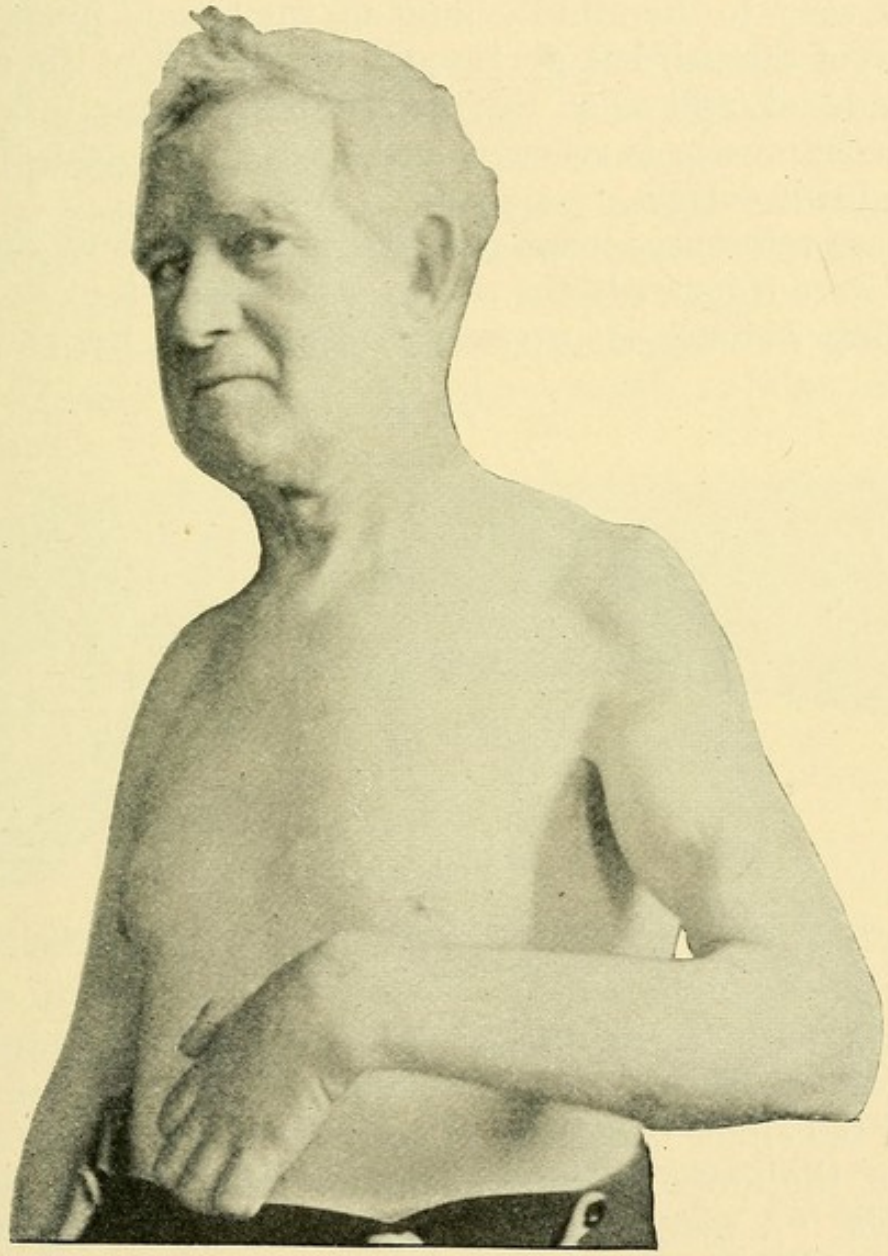
In January, 1864, it was found possible to use the battery, and improvement after this became more rapid. The patient was frequently etherized and adhesions in the joints broken up. In April he had three-fourths flexion of the fingers, with no pain, but with no power of extension and with perfect sensation. The thumb-muscles were improving.

Examination at the Infirmary for Nervous Diseases, February, 1890:

On leaving the United States Hospital sensation was noticed in the hand; motion also was improving, but soon after the hand began to lose motion, manipulation having been neglected. About one-quarter of supination is now present. The thumb is very much contracted at the first joint, but may be straightened. The thenar and hypo-

thenar eminences are wasted. The fingers are always contracted, but can be flexed somewhat more at will. There is no extension. The second joints of the fingers

FIG. 3.



A. D. M. Case XVII. Contraction and atrophy from gunshot-wound of brachial plexus.

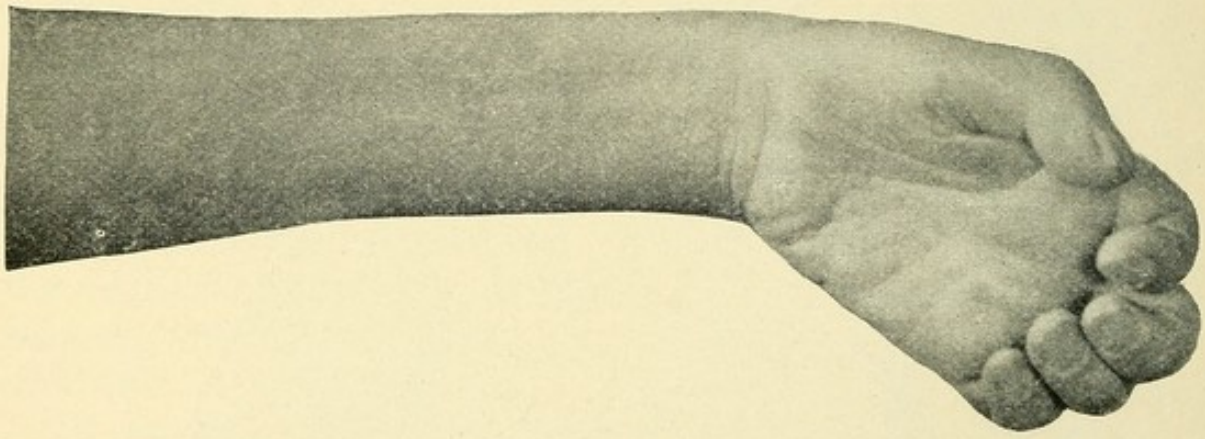
are all stiff. The temperature of the hand is moderate, but there is a burning pain in it when dependent. The wrist-joints cannot be extended. Flexion is perfect at the elbow, but extension is limited.

A Minie-ball was extracted from an abscess in the left axilla September, 1877.

Sensibility — touch. Localization is imperfect. On touching the tip of the fifth finger the contact is correctly referred; on the fourth finger it is referred, once to the elbow, once to the middle joint of the second finger. On the tip of the third finger a touch is referred to the middle of the hand, and so on the tip of the forefinger. A touch to the thumb-tip is referred to the wrist. Localization in the palm is correct.

These references were repeatedly studied, and the mistakes were constantly the same. On the back of the hand and fingers touch is properly referred, with the exception

FIG. 4.



A. D. M. Case XVII. Contraction of fingers and wasting of forearm muscles from wound of plexus and disuse.

that contact with the second joint of the third finger was referred to the back of the hand. On the arm a touch about the elbow is constantly referred to the hand; on the rest of the fore and upper arm it is fairly good.

Pain. A needle-prick is felt as touch throughout the median distribution in the hand on the palmar surface and on the ulnar surface of the fourth finger. The prick on the palmar aspect of the fifth finger is felt "like an electric thrill" running up the elbow. There is no pain-sense on back of hand anywhere, and pain-sensibility only begins distinctly about two inches above the hand. The local sensibility is natural from here upward, but gives

the same "sense of thrill" running toward the elbow. Pain-sensibility seems normal above the middle of the biceps. On the posterior aspect of the arm pain is clearly felt from the lower point mentioned (two inches above the hand), but there is the same curious thrill running upward through the limb.

Electric examination. There is great quantitative reduction to faradism in the forearm. The whole upper arm and shoulder-girdle muscles react perfectly. Similarly, there is great quantitative reduction to galvanic stimulation in the forearm, greater in the extensor muscles than in the flexors. 7M = KaCE, 11 M = AnCE.

On the hand the adductor of the thumb and the flexor brevis pollicis, though greatly wasted, exhibit normal reactions.

Nutrition. The nails of the left hand are horizontally ridged, thin as paper, very fragile, and darker red than those on the sound hand, which are very thick, hard, and smooth.

Measurements.

	Left.	Right.
Upper forearm . . .	$8\frac{1}{4}$ inches.	$9\frac{3}{4}$ inches.
Middle forearm . . .	6 "	$8\frac{1}{4}$ "
Hand	$6\frac{3}{4}$ "	$8\frac{1}{2}$ "

Remarks. The patient was somewhat older at the time of his injury than most of the cases studied, being then in his forty-third year; but to judge by his appearance in 1890 he was a sturdy, thick-set, little man of fine strength and good health. Could the wholesome discipline of a military hospital have been continued somewhat longer he would have had a much better result, as after his discharge he neglected the prescribed passive movements, and the improvement manifested in the spring of 1864 was lost. The general condition grew worse, and from that time until his death, in 1891, he suffered a good deal of pain and had a quite useless arm.

In spite of the passage of the second ball near the spine no harm to the column seems to have followed, and all

the terrible sequels of pain and deformity were due to the bullet which touched the left brachial plexus.

The variety of treatment tried with little or no success is instructive; nor was the distressing causalgia relieved more than temporarily by any means until a course of blisters, repeated every few days for two months, was used.

The curious mis-references of touch which some of these cases display were well shown in this patient. The general rule is that the touch-point is referred above its real place of contact. This was constantly so with him in repeated examinations, with the single exception that a touch above the elbow almost anywhere was consistently referred to the hand.

He died December, 1891, of dropsy from cardiac disease, this illness having probably no connection with the injury received in 1863.

CASE XVIII. *Gunshot-wound of the brachial plexus; early arthritic complications; atrophy and contraction of whole limb; causalgia; contractions and deformity; no improvement in motion.* (Case 51, *Injuries of Nerves.*)—David S. was wounded in his eighteenth year, at Gettysburg, July, 1863. He was aiming at the time, the right arm raised and adducted, holding his musket. The ball entered one inch above the sternal end of the left clavicle and one inch to the left of the mid-line of the body, passed in front of the trachea, broke the right clavicle, left untouched the vessels of the neck, the subclavian and axillary arteries, and, passing inside the humerus, made exit in the middle of the posterior part of the right upper arm, two inches below the axilla. There was momentary pain; "he thought his arm was shot off." He fell unconscious, and "when a little later he revived and raised his head a second ball struck him in the right temporal fossa and emerged through the right eye. He jumped up, ran a little way, and fell once more." The arm became numb, and there was complete loss of motion, but no pain after the first shock. Two weeks later feeble

power to move returned gradually in the elbow, shoulder, and arm, and after two months in the wrist and hand.

The joints became swollen early. About the tenth day burning pain began in the palm and fingers, especially in the cushions of the fingers and in the knuckles. It increased for a month, but after two months lessened. "When at its height he suffered from loud sounds, vibrations, or dry contact. The rubbing of his boots on the floor was the greatest annoyance, and this he relieved by wetting his stockings."

Examined December 17, 1863, *five months after wounding:*

Nutrition. Well-marked atrophy of the supra- and infra-spinatus, deltoid, and biceps, the loss in the last two being fully one-half; triceps, no wasting of moment; supinator longus and radial extensors, two-thirds loss; flexors and extensors in forearm, one-half loss. Thumb-muscles almost absent. Little finger and interossei group, no loss.

The flexor carpi ulnaris, palmaris longus, and flexor carpi radialis being strongly contracted, the wrist is bent at a right-angle to the arm and drawn to the ulnar side; the extensor group is in like manner contracted, and the first phalanges, having thus been violently extended while the wrist was flexed, have undergone subluxation. The color of the back of the arm and hand is natural as far as the knuckles. Thence to the finger-tips the skin is tense, shining, hairless, mottled red and blue, abraded in spots, the nails curved, and the joints swollen and very tender. The whole palmar face of the hand and fingers is polished, deep scarlet, abraded in points, and eczematous all over to a remarkable degree. The eruption began about six weeks later than the burning, nearly two months after the injury. The palm of the left hand is nearly equally eczematous, and began to be so almost a month before any eczema appeared in the wounded member.

Sensibility. Tact nearly normal. Localization not quite perfect in the radial distribution in the hand.

Motion. Shoulder good, but feeble; elbow limited to about one-third of normal; slight thumb-movements;

wrist-extension about one-fourth, from its position of flexion at a right-angle with forearm. Fingers are bent back in extension; can be flexed to a right ine with the hand; slight flexion of second and third fingers, fair abduction and adduction.

Pain. Constant intense causalgia, made worse by heat, dryness, emotion, especially loud noises. The soldier keeps the hand always wet. The unwounded hand is tender, and has pain too.

Electric reactions, though feeble, are normal in all the atrophied muscles, and sensibility very slightly impaired. The prognosis would be good were it not for the impairment of motion from the joint-lesions and the contractions.

The treatment was at first directed to the patient's miserably anæmic and worn-out state, and measures taken to relieve the pain. His health improved, but the burning continued until it became quite suddenly better, in August, 1864, and after this slowly left him. Restoration of motion was less complete, the arms and fingers remaining much atrophied, though the skin, hair, and nails became natural in their appearance.

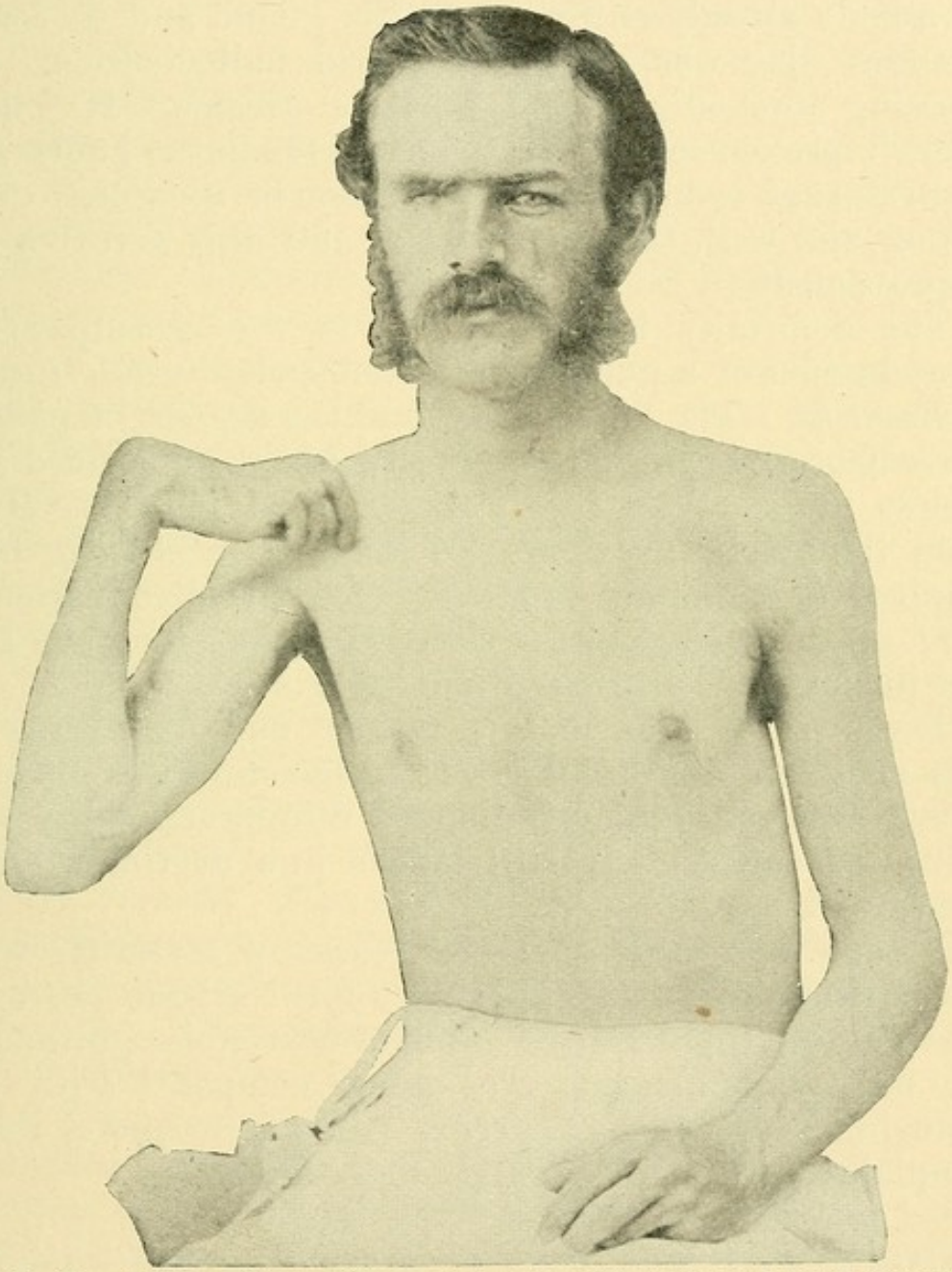
In 1875 he was seen again by Dr. Weir Mitchell, who noted the persistence of the curious "monkey-hand" deformity, and that the patient was without pain ordinarily. When overheated he had sharp pain in the arm, and suffered annoyance from loud sounds, which affected the weak arm. He occasionally wetted his hands "to take away a sense of constriction in the finger-tips."

Examination at Infirmary for Nervous Diseases, February, 1890:

The arm and hand, though somewhat improved in regard to use and strength, are still in the same deformed condition, with the fingers quite useless. (See illustration.) When heated there is an aching sensation that runs down the entire arm; on these occasions there is great desire to pour cold water over the arm and hand. About eleven or twelve years ago four abscesses formed under the right arm where the ball passed through. Just now there is very little burning sensation, except

when the limb is overheated. The sense of touch is more acute in the deformed hand than in the well one.

FIG. 5.



D. S. Case XVIII. Contraction and atrophy of forearm and hand muscles; "monkey-hand" deformity, from gunshot-wound of brachial plexus.

The patient has a frequent roaring in his head and black specks before the eyes. He has suffered much from an attack of nervous prostration, attributed to suffering from his wound.

Later in the above year the patient was admitted to the Infirmary for treatment of his general condition, and was found to be suffering from the effects of study and overwork in preparation for missionary enterprise, acting on a body already enfeebled by his wound and its consequences. He was melancholic, had hallucinations, depressing forebodings, and horrible dreams. He made great improvement during some months in the Infirmary, and returned to his evangelistic labor in the South quite strong and well, though the hand and arm were beyond improvement.

The deformity is well shown in the accompanying reproduction of a photograph taken several years since.

Remarks. The joint-lesions and the neglect of passive movement early in this case resulted in the deformed and useless limb. What injury the brachial plexus received from the wandering course of the ball must have been repaired or otherwise supplied before his examination at the hospital in 1875, as the electric response was then perfect in the muscles of the wounded arm.

The burning was most persistent and distressing in this man, and the usual resort to moisture was his only relief. The abrupt beginning of disappearance of this pain was curious. It still affects him at times, when overheated.

No note was made as to references of sensation when the patient was in the Infirmary for Nervous Diseases. The painful thrill caused by loud near noises, although the nerve-inflammation was gone, compares with the annoying sense of a "purring" in the wounded limb, complained of by XVII. and other patients.

CASE XIX. *Ball-wound of brachial plexus; pain and causalgia; lasting paralysis of motion and sensation; no hair-growth.* (MS. notes.)—A. A. K., Co. I, 12th New Hampshire, enlisted August, 1862. The patient was wounded in 1864. A ball entered through the clavicle four and one-half inches from mid-sternal line, and made exit on the right side one-eighth of an inch to the right

of the third dorsal vertebra. He fell after walking a short distance. There was not much hemorrhage, but all motion was lost for a time. Pain began at once in the wound, and in two weeks aching and burning pains followed in the hand and arm. The ache was constant; the burning was in daily paroxysms, and worst on back of hand and fingers.

Motion was largely lost below the shoulder; no flexion of the elbow; except slight flexion, there was no motion of the thumb or fingers.

Nutrition. There was great atrophy of the forearm and of all the thumb-muscles.

There was no evidence of any injury of the lung.

The patient died in his sixty-fifth year, November, 1889; his death being in part due to the remote effects of his wound.

His son writes that his arm and hand were very cold most of the time. He could not tell which finger was touched on the wounded side. The fingers were very numb all the time. He never could raise his hand to his head, and could not hold a fork to eat with. The arm and hand were withered to nearly one-half their normal size. After the wound healed pieces of bone worked out. For a long time no hair grew on that arm, and then very slight in amount. The nails did not grow so fast as upon the unaffected hand. The arm hung like a dead member, and to the time of his death he was a great sufferer.

Remarks. There seems to have been no spinal disturbance in spite of the proximity of the ball's track to the cord. The wound of the brachial plexus in the downward path of the ball, or its injury by bony fragments, was the cause of the symptoms, and this wound must have nearly destroyed the nerve-trunk, which never regained functional usefulness.

CASE XX. *Gunshot-wound of median and ulnar nerves; wasting of all muscles supplied by these nerves; neuralgic pain; great sensibility to changes of temperature, especially to heat; persistent "spring-trap" flexion of*

fingers; persistent increase of temperature on injured side. (Case 42, *Injuries of Nerves.*)—Henry G., Co. F, 1st Vermont Cavalry. The patient was wounded in his nineteenth year, July 7, 1863, by a bullet which entered at the edge of the biceps, six inches above the internal condyle of the humerus, and made its exit on the postero-internal face of the arm, wounding the artery, destroying in a short time motion below the shoulder, and lessening sensation from the elbow down. Slight motion soon returned, but the pain grew rapidly worse. On admission to the hospital the left hand and forearm were found much wasted, chiefly in the flexor and interosseous groups. There were anæsthesia and analgesia in the palm, on the palmar aspect of the fingers and on the dorsum of the hand, but not on the dorsal face of the fingers.

During two months' treatment with electricity, douches, and energetic passive motion the gain was great in all the muscles except the interossei, and the neuralgia nearly disappeared.

Re-examined April, 1867, *by Dr. W. W. Keen, three years after leaving the hospital:*

The left arm was found to have gained relatively; the flexors of the forearm, the thumb-muscles, and the interossei were all slightly wasted, but the thumb, which had been distorted by the contracted short flexor and the weakly opposed extensors so as to rotate the whole digit, turning the nail upward, had regained its normal position. A general slight improvement in sensibility had taken place, but the areas were the same. The temperature of the injured hand was at this time 0.5° F. higher than that of the right.

Examined by Dr. N. C. Reed, of Columbus, Ohio, February, 1890:

Considers he is not improved. Just as sensitive as ever to changes of temperature. Heat makes him feel as if his arm was burning off, whereas cold causes the prickling sensation of cold hands or feet just before becoming numb. The sensation of touch is dull in the hand, fair on the

side of the forearm next to the body, and almost *nil* on the outside. Fingers cramped. Cannot pick up anything, but can hold small, light articles when placed in the hand so that the fingers can be rolled over and made to grasp them.

Measurements of the injured arm as compared with the right show the following disparity: circumference at belly of biceps brachialis muscles, left, ten and one-half; right, ten and seven-eighths inches. Circumference of forearm at largest point, left, ten and one-half; right, eleven inches. Circumference of left hand around middle of metacarpal bones, eight; right, eight and seven-eighths inches. Muscles of entire left arm noticeably flaccid as compared with right arm. The deltoid, biceps, and triceps are slightly atrophied; the muscles showing the greatest degree of atrophy are the adductor pollicis and the first dorsal interosseous. All of the interossei dorsalis muscles share the atrophy as well as the palmar interossei and lumbricales, as to a less degree do the opponens pollicis, abductor pollicis, and the flexor brevis pollicis; the abductor minimi digiti and flexor brevis minimi digiti show a condition of atrophy, altogether giving the hand a peculiar shrunken appearance. The flexor profundus digitorum and the flexor sublimis digitorum muscles are in a state of permanent contraction (the former probably to a greater extent), flexing the fingers forcibly into the palm of the hand, with which the finger-tips are in constant contact unless forced therefrom. The functions of the internodii pollicis muscles are materially lessened. Especially is this true of the extensor secundi internodii pollicis, there being very little power of extension of the distal phalanx of the thumb. The extensor primi internodii seems to possess the greatest ability to flex, while the metacarpal bone of the thumb is movable to almost a normal degree. The flexor longus pollicis is also weakened. There is an apparently total inability to flex the thumb, except the attempt be made in unison with the entire set of flexors of the hand. There is no ankylosis. The flexed fingers can be almost fully extended by force, but when once released resume their condition of flexion with the rapidity

of the jaws of a spring-trap. Also by holding the hand with the dorsum upward, and making a forced extension of the proximal phalanges, the remaining phalangeal joints of the fingers are involuntarily extended. The mobility of the metacarpo-phalangeal joints is but little interfered with. There is no paralysis of the muscles of the arm beyond that due to contraction and atrophy. The power of grip of the left hand is far below that of its fellow. The sensibility of the peripheral nerves is lessened, especially on the inner surface below the axilla.

The patient can distinguish two points in the hand at distances varying from three-fourths to one-half inch. When the points are placed in line with the arm the distal point is more sensibly felt than the proximal point.

Remarks. The patient's injury involved originally both the median and ulnar nerves, and the artery was wounded by the bullet, the patient fainting from loss of blood as he went to the rear.

There is remarkably little change in the general condition of the arm, and it is curious to note that the "spring-trap" contraction of the flexors noted by Dr. Reed in 1890 was present at the examination in 1867. An especial sensibility to changes of temperature and to extremes of cold and heat had also lasted throughout the twenty-three years, although G.'s case was not one of those of intense burning pain which were so distressed by warmth, but suffered a pain rather of the character of an ordinary neuralgia.

In this, as in XVIII. (a much worse case), the temperature of the affected side was the higher three years after the injury, a condition the more remarkable as motion was so limited in the arm as to remove one important factor in an increase of local heat. No mention is made of the existence of continued tenderness in the track of the arm-nerves, a matter of some importance in determining the presence of neuritis. A subacute neuritis lasting twenty-seven years must produce sclerotic changes in the nerves (as has been found in some examinations) great enough to account for the very varied

sense-alterations, and perhaps for the increased temperature as well.

The occurrence of this lasting increase of local heat has been disputed, but Dr. Keen's examination of this case and the presence of the same symptom in XVIII. must establish at least the possibility of its happening.

CASE XXI. *Wound of lower cord of axillary plexus by small calibre rifle-ball; wasting of whole arm; slight neuritis; glossy skin.*—F. A., aged fourteen years. The patient was a healthy lad and perfectly well until in August, 1886, while shooting near Cleveland, a stumble caused the discharge of his light rifle, and a 22-calibre ball entered his right chest, as described below. He felt little pain, but was very dizzy and bled much from the wound of entry. He was in bed a month, and gained flesh rapidly. After getting out of bed there was no sign of a wound of the lung.

At first there was abrupt loss of all motion in the fingers; the arm could be flexed but not extended. The patient was brought by his father to consult Dr. Weir Mitchell four months after the accident, and the following account of his condition is from Dr. Mitchell's notes:

The wound of entry is one-half inch to the right of the right nipple and three-fourths of an inch above it in the third interspace. The ball passed upward and outward without breaking any ribs, and lodged half an inch above the right clavicle and in front of the edge of the trapezius muscle. There was very soon wasting of the deltoid; general wasting of the forearm muscles, especially in the flexor groups, quickly followed. Besides the results of the atrophy, there is limitation of motion from joint-stiffness. The arm can be flexed and extended and the wrist-flexion, though weak, is perfect; but there is no extension of the hand. Supination and pronation are weak but fairly good. All the fingers can be feebly extended; flexion of the fingers is very slight. The only flexor muscle which retains a fair amount of power is the flexor carpi radialis.

The supinator longus responds readily to a blow, but the arm is so sensitive it is difficult to be exact; any blow on the arm sends a thrill through the fingers.

Measurements. *Right* (injured) *arm*, around biceps seven and one-eighth inches, around forearm six and three-quarters inches. *Left arm*, around biceps eight and five-eighths, and forearm eight and one-quarter inches.

General movement is limited (by the pain?): even when an attempt is made to raise the arm to a level, passively, the chest-muscles contract to prevent it.

Sensibility. During the first three weeks after the wound the hand and fingers itched greatly.

Touch-sense is better in the median than in the ulnar distribution; there is a good deal of tenderness in the whole arm, and some increase of sensitiveness to pain in the median and radial areas. On the median side of the third finger, two points are distinguished at one-quarter inch, and tact is as acute on the radial border of this finger. In the ulnar supply the two points are not separated at one and one quarter inches. In the thumb and index-finger touch-sense is perfect.

Localization is good on the back of the hand; on the palm, fair in the median territory and in the ulnar regions irregular, with small areas where no touch is perceived. There is no analgesia.

The nails grow as well as usual, it is said, but there is some curving deformity.

The skin is thin and the surface somewhat glossy. The hand has at times been a little puffy.

The case had been very carefully and thoroughly treated, and the result was good, and improvement at the time of examination still continued.

Examined by Dr. D. N. Kinsman, Columbus, Ohio, who writes as follows (April, 1890, four years after injury):

"Skin on injured arm smoother and of less thickness; cool, very often sweating, and shining to a degree. Can extend hand, but fingers cannot be extended without holding hand across palm with the other. Has gained considerable in the flexion of the fingers. Can oppose thumb

and forefinger while flexing whole hand. Has partial supination while elbow is confined to side.

"I think he has made unusual progress for such a case since his return home from Philadelphia, and I feel convinced that there will be still more improvement."

A later report received from the patient's father (February, 1893) states that the fingers can be used for some purposes: he is able to hold a knife at the table, can grasp a large article like an umbrella or stick with the whole hand, but has had to learn to write with the left hand, as he cannot extend the fingers well. On the whole, there is very little improvement in two years past.

Remarks. The several cervical and dorsal nerves whose union forms the brachial plexus run in two great trunks behind the clavicle in company with the subclavian artery. Opposite the end of the clavicle these trunks divide into three—the "inner-cord" furnishing the ulnar supply, and, in common with the "outer-cord," the median nerve, while the third cord divides into the musculo-spiral and circumflex nerves.

In this case the muscles chiefly affected were those supplied by the circumflex and musculo-spiral nerves; the deltoid was early wasted, the triceps lost its ability to extend the forearm, while the flexion of the forearm was very feeble. The extensors of the hand grew too weak to perform their duties, which are governed by the musculo-spiral nerve, and when the power to extend the forearm had returned these muscles still remained weak. The examination of sensibility showed how much the ulnar nerve must have been injured.

Unless the splitting of the two cords into three began nearer the spinal cord than usual, in which case the posterior cord of the plexus may have been wholly or partly cut while the inner one was but slightly injured, the trunk wounded was probably the lower of the two main divisions of the plexus behind the clavicle. That the closely neighboring artery should escape is curious even here, and had the wound been further outward and the bullet traversed the complex nerves and arteries of the

axillary region, the result must have been more serious still.

A slight general neuritis throughout the injured nerve-tracts was one of the consequences. As Dr. Kinsman's note says nothing of this, it may have disappeared, although the skin remained glossy. No mention is made of the muscles of the upper arm, which would probably show a greater degree of improvement than those of the hand and forearm.

The lad's youth and good health were in his favor, and, at last accounts, he was making slight progress. The deltoid will most likely prove the most difficult muscle to repair, as it always wastes more readily and recovers less well than the other muscles of the arm.

CASE XXII. *Punctured wound of the left median nerve above wrist; partial loss of sensation and motion; return of sense of touch; hyperæsthesia; acute pain up arm into spine; general gain; continued loss of power in median muscles and rigid contraction of all of them; left unilateral aches elsewhere.* (Private Note Book 1, p. 327.)—C. T., aged forty-two years, tailor, in good health, without previous malady of moment, in October, 1880, ran the fine point of his shears into the left median nerve one inch above the hand. The radial artery being cut, bled freely until secured, but the wound was closed without examination of the nerve.

There was immediate loss of touch and pain in the lower half of the thumb and of the second digit and of the radial side of the third digit. This was irregular and incomplete. The early acute pain down into the hand and up the arm lessened in a few days, but although the sense of touch thenceforward grew better an increasing sensitiveness was present in nearly all of the median area, so that, while at last touch was felt and located correctly, all touch was also pain. He describes the feeling when touched as like that felt when an exposed tooth-pulp is touched. All of this increased without at any time redness or glossy skin, until all vibrations, as from music, etc., gave distress.

This man consulted Dr. Mitchell two years after the accident. He had then intense median hyperæsthesia, and carried the hand with care, allowing no one to touch it. As often happens in old cases, he had pain up the arm and here and there in the intercostals and the left leg, but none on the right side; also, he was emotional and timid.

But the unusual difficulty he presented was in the bone-like rigidness of all the median muscles in the hand, their immobility and functional failure. Nevertheless, there was no wasting. The thumb-muscles were the most remarkably affected. They presented a continual slight tremor, like a perpetual tonic spasm, and did not relax at night. The thenar muscles ached, but not severely.

Remarks. Very careful examination was difficult, because of the pain all touch occasioned. Whether this was a direct effect of the nerve-lesion or a reflex due to the painful palmar and digital neuritis is hard to say. So far I have found no case presenting this peculiar inconceivably rigid state of the muscles. It came on slowly and *pari passu* with the development of the extreme sensitiveness. In this way it suggests resemblance to hysterical rigidities, nor is it impossible that this may explain it. An operation was thought advisable, but was resolutely refused, and the later history is unknown, so that the case is reported here only on account of the peculiar symptoms presented. The end could hardly fail to be disastrous.

CASE XXIII. *Gunshot-wound of musculo-spiral nerve; paralysis of extensor muscles; recovery, except of extensor communis; relapse later; mis-reference of touch.* (Case 29, *Gunshot Wounds.*)—The patient's left arm was wounded May 3, 1863, at Chancellorsville, while in the act of loading. The ball entered three inches above the styloid process, externally, over the ulna, and was cut out two inches below the external condyle an hour later. The extensor muscles were traversed diagonally and the bone was injured. On admission to the United States Hospital the hand was contracted by the unopposed flexor muscles, the nerves supplying the extensor communis and the ex-

tensors of the thumb and wrist having been injured. The hand had been long motionless on a splint, and the other muscles probably had partial loss of power from disuse. They rapidly recovered under electricity, but the extensor communis on his discharge, January, 1864, was still powerless. Sensation was perfect in hand and arm.

Examined by Dr. F. W. Rice, Rome, Pa., March, 1890:

Sensibility. The injured arm is not susceptible to the prick of a pin, particularly upon its dorsal surface, and two points cannot be distinguished from one at a much greater distance than on the sound arm. He suffers much from cold after the part has been exposed to low temperature, but does not notice it at the moment of exposure.

Nutrition. The extensor muscles of the forearm are greatly atrophied, there being from three-quarters of an inch to one inch difference in the circumference of the two arms at the same point.

Motion. There is no ability to extend the fingers or the thumb of the injured hand, owing to paresis of the extensor muscles. The finger-nails of the affected hand grow slowly and are much more brittle than those of the other hand.

Re-examined, April, 1893, *Infirmary for Nervous Diseases:*

This man has the general appearance of good health, but rather too much flush of face. He complains now of constant headache, caused by an attack of sun-prostration, which occurred in July, 1892. The exposure to the sun was extreme, and was followed by a series of fainting-attacks with loss of vision and a sense of prickling all over. Ever since he has had more or less constant headache; not incessant, but worse on exposure to the sun or other forms of heat.

In regard to his wound, his left hand presents a deep furrow on the back from the wrist to the elbow, caused partly by the track of the ball and partly by the extreme atrophy of the extensor communis. This gutter is from half an inch to an inch deep and presents a quite extra-

ordinary appearance; it looks as if a portion of the arm had been gouged out.

Motion. He can pronate and supinate, flex and extend the wrist; but there is entire absence of power to extend the fingers and thumb.

Nutrition. No wasting except of the muscles mentioned, in which the atrophy is complete. No joint-lesions. Nails said to be brittle, but unchanged in appearance.

Secretions. The left arm from the palm to the shoulder sweats more easily than the right. The nail-growth is normal, but there is considerable increase in the length and amount of hair of the left arm, especially extending down on the back of the hand; this hair is red, like that of his head.

Sensation. Localization on palmar face and fingers is good, but he says that it is dulled everywhere on the dorsum of the hand; he always imperfectly refers touch on the ulnar digits, making a misplacement of the point of contact half an inch upward; this is worse for the fifth than for the fourth digit. He has no pain-sense on the dorsum of the hand at all. There is no place on the back of the hand where he can localize with distinctness. If he works with this hand at all, it begins to ache, and he is finally driven to stop work from the excess of pain. He suffers from both heat and cold.

Remarks. At the time of his discharge from the hospital the sensation in the hand and arm was said to be perfect. Since then some change must have taken place affecting the sensibility, both in the ulnar and musculo-spiral territories, aided perhaps by the soldier's neglecting to use the arm or keep up the treatment.

CASE XXIV. *Ball-wound of sciatic nerve; loss of sensation; a touch below the knee produces fibrillary twitching in thigh-muscles; possible ascending neuritis affecting cord.* (From Pension Office Reports.)—E. J. R., Co. F, 19th Indiana. The patient has gunshot-wound of right thigh, received in the service; the ball entered at junction

of middle and lower third, on the outside and posteriorly, and, traversing the limb behind the bone, was cut out about an inch above the internal condyle of the femur near the knee-joint.

The patient says that a small piece of bone was taken out from the wound of entrance a year after the wound was incurred. He says that at the time he received the wound, after the first numbness, the limb was full of pricking sensations like the pricking of needles. This was but momentary. Normal sensation has been completely lost since the injury. The limb has been cold, clammy, and numb. With change in the weather he suffers a deeply seated burning sensation extending from the bottom of the foot up through the leg. There is great wasting in the leg below the knee; not marked above the wound. The ankle is ankylosed and the foot in a position of talipes equinus. The soldier wears the toe of his shoe and uses two crutches in walking. The heel does not reach the ground by several inches. There is exaggerated knee-jerk, and touching the tissues below the knee produces fibrillary twitchings in the muscles of the thigh. The patient states that the muscles below the knee give no response to an electric current.

Remarks. The case is one obtained from somewhat imperfect notes through the Pension Bureau. The only excuse for presenting so fragmentary and incomplete a report is to point out the one curious symptom that a touch below the knee will produce fibrillary movements in the muscles of the thigh. This and the increased knee-jerk may indicate some late spinal changes, but as to the connection between this possible condition and the original injury there is no ground for judging. An ascending neuritis from the sciatic wound may have reached the cord, but evidence of its presence and progress is wanting.

CASE XXV. *Ball-wound of upper arm; partial involvement of musculo-spiral nerve; probable anomalous distribution; complete recovery of motion; partial return of sensation.* (Case 31, *Injuries of Nerves.*)—B. G., 5th

Battery, Massachusetts Artillery. The patient had been three years in the service when, in his twenty-second year, he was wounded, May, 1864, by a piece of shell striking the outer back part of the right arm, laying bare the humerus, but not breaking it. The upper edge of the wound was below the deltoid insertion, and measured five inches across by three inches from above downward. The pain was not great, and, as he went to the rear, examining his wound he found that he could move the fingers very slightly and that the loss of feeling was not great. In a month the wound was level with the skin.

There were two areas of lessened sensation, one outside of the elbow and quite small; in the whole of the radial distribution touch was slightly impaired. The supinator longus muscle acted pretty well; the extensors of wrist and thumb and the extensor communis were completely paralyzed; the interossei and the triceps acted well. The paralyzed muscles had no electric contractility.

There was no note made as to the condition of the joints or as to the growth of hair; only the general statement that nutrition was impaired.

Examined at the Infirmary for Nervous Diseases, March, 1890:

Left Turner's Lane Hospital September 11, 1864. Before the war worked in a rolling-mill. Unable to do so since injury. Now works at Britanniaware-making.

Nutrition. Half-way up the outside of the arm, just at the exit of the musculo-spiral nerve, is a deep scar in which three fingers may be laid. It extends three inches across the middle outside of the arm, and then in a straight line downward three and one-half inches, interrupting the continuity of the muscles of the outside of the arm rather than of the back. The scar lies immediately behind the posterior border of the biceps. The right forearm measures ten and one-quarter inches; the left ten inches. The injured arm is, therefore, better developed. He says that since the wound the hair on the

arm has not grown so fully as on the left. At present no particular difference is to be noticed, except that there is not quite so much on the back of the right hand. The nails of the hand of the wounded arm are brittle, and do not grow so fast as upon the other hand. There is some enlargement of the joints of the second and third fingers. No enlargement of the other fingers or of the thumb.

Sensation. In the centre of the scar is a spot so excessively tender that a touch upon it will make him fall; the remainder of the scar is not sensitive. The wound was open for seven years, discharging a secretion slightly malodorous. Finally an ulcer formed on the forearm, after which the wound healed.

Sensation is natural from the scar down to the elbow. From immediately over the supinator two and one-half inches downward it is insensible to touch. Below that the touch is good, but not quite so good as in the forearm. In the radial region on the back of the hand there is lessened sensibility to touch, and here he cannot separate compass-points at two inches.

Dynamometer. Right (injured) arm, 50; left, 45. Biceps-jerk good. Muscle-jerk, supinator, not good. Supinator acts perfectly. He has all the movements of the interossei: flexion perfect; extension feeble. With the fingers extended he can lift the hand to the level of the wrist. With the fingers flexed he can fully extend the wrist. It was five years after the wound before he could lift the hand at all.

Electric contractility. There is considerable quantitative loss of faradic contractility in the right forearm compared with the well side.

Remarks. No mention is made in the notes of the United States Hospital of the conditions of the nails, hair, or joints of the injured limb. He was in the hospital only about three months, and the changes were probably not very marked in that time. The case is an exceedingly curious one in the distribution of paralysis and preservation of sensation, the forearm preserving its sensibility almost intact. The region described in the

examination in 1864 as showing "enfeebled" tact is now insensible altogether to touch, but the slight changes then noted in the radial distribution have not altered. The nerve originally injured was the musculo-spiral, but the distribution must here have been anomalous, as the triceps is said to have retained its contractile power, while the area of lessened sensation outside the elbow was in the region supplied by the posterior external cutaneous nerve, a branch of the musculo-spiral. The supinator longus, another muscle governed by the musculo-spiral, also acted well, while the extensors ordinarily supplied by it were completely palsied, and there was partial touch-loss in the whole radial distribution.

The dynamometer and the measuring-tape show the right, the injured, forearm both stronger and larger than the unhurt left, and the patient possesses a perfectly useful member, although the limb is not capable of heavy work.

The painful point in the scar on close examination proved to be over a rough edge of bone, a small exostosis resulting from the impact of the shell, and very sensitive, because the skin pressed directly upon it, the upper arm being without any padding of muscle between the skin and the sharp bone.

CASE XXVI. *Gunshot-wound of left arm; late affection of median nerve; mis-reference of touch.*—D. W., aged forty-eight years, born in Pennsylvania, a riveter by trade, was sent to the Infirmary in March, 1892, by Dr. C. B. Penrose, for treatment of the results of a gunshot-injury received in the battle of the Wilderness, May 15, 1864.

A bullet entered posteriorly above the inside bend of the left elbow and passed through the arm behind the bone, but probably slightly injured the bone, as a small osseous fragment afterward escaped. The soldier tied up the injury himself, and no further dressing was applied for nine days, when the surgeon found the wound full of maggots and the arm extremely swollen. A water-

dressing was used, but the result was bad, as healing was not completed until November. There was no immediate loss of power, and the patient asserts that the only loss of movement was from the stiffness of the elbow-joint, caused by six months' disuse.

His present complaint is of a dull ache and of numbness in the thumb and first two fingers. The disability must have been slight at the time, as he returned to his regiment and served with it, receiving the following spring a bayonet-wound in the right foot, which destroyed altogether the use of the fourth and fifth toes.

Examination of arms. There is no loss of motion, only weakness. Dynamometer, using only the two fingers involved: right, 120; left, 70. Dynamometer, using the whole hand: right, 175; left, 100.

Nutrition. Growth of hair and nails on the affected part does not differ from the well side, except that the patient states that the nails are more brittle on the left hand than on the other.

Sensibility. Touch is perfectly preserved in the ulnar distribution of the hurt side, but is lost in the musculo-cutaneous and median areas on the dorsal, and in the radial on the palmar surfaces. Although he recognizes a sharp prick with a needle-point in these partly anæsthetic surfaces, he sometimes fails to refer it properly, always saying, for instance, that the extremity of the thumb is pricked when the stab is in the ball.

There is lessened tactile sensibility in the circumflex distribution above the wound as well as in the areas supplied by the cutaneous branches of the musculo-spiral. Pain-sense is somewhat diminished in the same regions.

Remarks. Although the patient's statement is that there was no original loss of motion beyond that caused by stiffness of the elbow from disuse, it would seem as if the median must have been hurt by the missile and afterward suffered a slow change, to cause the present pain and weakness.

The mis-reference of sensation *downward* is very unusual; indeed, I have not seen this symptom in any other

case except XVII., who mis-referred touch upward in one part of his arm and downward in another.

CASE XXVII.—*Crushed and lacerated wound of right forearm; section of median and radial nerves, radial artery, and several muscles; suture of the injured parts; nearly perfect recovery.*—W. T., aged forty-eight years, Scotch, weaver (Infirmary for Nervous Diseases).

Previous history good. The patient was admitted to the Episcopal Hospital August 15, 1891, with an injury received from a crush between a belt and a pulley. The notes of the resident surgeon, Dr. Joseph P. Tunis, describe his condition at the time as follows:

"There was severe laceration of the flexor surface of the right forearm. Even the periosteum was denuded, and the wound was seven inches long. It was necessary to suture the median and radial nerves, the pronator radii teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris, flexor sublimis digitorum, flexor profundus digitorum, flexor longus pollicis, and to ligate the radial artery and some small branches. The flexor carpi radialis was not completely divided. The pronator quadratus was slightly injured, but did not require stitches.

"Approximation of the divided ends was rendered very difficult by the great loss of tissue, and to secure and preserve approximation it was found necessary to flex the hand at a right-angle with the forearm, and keep it in this position on an exterior splint.

"A severe brush-burn of the extensor surfaces also existed and gave the patient greater pain than the more serious injury. The wound healed without suppuration."

The patient was discharged from hospital on the twenty-first day. Passive motion and bathing with hot water were kept up for some time, and the patient applied to Dr. Morris J. Lewis's clinic at the Infirmary for treatment of paralysis and loss of sensation in December, 1891.

At that time he had no pain and no burning. There was some glossiness of the skin of the fingers and of the

back of the hand. The condition was described as follows:

A scar extends two-thirds of the way up the forearm from the wrist on the palmar aspect. On the dorsum a scar runs from the base of the second finger to the radial side of the wrist, and there are several lateral extensions of these larger cicatrices, and some smaller ones from the brush-burn on the forearm. The palmar muscles are slightly contracted, making a "cup-shaped" hand. There is a little lateral curving of the nails. The tendons are adherent to the scar in the wrist, so that the scar moves in both directions with attempts at flexion and extension. Flexion and extension of hand on wrist are about one-fourth of normal. The fingers are not contracted. There is constant slight tremor of the muscles on the ulnar side of the palm. He can approach thumb to index, but not to little finger. All muscles react to faradism. There is marked anæsthesia to touch on palmar aspect of index-finger and marked analgesia in the same distribution. There is very slight general impairment of touch-perception on the hand; none on the forearm. The whole hand and forearm are much wasted. No change is noted in the growth of the hair. The nails are very different from those on the other hand, thinner and softer, but the patient thinks they grow as fast as those of the other side.

Some of the disability in this case was due to the stiffness of long disuse. The patient was ordered massage three times a week, frequent hot bathing, interrupted faradic currents to the forearm and hand-muscles and rapidly interrupted currents to the skin. He was advised to keep up passive and active motion for himself.

He attended with regularity and carried on the part of the treatment which was left to himself with diligence and intelligence, and made rapid improvement.

On April 15th the arm was greatly increased in size, the general appearance of nutrition was much improved, the glossiness of the skin had disappeared, sensation was much more acute in the arm and was bettering steadily in the hand, and the area of anæsthesia had lessened. He

was able to close the fingers into the palm, but not to flex them upon themselves.

The ultimate result was remarkably good, the patient reporting one year later with his hand restored to a great degree of usefulness.

Remarks. I have reported this case in full as a remarkable illustration of the success of surgical means in a kind of injury which would once have caused the loss of a limb, if not primarily by amputation, almost certainly later by suppuration. The extent of the wound, the number of muscles sutured, and the fact that both nerves were joined and both united perfectly, with nearly complete restoration of every function, mark the case as an unusual and encouraging one.

CHAPTER III.

INCOMPLETE SECTIONS OF NERVES; INJURIES OF THE SPINAL CORD AND ITS NEIGHBORHOOD.

Of six cases of injury to the spine by bullets reported in *Gunshot Wounds*, I have been able to trace the subsequent history of three, and these present points of very great interest.

As there are no immediate diagnostic tests by which it may be decided whether a nerve has been divided, lacerated, or merely contused, so we have no means of at once and infallibly judging the extent to which the spinal cord itself may have been damaged by a wound in its neighborhood. The effects of concussion upon the delicate organizations of the cord are for the moment so severe as to make it impossible until some time has elapsed to tell whether the missile has actually reached the nerves contained in the column or not.

The column was certainly struck by the ball in XXXI. and XXXII. In the former the canal was opened, whether at the time of the hurt or later, by necrosis, is not certain; but two bits of bone came away, both bearing portions of the internal face of the third vertebra. In the latter, nothing is known of the depth to which the bullet may have penetrated, but there is no doubt that it reached the column, and in XXXIII. and XXXIV. the bone was probably struck also, while in XXXV. the spinous processes were torn off and dropped out of the wound.

Only the first of these men was rendered unconscious, nor does there appear to have been much shock in any of them. The sequent symptoms were too various to be analyzed apart from the individual cases to any advantage. All suffered severely: J., XXXII., who went through very great suffering, had ankylosis and swollen joints, glossy skin, eczema, causalgia, muscular contraction, hyperæsthesia, and bedsores. Yet ultimately he made a remarkably complete recovery, except of motion in the left arm. In XXXIII. the direct evidence that the cord itself was wounded was stronger than in XXXII., but the results were far less severe, less widely distributed, and the recovery more complete.

Col. J., XXXV., a Confederate officer, sustained an extensive injury, a fragment of shell tearing his back open for nine inches and breaking off the processes of at least two vertebræ. The huge scar was closely adherent and the thickened tissues so dense that it was difficult to tell exactly what vertebræ had suffered, nor, in the absence of details from the field-surgeon's examination, could it be known how deep the wound had reached. The other causes operating seriously against perfect restoration are sufficiently described in the history of the case. One more recent case has been added in illustration and amplification of certain points. In this, XXXVII., there was either a subluxation or a fracture at the second dorsal vertebra, though the precise nature of the injury could not be determined.

In considering all of these cases together, one deduction is at once apparent. With no matter what care we may study and examine spinal wounds, but one judge can decide their future course, and that is time himself. No completeness of recovery, no seemingly perfect return to

health, even though it should have lasted several years, will bar out the possibility of late sclerotic or other change.

Nor can we predict at all what these remote effects may be from any signs now known to our diagnosis. The part of the cord lying most directly open to injury may not be that which ultimately suffers. In XXXI. the ball struck, and most probably opened, the canal at the anterior face of the third cervical vertebra, yet when changes began to show themselves in the cord it was the posterior columns which were most affected In XXXII., while the anterior columns alone could have been directly injured by the missile, there was universal disturbance, affecting the muscles, joints, and nerves of the whole body below the level of the wound. In XXXV. the direct impact was upon the posterior portion of the lumbar region; but the convulsive seizures indicate the most widespread involvement of the cord. XXXIV. had a concussion of the lumbar column, and a large, though uncertain, amount of damage to the pelvic bone, and made a rapid and almost complete recovery; at least, the symptoms which persist are rather uncomfortable than serious.

Upon looking carefully for symptoms, the long continuance or presence of which may cause us to fear for the future of a "spine-case," there seem to be no constant signs; but some which occur irregularly should at least make us suspicious. Frequent or constant pain in the back, whether sharp and stabbing, aching, or even only numbness, must be looked upon as of some importance, always with the recollection that such symptoms are readily assumed by malingerers. The passage of excessive quantities of urine, whether too frequently emitted or not, is another sign to which attention has been directed in the "Remarks" on

several cases. This, again, is a symptom not very difficult of imitation by litigants or malingerers, where the whole control of the patient is not in the physician's hands. Mere water-drinking would produce it, as the urine presents no special character in these cases. It is abundant, it is pale, it is of low specific gravity, but no chemical or microscopic examination will enable us to relate it to an affection of the spine. It is true that often there may at first be blood in it, and this, taken with its quantity and a history of accident or injury, would be of moment.[1]

Polyuria has no relation to hurts of any special region of the spine. Case VII. is described rather vaguely as a "sprain of the back-muscles," and the examining-boards place his pain "in the small of the back" or "in the lumbar region." The hurt of XXXIV. was at the edge of the pelvis, and that in XXXVIII. was in the upper dorsal spine.

The causalgia has entirely disappeared in the only one of these patients who had suffered with it (XXXII.), and sensation is restored with remarkable completeness, his thermal sense being unusually delicate.

The most remarkable cases here recorded are certainly those in which overuse of a certain large group of muscles (or in XXXV., excessive intellectual work) produces various forms of spasm. Little need be said of them beyond the comment attached to each history. It is said there that in three of the four cases related there was a suspected hysterical element. The presence of this is improbable in XXXVIII., which is added as illustrative of certain points in spinal injury, although here the

[1] However, polyuria is not likely to be known to malingerers as a desirable expression of spinal injury.

patient was of the sex usually more susceptible to hysterical complications; but where spinal irritation, or, still more markedly, where neuritis has lasted long, hysteria is apt to appear as a disturbing element in diagnosis and treatment, whatever the sex of the sufferer. One, and only one, sign in XXXVIII. pointed to hysteria, namely, the contraction and reversal of the color-fields. The case has already been reported in a paper[1] by Dr. George de Schweinitz and myself, and very fully discussed there. Another case related in the same article gives a slight ground for the somewhat startling suggestion that these changes in the color-field may occur in cases of spinal injury independent of hysteria.

CASE XXVIII. *Ball-wound of sciatic nerve; œdema of foot; causalgia, made worse by heat; persistent sciatic pain and cramps of leg-muscles; "purring" sensation in leg; chronic neuritis or congestion.* (Case 54, *Injuries of Nerves.*) —Peter C. K., 48th Pennsylvania Vol. The patient was shot through the right thigh, a little above the middle, August 29, 1862. The ball passed from without inward behind the femur, probably wounding the sciatic nerve, as symptoms of neuritis began within a week, the foot swelled, and there was intense burning pain on top of instep and toes. He had at first loss of extension of foot and toes, but preserved slight flexion. In the third week after the injury the toes began to twitch laterally in a curious manner, and this symptom long persisted. The wound healed in a month, though it was more than six months before the œdema disappeared. The patient stated that touch and pain were both totally lost in the foot at first, but when admitted to the hospital, June 15, 1863, both were normal on the sides of the foot. At this date there was a slight swelling of the foot—worse in hot weather or when the foot hung down. Intense burning was still

[1] Journal of Nervous and Mental Disease, January, 1894.

present, which was relieved by water, either cold or hot, by cold weather and exercise. Repeated crops of papules had scarred the leg, breaking out every two weeks with unendurable itching, but leaving the foot much better after their disappearance.

The track of the internal saphena nerve was fully sensitive to touch, which was elsewhere deficient. The extensors of the foot and toes had lost electro-muscular contractibility and sensibility, but the flexors responded well.

During the next six months the patient's condition varied, on the whole improving. The burning pain was much lessened by repeated severe blistering, and grew worse when this treatment was omitted during a period of furlough. He was transferred December 1, 1863, greatly improved.

Personal statement (February, 1890) :

For a long time after the injury had frequently a lateral twitching and a feeling as if the toes were crawling on top of one another. Very little or none of this twitching persists now. The burning sensation is almost entirely gone. Does not remember that hot applications relieved the burning; but cold did. At present the whole leg feels best when the foot is cold; it is naturally cold, and he always feels best in winter. He cannot recall papules or itching, but remembers having had shooting-pains down the limb to the end of the foot, and that the foot felt very large and painful; also, he recalls the twitching and crawling sensation.

Four or five weeks after the injury the leg, at the seat of the wound, broke open and a small piece of his drawers, "probably an inch long," came out. In the leg he experiences a sensation as if "walking on tacks," and a sharp shooting-pain like needles going into the legs in all directions. When these lancinating pains shoot through the leg he has to stop walking, else severe cramps come on and prevent his taking a step. These pains shoot through the locality of the injury and are apt to be worse when going down hill.

Examination in 1883:

He was a patient at the Pennsylvania Hospital, in Philadelphia, under the care of the late Dr. James Hutchinson, and the notes from the hospital records are as follows:

"Ever since the injury he has at times experienced sensations of heat and cold in the foot. In 1863, he says he 'was inoculated with syphilis through vaccination;' soon after this he had caries in the lower end of the right femur. In 1872, in consequence of a blow, the upper part of the tibia necrosed, and a large sequestrum was removed. In 1873, from a strain, he had cramps in the calf for several weeks. He experienced no further trouble until two months ago (January, 1883). While lifting a basket weighing about five pounds he was seized with a severe pain in the right gluteal region. This was followed by cramps in the muscles on the posterior part of the thigh and leg. The pain is now mostly in the gluteal region with painful cramps at intervals and twitching in the gastrocnemius and soleus on the right side. The pain is so much aggravated by motion that he walks with difficulty. Even coughing or sneezing causes pain down the leg. The lower limbs are the same size and their reflexes are alike normal."

He improved so much under treatment that he declined to have the nerve stretched, as the physicians proposed.

In 1886 he had a bad attack of sciatica which confined him to his bed for several weeks.

Examined by Dr. Straup, of Shenandoah, Pa., 1890:

Motion. There is a sensation "as of a cat purring" in the leg; has this feeling very often when he walks far or after severe exercise. When he is very tired he must keep his mind on the action or he will trip and stumble as the toes hang down so much. He cannot walk on that foot with the toes turned up; indeed, he has not the power to turn up the toes. He frequently has little cramps of four or five minutes' duration, which pass off with, or sometimes without, rubbing.

Sensibility. The tract of the internal saphena nerve is alone fully sensitive to a prick of a needle or an electric

current. The extensors, except, perhaps, on the dorsum of the foot, have lost contractility and sensibility to a marked degree, varying, of course, in different locations. There is no response in the toes, and a prick to bleeding he claims not to feel. Inside of foot, from the great toe to the heel, sensibility is acute; on dorsum of foot, acute; inside of leg, acute; posterior part of leg, sensation impaired; outer aspect of leg, greatly impaired. From lowest third of leg to the heel, posteriorly, he claims not to feel needle at all. This spot (posterior part of lower third) and the toes have no sensibility whatever. He says he can cut his toes and does not feel that he has done so, but sees them bleed. Sensibility above the knee is normal.

Remarks. The neuritis, which originally followed the injury, left an excitable nerve with a liability to sciatica. Possibly a low state of neuritis, or a constant congestion, may still be present, which needs but a small irritation to cause an increase and a spread in the inflammation. "To cough or sneeze causes pain," he says. The defects of power seem to have grown greater with the passage of time. The supposed syphilitic inoculation is highly improbable, and certainly could not have caused bone-trouble so soon; nor are necrosis and other bone-diseases unknown after simple nerve-injury, though rare. Then, too, the lowered local tone causes increased liability to accident and disproportionate results from slight wounds, as in the burns in X. and XLV., and in Gowers's case. (Gowers, *Nervous Diseases*, p. 72; also Bowlby, *Injuries of Nerves*, p. 65.)

The sensation of "purring in the leg" is a strange one, and is occasionally complained of by neurasthenic patients who have suffered no injury. It is sometimes felt even by healthy people, to whom it occasions alarm, and also it is apt in these to occur, or at least to be noticed, in the prædormitium.

CASE XXIX. *Shell-wound of calf; injury to tibial and saphena nerve by missile; subsequent abscesses; bullet-wound of thigh at the same time; slight commotion of sciatic nerve.*—J. L. (personally examined, December, 1892).

Captain L. was wounded in the left leg at Antietam by two separate missiles. The first, a musket-ball, struck the outer anterior aspect of the lower third of the left thigh, about the edge of the rectus muscle, and passed backward, inward, and upward, to emerge a little to the inside of the mid-thigh, posteriorly, without touching the bone.

A second wound was received at the same time, probably from a fragment of shell or canister-shot entering at the middle of the inside of the left calf, travelling at first anterior to the body of the calf-muscles and close to the bones, and passing out in the middle of the outside of the leg.

The officer fell, and was later carried from the field and sent to the hospital at Frederick. There was no great hemorrhage, and though the loss of power was complete, pain began only after his reception in the hospital. The pain continued severe, and the patient was for two months perfectly helpless, and suffered much from sharp, constant, stabbing, prickling pain in the knee and thigh. There has never been any pain below the wound in the calf.

Captain L. does not recall any unusual appearance of the skin surface during the five months which passed before he could get about. After the lapse of six weeks the pain slowly lessened, and he has not since suffered any spontaneous pain in the leg, although it is weak, lame, and almost useless.

In 1868 a series of abscesses formed, which must have had their seat, to judge from Captain L.'s description, deep in the muscles of the calf. Extensive destruction of the remaining tissues of the leg resulted, and the abscesses progressed until the late Professor Gross laid open the whole leg, from below the popliteal space to the beginning of the heel tendons, and the wound healed under proper treatment. The abscesses are supposed to have been caused by overuse of the lame leg, the officer being obliged, by his occupation, to be actively upon his feet. The foot has been repeatedly frostbitten.

Nutrition. The left thigh is not much smaller than its fellow. The scars of exit and entrance are well marked. The skin of the thigh is natural in appearance, but the hair thicker and longer than that on the other limb. The calf is wasted to one-half the size of that of the opposite leg. About one-half of the calf-muscle remains to the outer side of the wounds and the deep scars from the abscesses; but this is only a semblance of muscular tissue, fatty to the touch, and almost without contractile power. Long, irregular, depressed cicatrices, partially adherent to the bones, extend along the back of the upper half of the leg. About the ankle the subcutaneous tissues are thickened, hard, and discolored. The foot is (at present) congested, red, all its muscles atrophied; the toes small, deformed, and marked with scars from the frostbites. There is no nail on the first toe, and the nails on the other toes are little, ragged lumps of horny excrescence. The upper half of the leg is more hairy than the right leg; the lower third devoid entirely of hair. There is no glossiness of the skin and no ankylosis of the joints.

Motion. The foot is dropped in rest, and cannot be moved at all by voluntary effort. There are no contractions. There is no plantar reflex, nor does a blow on the tendo Achillis produce any response. The wasting of all the muscles of the foot has reduced it to a size much smaller than the right. The knee-jerk is normal. Adduction, abduction, flexion, and extension of the thigh on the trunk are unimpaired.

Sensibility. There is slight impairment of touch in all respects, to sharp and dull and to two points, everywhere below the knee, down to the wound of the calf. Below this there is increasing dulness to touch, until on the foot there is neither touch nor pain felt below the ankle. About the knee and on the thigh the touch and pain sense seem unaltered, except that there is a little more acuteness of feeling on the inner than on the outer side of the knee. The foot is peculiarly sensitive to cold, and suffers from frostbite in ordinary winter weather. The patient is unaware of anything wrong until he sees the wounds of

the frost-bitten parts. Heat does not in any way affect the leg. No part of the leg below the groin has sweated since the injury.

Remarks. The sciatic nerve seems to have escaped injury by the missile which passed through the thigh, as there is no alteration of sensation in this part of the limb, and the only changes noted are slight wasting from lack of use and an increase of hair-growth. There may have been a commotion of this nerve. By the lower wound and the subsequent abscesses the posterior tibial and the saphena nerves were probably altogether destroyed. It is remarkable that the suffering should not have been greater, but partially destroyed nerves are the painful ones; destruction was here complete. There has been no ascending degeneration, and none of the usual nutritive changes found in so many of the cases reported.

The patient is a large, robust man, but the leg is a nearly useless appendage, and he would probably be better off without it in view of the liability to frequent frost-bites which results from the low vitality of the nerveless foot.

I made the suggestion to him that an operation which should shorten the anterior tendons would place the foot in a more natural and less inconvenient position. Otherwise little could be done to aid him.

CASE XXX. *Ball-wound of facial nerve in the canal; total paralysis of face on wounded side, except of tongue, palate, and external masticatory muscles; neuralgia; slight improvement; continued pain.* (Case 62, *Injuries of Nerves.*) —J. C. D., Co. E, 71st Pennsylvania, was wounded at Gettysburg, in his nineteenth year, July 3, 1863. The ball entered just behind the left ear at the level of the meatus; it broke the mastoid process slightly in its course forward and downward, and has never been found. Besides the resulting facial paralysis and pain in ear, cheek, and brow, he suffered at first pain in the left neck, shoulder, arm, and hand, which all disappeared in the course of five weeks.

Examined eight months after injury, February, 1864:

Complete characteristic facial palsy; sensibility normal. Electric contractility entirely lost in the muscles of expression, with the curious exception of the orbicularis oris, which responds to a current, though there is no voluntary control of the muscle.

The buccinator contracts feebly to electric stimulation.

Speech is a good deal affected, the pronunciation of labial sounds most.

Examined January 15, 1890; *Infirmary for Nervous Diseases:*

Present condition. The patient is now a member of the Philadelphia Fire Department. On the left side there is no change from the description given in *Injuries of Nerves*, p. 332.

Motion. There is absolutely no motion on the left side of the face above or below. He cannot shut the left eye at all while holding the right eye open. The left lid closes half-way down to the lower lid, and he rolls the ball up to get the pupil covered. Tears run over the lid, and the eyes water most of the time. The tongue moves as in the previous examination; but when asked to put it out it turns to the right and cannot be put out straight. It is turned downward with more ease, and there is slight upward motion of the tip. The palate acts perfectly on both sides. The masticatory muscles seem to act on the outside.

Speech. Speech is improved; this improvement is due to the fact that he has learned to pronounce better; the trouble is simply labial.

Taste. Taste seems to be defective, but the examination was imperfect in this respect.

Sensation. In lips on left side, also tip of the tongue and back of the tongue, touch is very imperfect. Compass-points not felt at half an inch on left side. Some want of touch in left ear and whole left side of the face; also, there is defective feeling in the neck down to the shoulder in an irregular region.

The left arm, which was weak after the wound, still not strong. Dynamometer shows 60, left; full limit on the right.

Pain. Greatly impaired all over the left side of the face, except upon the nose; in the left ala it is very distinct. There is an irregular area of perception on the left cheek, the lips also have limitations. Irregular places on the back of the head and neck still have some sense of pain. There is pain in the parietal and temporal regions and also in the left face. He complains of having constant pain when he thinks about it. No pain in the arm or hand now. The pain in the head grows worse.

Sufficient commentary has already been made upon the salient features of this case.

Case XXXI. *Ball-wound of third vertebra; spinal canal opened; recovery; late wasting of right arm; development of degenerative changes in posterior columns of the cord twenty-six or twenty-seven years later.*—Mr. C. enlisted in August, 1861. Wounded at Gettysburg July, 1863, in his nineteenth year, by a Minie-ball passing through the upper lip, jaw, and burying itself in the pharynx in the mid-line. Neither the tongue nor the palate was touched by the ball. He fell unconscious, and on recovering his senses, half an hour later, with some pain in the wounds, he found himself unable to move any of his limbs. Within an hour motion and sensation returned in the legs, preceded by a pricking sensation. In forty-eight hours the sensitiveness and muscular control of the left arm were regained.

On admission to the United States Hospital, August 9, 1863, five weeks after the injury, the wound had healed, except in the pharynx, where a purulent discharge continued. His condition at that date was as follows:

Head carried erect and rigid, any motion causing excessive pain. Shoulder-movements of the right arm normal, except that the deltoid can raise the arm only about three inches from the side. The biceps can flex the forearm only to a right-angle, and the posterior muscles are equally weak. Pronation is complete but feeble, and supination is limited by the contraction of the pronator radii teres. Wrist and finger movements very feebly executed. Slight impairment of sensation in forearm and hand. In the left

hand there is slight numbness of the fingers, and the patient complains of numbness in the left lateral region of the chest.

The only absolute loss of touch and pain sense is in a space below and behind the right ear, extending forward to the chin and half-way down the neck, in the area supplied by the superficial cervical nerves.

A swelling on the tongue was opened and a fragment of an incisor tooth, driven into it at the time of the wound, removed. In a mass of soft granulations at the back of the throat and at the level of the third vertebra, from which pus oozed freely, the probe detected a ball and small splinters of bone. They were removed without difficulty; the ball was found flattened and distorted, and dotted with bits of broken teeth. There was rapid improvement after this. Two fragments of a vertebra escaped later from the wound, one a part of the carotid foramen of the third vertebra, and the other a portion of a vertebral body showing on one side a part of the surface which looks toward the interior of the canal.

On November 1st the patient was transferred to the Veteran Reserves, and afterward re-enlisted in the First Battalion.

Examined by Dr. W. T. Mulhern, Greenfield, Iowa, April, 1890:

Mr. C. G. C., Co. G, 7th Wisconsin, now forty-seven years old, 5 feet 8½ inches in height, and weighs 210 pounds. His general appearance is that of perfect health. On examination I find the cicatrix of a wound said to have been inflicted by a Minie-ball at Gettysburg, July 1, 1863. The ball carried away five or six teeth to the right of the median line, and lodged in the posterior pharynx in front of the third cervical vertebra. He reports that the ball was removed by Drs. Mitchell and Morehouse, at Philadelphia, on August 11, 1863.

So far as I can detect, the constitutional defects are very slight for such a wound. His sensations in the region of the wound and the lower portions of the body and extremities, as far as the sense of touch is concerned, are very nearly, if not altogether, normal. He claims, however,

that he cannot distinguish between heat and cold, though I had no opportunity to test this. All his movements are normal, his control of the voluntary muscles in all parts of the body perfect. There is a difference of three-quarters of an inch in circumference of the arms over the belly of the biceps, the left arm being that much larger than the right. There is no difference in the size of the lower extremities. No difference is discernible in the shape or character of the nails. The right side of the face seems a little flabby, upon close inspection, as though the muscles had lost their tonicity, and they cannot be outlined so well as the same muscles on the other side; yet the difference is scarcely noticeable, unless special attention be called to it. The secretions, so far as I can tell, are normal. He claims that his bowels have been very inactive ever since he received the wound, yet he seldom takes a cathartic, and encounters no difficulty in passing the feces. His lungs are sound, and his heart-action good though a little weak.

The patient's own statement of his condition reports that he is numb in various parts of the body; that his legs below the knee are weak and atrophied; that he has pain in the back and shoulders, and difficulty in retaining his urine. His weight, in the last two years, has increased from 175 to 210 pounds.

Dr. Mulhern, in a second letter, *November*, 1892, writes as follows: "There are some very decided changes in his condition, and marked symptoms of progressive paralysis and want of coördination in the locomotor apparatus. His gait is tottering, and it requires time and a very decided effort to accomplish a desired movement. He is as apt to totter backward or sidewise, on arising, as to move forward, and frequently he will fall without any apparent cause. The extensor muscles of the legs are so paralyzed that the limbs have a marked convexity backward. There has been no evidence of mental aberration, and the muscular development is good."

Remarks. This case teaches a useful lesson as to too hasty judgment upon the future of spinal injuries.

Originally his return to health was complete enough to permit of his re-enlistment, and, in spite of the patient's complaints of his subjective sensations, his appearance and the evidence of an examination made even so late as two years ago, would have led to an inference of good health, and perhaps even to a suspicion of malingering. Giving the fullest credence to his statement of his feelings, yet no one would have predicted from them that after so long a period of quiescence distinct spinal degenerative changes in the posterior columns would be set up. In this respect the history may be usefully compared with VII., in whom a similar long interval had elapsed, during which somewhat vague complaints of the condition of his back were made, until quite suddenly serious alterations took place.

Could the full extent of the injury have been known at first the prognosis must then have been most unfavorable. But it was not until recovery was nearly complete that the discharge from the wound of portions of a vertebra showed that the spinal canal had been actually opened by the crushing of the body of the third vertebra.

It is curious that the injury should have been just sufficient to cause a temporary and partial paralysis of motion. The marked impairment of sensation was in an area supplied directly by the superficial branches of the cervical plexus. The plexus, lying opposite the four upper vertebræ, might have been injured by the ball, or the fibres supplying it may have been divided or bruised by the crushing of the third cervical vertebra. Strange is it also that the vertebral artery should have been unhurt and that there should have been no evidence that the anterior columns of the cord suffered at any time.

If the patient's statement that he has difficulty in the differentiation of heat and cold be correct, there must have been some late alteration in the lateral columns.

CASE XXXII. *Gunshot-wound of spinal column; nearly complete general paralysis of motion; enfeebled tactile sense; causalgia; muscular hyperæsthesia; recovery, except of mo-*

tion in left arm (Case 43, *Injuries of Nerves.*)—S. J., Company I, 8th Pennsylvania Cavalry, received his wound May, 1863, in his nineteenth year. A small bullet entered the ramus of the left jaw near the middle and a little below the level of the teeth. The missile passed backward and inward, and finally lodged in the spinal column. He was confused by the wound, though conscious, and said that he felt as if he had been struck in the ear and then lifted into the air. There was instant pain in the back of the neck and in all the limbs. Soon there was total paralysis. The man is uncertain if there was loss of sensibility. July 19, 1863, eleven weeks after injury, his condition was thus described on admission to the United States Hospital:

"A more wretched spectacle than this man presents can hardly be imagined. He lies in bed motionless, emaciated to the last degree, and with bedsores on both elbows and both hips. His hands lie crossed on his chest, perfectly rigid, the fingers extended, the skin congested and thin, the nails curved; false ankylosis of all the joints of the upper limbs; the head and neck rigid, with acute pain in these parts on movement. The right leg has motion of a feeble nature in all the joints; the left only very slight voluntary movement. The hands present certain characteristics which belong usually to cases in which there have been wounds of the brachial nerves. In the present instance, as in many others, these peculiarities have been modified by the long-continued rest of the limbs in one posture. Thus, the shining palm, the slight eczema, the burning pain, the atrophy, and the swollen joints, whose appearance simulates subacute rheumatism, with the contractions of certain muscles, are all owing to nerve-lesion, while the ankylosis and the peculiar flattening of the hand are perhaps owing to this and to the long rest and disuse, the arms meanwhile lying crossed on the chest, the fingers in extension. Disuse alone might have caused some stiffness, but never to such a degree as occurs when the joints have been subacutely inflamed at the same time. The loss of the lateral palmar arch is owing to both causes, and the

monkey-like appearance of the hand, the thumb rotated outward, and its nail looking upward and even toward the forefinger, is caused, first, by the subluxation of the meta-carpo-phalangeal articulations, and, secondly, by the weakening and atrophy of the adductor and short flexors of the thumb. The nerve-lesion affecting the muscles and the general nutrition of the part has so relaxed the unused tissues of the limb as to make the pressure of its own weight effective in thus altering its form."

Sensation. Tactile sense enfeebled in both arms, worse in left. Feeble in both legs; worse in left. Confused power of localizing sensation in both legs. Mistakes right for left, but not left for right. Muscular hyperæsthesia of upper limbs, shoulders, and neck; not of legs. Pressure on left brachial plexus causes pain extending into arm and hand; palms burn, feet not at all.

The hyperæsthesia of the muscles and the false ankylosis make attempts at passive motion very painful. The trapezius and the arm-muscles are rigid and atrophied, and either he is too weak to move or the spinal muscles are also paralyzed.

Treatment. In spite of the pain which they caused, passive motion and massage were thoroughly used, the bedsores treated with alternate applications of heat and cold as recommended by Brown-Séquard, and after the first four or five weeks the improvement was rapid.

January 7, 1864, the patient was re-examined with the following results:

Nutrition. Much improved; the glossy skin has disappeared; the nails are less curved; the temperature better.

Sensibility. In right arm, tactility and localization good; in left arm, less good; nearly normal in legs. Pain-sense improved; not yet normal. A pinch causes sense of pricking only.

Motion. Voluntary motion normal in right leg; normal in extent in left leg, but feeble. The slight contraction of the right biceps limits somewhat extension in that arm, but otherwise the movements are perfect in the shoulder and elbow. Wrist-extension incomplete from con-

tracted flexors; flexion perfect. Thumb-abduction lost. Finger-extension normal; flexion limited in second and third by the swollen joints. Left arm improving; some voluntary motion of shoulder; slight flexion and extension of wrist; feeble pronation and supination. No elbow-movement.

From this time till March, 1864, when he was discharged, his progress was very rapid, and he left the hospital with "nearly entire use of all his limbs, except the left hand and forearm," and a slight shuffling in his walk.

The patient's own statement is that on his discharge he could not use his left arm or forearm much. The left leg was weak, but not entirely without motion, though needing the aid of a cane. The right arm, which at the time of the original injury was completely palsied, was in good condition.

Examined at the Infirmary for Nervous Diseases, 1890:

A fairly healthy-looking man, aged forty-five years. The left arm hangs helpless and shrunken at the side. The left leg drags slightly in walking. There is a scar at the angle of the left jaw where the ball entered. There are many small scars at the back of the neck and a short distance down the back, like those made by croton oil, and two others said to have been caused by boils.

Nutrition. The left arm is much wasted through its whole extent, as are also the shoulder-muscles and those of the left side of the neck behind and the left pectoralis major. The right forearm at its largest part measures nine and one-quarter inches, and the left eight and one-quarter inches. The left arm is colder than the right. The skin is somewhat glossy on the left hand, and can be pinched up more readily than on the right. The hand is a little swollen, especially over the metacarpo-phalangeal joints. The finger-nails are curved from side to side, but not overhanging at the ends, and the patient says they grow *more* rapidly than on the right hand.

Motion. He can raise the left shoulder somewhat, but cannot bend the elbow at all. If the wrist be held, he can slightly flex the thumb and extend the last joint. He can

partially extend and flex the second finger, and in a less degree the other fingers, but cannot separate them. He can extend the first joint of the little finger, but not of the others. The little finger can be abducted. There is some slight power of pronation. The arm hangs with the elbow flexed; the thumb is held in the palm and the fingers flexed. The hand cannot be completely extended, and there seems to be some restriction of lateral motion at the wrist.

Sensibility. There is no paræsthesia or burning pain. He localizes touch well in the hand, but on the second finger he does not discriminate points as two at half an inch distance; on the third finger he can do so at a quarter of an inch; while on the fourth finger two points three-quarters of an inch apart are still felt as one.

The temperature-sense is preserved and is very delicate, distinguishing with ease between a piece of metal which has been slightly warmed and one which has not. There is more and worse-smelling sweat under the left armpit than under the right, and the patient says the entire left arm sweats more. He is sure that the odor is not due to less frequent washing of the left arm.

All the arm-muscles respond extremely to a tap with the hammer, and the elbow-jerk is present. The wasting is so great that the median nerve can be rolled under the finger. It is tender on pressure. There are no ankyloses of the joints of the fingers. Considerable force must be used to flex the elbow passively or completely rotate the shoulder. A rapid clonus of the flexors of the wrist may be developed, which, however, does not last very long, and after repeated efforts dies out altogether.

The left radial pulse is smaller and feebler than the right. The left leg is somewhat wasted, its calf measuring twelve and one-half inches at the thickest part, while the right measures thirteen and one-half inches. Sensation is normal to touch and pain. Knee-jerk excessive; no clonus. All movements are perfect, except a very slight dragging of the foot.

The patient says the right arm is weak (dynamometer

70), but all motions are perfect and sensation good. There is no apparent wasting.

Remarks. Judging from the manner in which the injury was received, and from the immediate and later symptoms resulting, there can be no doubt that the spinal column was wounded or greatly shocked. The swiftly following trophic changes; their wide distribution, involving every limb; the peculiar joint-swellings; the general loss or disturbance of the tactile and localizing senses, all unite to make this certain. By the time of his admission to the wards of the hospital in Philadelphia the first effects of the injury were past, the ball encapsulated, and the wound already healed. There remained for treatment the severe and widespread results, combined with the secondary ills caused by enforced rest in one position. Without energetic care, death must soon have followed from exhaustion, and probably had the patient been a civilian in a civil hospital, where he could have had his own will as to painful methods, he would have died.

The relative completeness of recovery is remarkable. Twenty-seven years after the injury little further evil effects have occurred. The patient has good use of his legs and of his right arm, and suffers in no way, except from the inconvenience of the left arm, which is merely an appendage of no service. It is altogether likely that had active treatment been continued after his discharge the condition of the arm would to-day have been better than it is.

The case illustrates the difficulty there may be in distinguishing between injuries or disease of the gray matter of the anterior columns of the cord and multiple neuritis. Perhaps both may have been present here; it is now impossible to be sure, and I only call attention to it as a problem frequently placed before us for diagnostic differentiation. It is remarkable, too, that the trophic and paralytic troubles should have been so distributed throughout the whole body when there is every probability that the anterior columns were the only part of the cord injured.

CASE XXXIII. *Commotion or concussion of spine from ball-wound; slight improvement; continued weakness of right arm; extreme sensitiveness to cold.* (Case 6, *Gunshot Wounds.*)—C., in July, 1862, while lying prone and loading, was shot one inch to the left of the fifth dorsal vertebra. The ball crossed over the spine and downward, emerging three and one-half inches to the right of the tenth dorsal vertebra. He did not lose consciousness, but suffered at the time great pain in the right arm, and developed early an "exquisite hyperæsthesia of the shoulder-muscles on both sides, including the deltoids and trapezii, affecting as well the muscles and sub-cuticular tissues." Touch-sense was preserved, but touch was perceived as pain. The patient's symptoms were abating when he was admitted to the hospital, February, 1864, and, after a short course of treatment with bromide of potash, he was returned to duty at his own request, better, but not entirely well. The right arm was feeble, and measured less than the left, but had normal range of movement.

The patient reports (1890) that his back and right shoulder have always been very sensitive and sore, so much so that he has never been able to lie on his back. The back-muscles jerk and twitch and ache "after the manner of a toothache." This condition troubles him worse in damp and cold weather than on a warm day, and he feels cold sensibly, even in summer. The neck and upper part of the back are stiff. Right arm not so strong as the left; unable to use it to brush his hair or to button his collar.

Remarks. This case seems to have remained nearly at a standstill. The patient has diligently treated himself with liniments, hop-pillows, and so on, with little helpful result. The statement of his condition rests on his own report, as he was not examined by any physician at the time of writing.

CASE XXXIV. *Gunshot-wound in pelvic region; spinal shock; temporary paralysis; recovery.* (MS. notes.)—T. W. J., aged eighteen years, Company I, 24th Massachusetts, was admitted October 3, 1864, with a wound received

on the 16th of the previous June, at Petersburg. The ball entered on the left side of the back immediately above the pelvic brim, three inches from the spine, passed transversely downward, struck the pelvis on the left and glanced up, making exit at the same point on the right three and one-half inches from the spine.

He fell backward, with a stinging sensation at the site of the wound, and could not rise nor use his legs at all, but could move the arms. This condition continued for four days, when he began rapidly to improve. There was little pain except in the wound, which was dressed within five hours of the injury, and healed entirely in the latter part of August. A number of pieces of bone escaped from it in the course of its healing, evidently portions of the pelvis.

He passed water on the fourth day with great difficulty and with some pain, but no blood came with it; the bowels were not moved for nine days, and then only after active purgative medication. He has not had any noticeable trouble since with the water, but the bowels are costive. There has been a gradual gain since. The soldier is positive that he has never lost sensation at all.

October 13, 1864. His present state is described as follows: his movement is now good, and he can walk well with the assistance of two sticks. There is no spinal tenderness at all, and he is improving daily under galvanism.

March, 1890. J. at present is resident in Barnstable, Mass., and writes as follows: There is a good deal of pain about the site of the wound, which is readily affected by cold or fatigue. The urine burns in its passage, and the patient thinks that he passes a great deal more than is natural. He states that, although most of his pain and inability is in the lower limbs, there is a very frequent numbness of the arms, which go to sleep if kept long in one position.

Remarks. This case of gunshot-wound of the back appears to have injured the spine only by shock from the contiguity of the ball's passage. The only noticeable fea-

ture is the passage of large quantities of urine, as has been noted in several other cases of concussion of the cord or wound near it. The man seems, considering the large extent of the injury, to have made an excellent recovery.

CASE XXXV. *Shell-wound of lower lumbar vertebræ; paraplegia; pain in legs; overwork, general nervousness; convulsive seizures brought on by fatigue.*—T. G. J., aged fifty-five years, Richmond, Va., attorney (staff officer, C. S. A.). Though the patient had received several slight wounds he had never had a serious one until, during the battle of Gettysburg, he was struck while giving orders to change front of regiment, and holding the right arm raised with his sword. He was sure that the missile was the upper portion of an "A" shell from the battery next to the one they were attacking. He fell, not unconscious, but unable to move his legs. He put his arm back to feel the wound, and picked out of it a portion of bone—one of the spinous processes. The ball crossed the lower portion of the back from right to left He remained on the field an hour and a half before being carried to a field hospital. His first recollection was of pain in the legs and in the head, but he did not suffer at the seat of the wound, which was dressed with claret by Dr. Means, of Georgia. He continued in hospital two or three months, helpless; could not stand, but could move arms, though weak.

The wound closed late in October of the same year, and he was sent to a hospital in Baltimore, where he began to walk a little; until this time he could not bend or stoop. He had no incontinence of urine, and his bowels were constipated.

Later, Mr. J. was sent to Fort McHenry as a prisoner, where he was much exposed to cold and had insufficient food. He noticed then great shortness of breath on exertion. Afterward he was at Fort Delaware, where he improved, and found he was able to stoop to pick up an article from the floor. Some neuralgic pain was constant in the legs during all this time, but not severe after the first ten days.

He was sent from Fort Delaware to Hilton Head as one of the hostages. He was placed upon a prison-ship, and there grew better during a sixty-two days' confinement; was exchanged at Charleston in August, 1864, and returned to service at once, although unable to mount his horse by himself. He found that motion made him worse, bringing on pain about the seat of the wound for the first time, and a feeling of fulness in the head. The pain and prostration were extreme, and he suffered horribly during the retreat from Petersburg, and finally surrendered with Lee, utterly worn out. He had grown very restless, nervous, and irritable; of course, the bad and scanty rations added to this.

He began practising as a lawyer in Richmond. Hard mental work soon told upon him. He had pains about the body which were made worse by exertion, especially by the effort of going up stairs. He had headache and pain in the right ear, which were made worse by study. His work has always been an exertion, needing constant effort.

In the spring of 1873 he had once or more spasmodic contraction of the muscles of the neck, drawing the head forward and downward. About one month after this, while riding, he had to check his horse suddenly and sharply. As he did so he felt extreme pain at the seat of the wound, and he thinks he may have become momentarily unconscious, and thus fallen from the saddle.

After three days' illness from this fall the convulsive seizures began (see page 129 for the character of the convulsions). They occurred almost daily for a short time, and were then controlled by the use of bromide, ergot, and blisters. They have recurred ever since at irregular intervals, when he was run down, worried, or nervous in body or mind. At one time two years passed without an attack.

In 1889 he was obliged to travel a good deal, and since then the convulsions have been more frequent. Sitting long on a hard seat makes him uneasy, and he grows restless and unable to concentrate his attention. He has a

sinking feeling at the epigastrium in the morning. Pain in the left leg is very frequent, especially after exertion or mental labor.

He has consistently neglected his health until the last year or two; has never slept well, and worse if he has exercised much. Always worked hard, and to exhaustion; irregular meals, etc.; does not smoke; chews a great deal of tobacco; has not used any alcoholic drink for some years; has gained forty pounds in twelve months past, and thinks he is worse for it. Some fine tremor of head and of hands has appeared in the last year.

Dr. Deas, of Richmond, his physician, has frequently seen the convulsions. They begin with the part most used: arms, if he has been writing; legs, if walking. There is at once tonic contraction of these limbs; hands and elbows flexed; head bent forward on trunk; eyes somewhat suffused; no great flush; pupils are sometimes, but not always, contracted, never excessively. The legs are drawn up and the trunk bent. Meanwhile, in addition to the tonic contraction, there is large tremor of head, hands, and arms, but not of legs. He never has any but a tonic contraction of the legs. The whole convulsion lasts not more than a minute or two. There may be several during the day, with great prostration in the intervals. He has never been unconscious during these attacks, unless at the time of the fall mentioned. Sexual desire is increased ever since wound. Suffers very often with girdle-pains around the chest and back on the level of the fifth and sixth ribs; the pains are neuralgic in character, but not constant. The patient has pain in the eyes, if they are used long at a time, and thinks this is worse now than formerly. Heart-beat, at rest, 85 to 95. During examination it went up to 120 per minute; no murmur. Lungs normal.

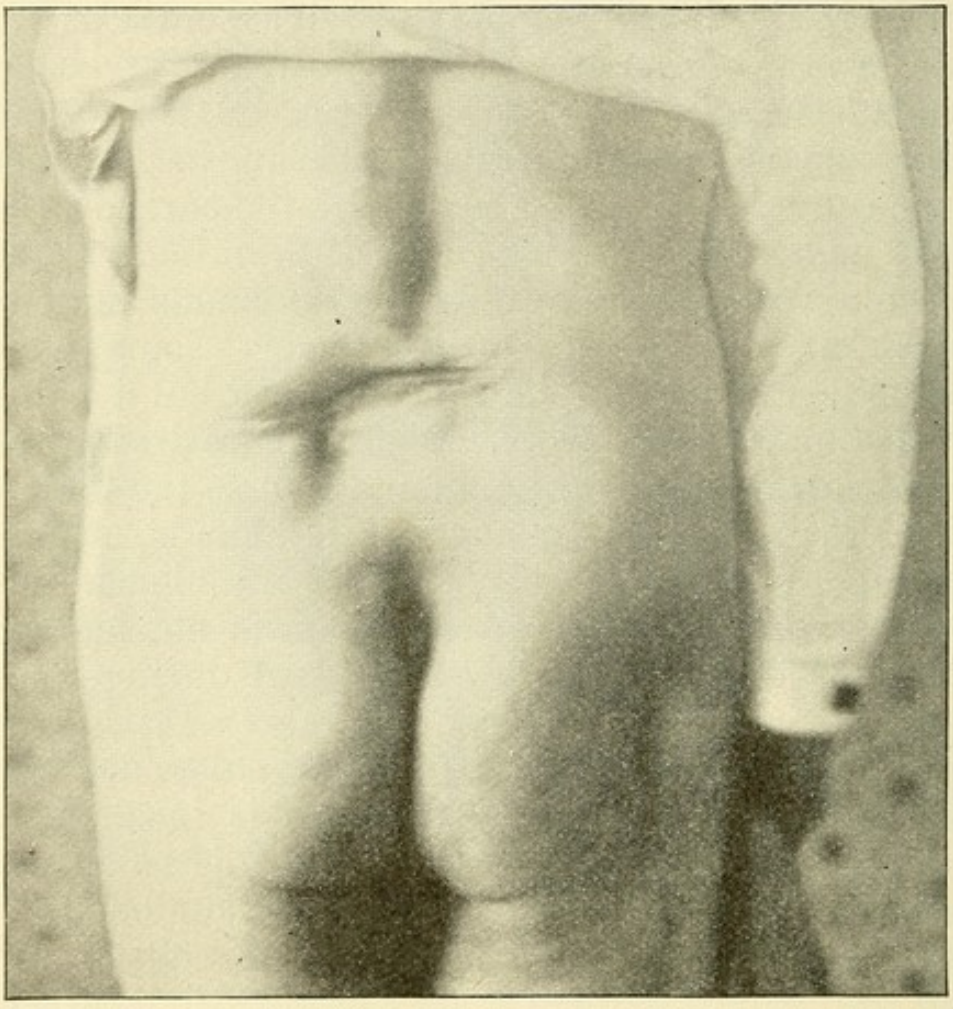
Examination September 23, 1890:

Stout, fairly well made, large man. Looks older than his age. Arcus senilis. Slight fine tremor of head and hands, especially of right hand. Walks about office; cannot sit still. Wears rubber heels to relieve shock to spine.

The wound is a tear from right to left, one and one-half

inches wide and nine inches long, over the last two(?) lumbar vertebræ. The scar is closely adherent to sacrum and vertebræ, and on both sides, so as to make it hard to determine with certainty the bony parts affected. The portion of the scar directly over the spine and on both sides is tender on pressure, and for one inch above, but not

FIG. 6.



T. G. J. Case XXXV. Wound of lower lumbar vertebræ from shell.

elsewhere. There is no tenderness on the sides of the body, or over the course of the nerves from the spine. Knee-jerk + + on both sides. Reinforcement + on both sides. No clonus. No testicle reflex, no abdominal reflex. Sensation perfect everywhere. On legs and back distinguishes points clearly; on back at one and one-half inches, and on thighs, front and back, at one inch. The urine is sometimes excessive for a single day.

While in Philadelphia, September 24, 1890, he was seized with a convulsion about 3.45 A.M. Was seen at once, and from that time until about 6.30 A.M. the attacks were almost constant. They began in the legs, but soon extended to the arms and neck. Between the attacks there was intense restlessness. Attacks always commence in the legs, when, as on this occasion, he has walked much, but in the arms and neck when he has been exerting much mental effort or has been handling large law books. During the intervals between them he is apt to be despondent and to take discouraged views of his condition and business. To-day, September 24th, the legs became rigid and extended; once or twice the feet were flexed and again extended. There was rigidity, first of one arm and then of the other. At times the wrists were bent; again not so, but in either case the arms continued bent at right-angles. The rigidity of the legs at one time lasted for almost five minutes.

Remarks. The patient's case is a curious and suggestive one of a very rare type. Undoubtedly the grave results of the extensive wound were made more serious by the terrible privation and exposure that preceded it and that followed his return to the Confederate ranks, which he reached only in time to go through a winter campaign, and then to share the desperate fighting, forced marches, and starvation of Lee's last struggle. He was long in a rough field hospital, and went from hospital to prison before he had well begun to recover from his wound. The origin of the malady was clearly spinal in the first instance, even if in its later development other causes may have shared, such as sprain of the muscles of the back—an injury sometimes competent of itself to cause serious spinal changes, and even paralysis it may be, by an injury to spinal nerves at their exits from the column. (Compare VII.) To use his mind or his arms brings on convulsions, beginning in the upper limbs, but extending to and including the legs. If he overuses his lower limbs, then the spasm begins in them. Some general spinal alteration must lie at the bottom of such a tendency, although it is likely

enough in a patient of such emotional character that hysteria may have a share in the performance.

That functional activity should cause tonic spasm of the parts used relates the case valuably to some seen at the Infirmary, in which use of certain parts caused some form of spasm. Several years ago a patient was long in the wards who presented these peculiar conditions:

Case XXXVI. Was a watchmaker, aged about twenty-four years, in fair general health, and with no bad habits. He had several times strained his back in lifting, and once in holding a rearing horse. Finally, after an illness, probably a mild typhoid fever, in which he passed blood by the bowels, his spasms appeared. He was so weak that he had been in bed a year when first seen. If he turned his head from side to side a dozen times, he had firm spasm of the neck-muscles, sometimes on the right, sometimes on the left side, lasting a few minutes and causing pain in the opposing muscles from their overstretching.

If, lying in bed, he held a book long, he suffered a like violent extension spasm of one or both arms. To lift a leg a few times brought about a similar result. If he raised both legs, he had spasm in both or in the more tired one. There was no loss of sensation in any form, but all the muscular reflexes were greatly exaggerated.

Violent clonic spasm of the tired part coming on some time after the exertion was the peculiarity in the case of Dr. L., who was some months in the Infirmary in 1891. There was no loss of consciousness and no cerebral disturbance in either of these persons. Both were undoubtedly of hysterical origin, although there was no alteration of sensibility in either.

There was no such element to be discerned in the following case, which also presented what we may reasonably call spinal convulsions:

Case XXXVII.—A., a stout, strong, ruddy butcher, aged forty-nine years, not an excessive drinker of beer, used tobacco freely, unemotional, no history of injury. A. com-

plained that whenever he was at work afoot for unusually long hours he was subject some hours later, and always coming on during his sleep, to terrible extension-spasm of the legs and rigidity of the belly-muscles. The pain was agonizing, and relieved by morphia only. He gave up tobacco and beer, became a vegetarian, and the attacks soon after ceased.

CASE XXXVIII. *Injury to the spinal column and cord by fall; spastic paralysis of legs; partial paralysis of hands and arms; excessive flow of urine; excessive one-sided sweating; alteration of visual fields; mis-reference of touch.*—R. N., aged thirteen years. At the age of ten years the child fell twenty or thirty feet from a tree. There were no bruises or apparent injuries, and she was not stunned, but immediately upon being taken up she exclaimed, "stretch my arms and legs, and my fingers and toes;" but she could not move her arms, hands, legs, feet, or head, and suffered from a pain so intolerable that she could not be moved in any way.

The hands and arms and the whole anterior aspect of her body as low as the hips were extremely sensitive, so that she could scarcely be touched even with a soft sponge. There was early and entire loss of sensation to pain and touch below this point.

She did not pass her water from the beginning voluntarily, and after the first few days there was a constant flow of urine for three months; since then, however, the bladder is able to retain, though not to excrete, the urine.

The bowels only moved by enema, and the urine was for the first nine weeks very pale, almost watery in its color, and extremely abundant. After the first few weeks the nervousness which followed the accident passed away, and she began to move her head, and presently her arms, and about the same time (the end of the first month) the extreme sensitiveness of the arms gradually disappeared. With the exception of the contraction of the fingers she has entire control of her body above the waist, although she is easily fatigued by sitting erect in a chair, and if the

erect position is too long maintained, begins to feel faint. This was the history up to December, 1892, when the patient was first seen by Dr. Weir Mitchell.

At that time the following notes were made: As the child lies in bed she cannot move her legs, although, by continued effort, it is possible to make some small movements. The fingers are flexed in the palm and can be readily straightened, with some pain when extended. The hands both turn inward and there is no voluntary movement of the digits. The hand can be extended from the wrist, but not flexed, abducted, or adducted. There is free movement of the forearm and shoulder in every direction, but some weakness. The head and neck are perfectly moved. There is complete anæsthesia on the trunk from the level of the second dorsal vertebra. On the arms there is anæsthesia on the ulnar side and posteriorly from finger-tips to shoulder. The boundaries of sensation for touch, pain, and temperature correspond, except that on parts of the arms pain is felt.

Plantar jerk present; clonus is sometimes present and sometimes absent. No knee-jerk; no marked muscular jerk in legs or arms; elbow-jerk marked. At times without apparent cause the legs become suddenly spastic, but usually are perfectly relaxed. On waking in the morning the legs are always spastic. Any pain, as the prick of a pin, or a faradic shock, causes jerking of the entire leg. A prick on the head is felt, but incorrectly located, as if the spine could not translate the nervous message. A prick upon the feet or legs, when felt, as sometimes happens, is referred to the head; this is true of both touch and pain.

There is much atrophy in the intrinsic muscles of the hands and in all the thumb-muscles; some atrophy in all the arm-muscles, especially in the extensors, and the legs are a good deal wasted.

On examination of the spine no deformity could be seen. Sensitive spots were developed by percussion, but the position of these tender places seemed to vary almost minute by minute. During one of the early examinations it was

noticed that the excitement of the examination had caused profuse sweating of the face, limited entirely to the right side.

The urine was alkaline and contained some pus and mucus, but no casts.

The child was of unusual intelligence, of most amiable and pleasing disposition, very quick and observing, and not at all hysterical. She had, with great patience and pains, learned to use her hands in spite of the contraction of the fingers, so that she writes rather better than most children of her age, and draws quite cleverly with a pencil held between the contracted fingers and the palm of the hand.

Remarks. This case has been already reported[1] and examined in detail as to certain symptoms, but those which concern us here were not within the scope of that discussion. The unilateral sweating and the very extraordinary mis-reference of touch are of much interest, and will be considered in the chapter devoted to the changes of nutrition and sensation.

Severeanau, of Bucharest, has reported the following interesting case of gunshot-wound and fracture of a vertebra with ultimate recovery:[2] A boy aged sixteen years received a gunshot-wound in the back between the spinal column and the left shoulder-blade. No bleeding resulted, nor was there any subcutaneous emphysema. The ball was not at once explored for, as no alarming symptoms were present.

Three days after admission, fever, local swelling, and paralysis began, which attained to a complete paraplegia, and even contractures. Eight days after the injury an operation was done. Some pus was found on deep incision. The posterior arch of the second dorsal vertebra was cracked, and, by the aid of Trouvé's apparatus, the ball

[1] Mitchell and de Schweinitz, Journal of Nervous and Mental Disease, January, 1894.

[2] Arch. f. klin. Chirurgie, vol. 37, p. 664.

was found lying under the cracked fragments of the vertebra, and was extracted without any trouble.

The boy made a very slow recovery, interrupted by a large sacral bedsore, and only regained complete health six months after the operation, up to which time the spinal cord had remained entirely unaffected by the injury.

CHAPTER IV.

ASCENDING AND MIGRATORY NEURITIS.

Several of the cases which have been detailed in previous chapters presented extreme examples of acute traumatic neuritis. In varying degrees of severity it was a common complication of bullet-wounds of nerves, as seen during the Rebellion, and some neuritis is probably very frequent where a nerve has been directly wounded, although it is often limited to the immediate neighborhood of the hurt. It may begin as an acute inflammatory trouble, or from the first its course may be rather chronic, but otherwise not essentially different, or the acute may pass into the chronic form; and, thirdly, the change may be a very slow degenerative one, with less of irritation, but a still greater amount of impairment of nutrition. These forms of disorder rarely pass beyond the immediate nerve territories in which they originate or their directly communicating branches, except, as hereafter noted, the subacute variety.

All of these kinds of inflammation are somewhat diffused, but it is the characteristic of what is called "ascending," or, as I should prefer to call it, "migratory" neuritis to exhibit more of this tendency to spread, sometimes causing death by its attack upon the ganglionic centres in the spinal cord. In speaking of it I shall limit the meaning of the term to neuritis which extends so as to involve nerves anatomically remote from the region primarily affected.

Acute neuritis from an injury—often a slight one—begins suddenly with a rigor, at an interval of a few days after the reception of the wound, and at once invades the whole nerve, causing extreme pain and the other symptoms already described—impairment of function, vasomotor, trophic, and secretory disorders. It is said that acute neuritis may "terminate early in resolution without mischief to the nerve," but this is certainly rare. It is more usual to see the symptoms lessen and a subacute inflammation follow, which lasts for a long time. It is then that the tendency to spread is developed.

Clinically there are many intermediate degrees between typical acute and typical chronic neuritis. "Acute" and "chronic" are terms convenient in use to describe the severer and the milder inflammations, but they intend really tissue-changes, not time-differences, and imply nothing as to brevity or length of the pathological processes.

When therapeutics are under consideration it will be found that several neural inflammations may behave very differently to like treatment, a difference which may point to varying grades of inflammation.

Many isolated cases have been reported by various authors, but there is need still of a systematic treatise upon this ill-understood subject.

A severed nerve will always degenerate; a contused one sometimes does so; but there can be no rule made for the occurrence of spreading inflammation. It cannot be produced at will by experimental injury, and is, indeed, difficult to produce at all in animals, even by repeated lacerated wounds. Nothing in the nature of the injury will enable us to prophesy its future occurrence, nor when it has appeared is it usually possible to say what condi-

tions have brought it about. That it is exceedingly rare is shown by the records of the many efforts to evolve it, as well as by its infrequency as a complication in the experimental injury of nerves for other purposes

For instance, in the large number of experiments made by Drs. Howell and Huber for the study of the phenomena of degeneration and regeneration of nerve-fibres, although this point is not specifically stated, I can find no instance of the appearance of neural inflammation of any sort. The injuries to nerves in the course of their work were of all kinds and of every degree of severity : section, crushing, coagulation by heat, all with a few exceptions done on dogs, and post-mortem examinations with microscopic studies had in all instances.[1]

Others have been equally unsuccessful in their efforts to produce this lesion. Dr. Mitchell in a number of experiments could find evidence but once of the presence of any disorder (sclerosis) of the cord as a result of an ascending inflammatory change. Roessing failed to get any but local results in numerous rabbits experimented upon, while Traub succeeded in causing extending inflammation after violent injury by cautery or by ligation ; but the inflammation did not reach so far as the cord. Vulpian says that he never could bring it about. Hayem saw ascending neuritis and myelitis of the spinal cord as a result of the avulsion of the sciatic ; but this was a wound of almost too extreme a character to be valuable as evidence, and it is probable that in these cases the strain upon the nerve which was torn extended to the cord itself, and resulted in a direct injury to the cord.

[1] That the wounds of their subjects were made aseptically, and treated with every precaution to avoid sepsis, may have had an influence against the occurrence of neuritic disorder. *Vide infra.*

Klemm states that he succeeded in producing inflammation in small areas of the cord as a result of irritation of the peripheral nerves, and this without evidence of any change in the intervening trunk communicating with the cord. He even holds that inflammation of a nerve may "propagate itself" to the corresponding nerve on the opposite side without the cord or its covers participating to any marked degree in the inflammation; but this may be looked upon as a very doubtful statement.

Dr. Brinton's cases reported in *Injuries of Nerves* showed well how small an amount of constant pressure might produce a local neuritis, exhibiting a curiously strong tendency to spread upward upon the filaments of the ulnar nerve. The pressure was only the weight of the bridle-rein upon the inside of the ring-finger, as the reins were held by the cavalrymen throughout a long march. So small an extension of the neural inflammation as this, however, can scarcely be looked upon as a typical example of the disease. Almost any wound or injury of a nerve results in a neuritis in the neighborhood, which may, and commonly does, spread both up and down a little; but by ascending neuritis we should ordinarily mean a much more extended result than this.

A few of the surgical text-books mention the occurrence of ascending and sometimes of descending neuritis as complications in nerve-wounds, but say little as to their frequency. In most works upon nervous disease from the medical standpoint the subject is totally neglected. Hammond, for example, only says: "Chronic neuritis often exhibits a tendency to ascend and to involve more central trunks." Ross says: "Neuritis manifests a constant disposition to propagate itself along a nerve in a centripetal direction, and then to extend to nerves lying

in a higher plane and to the spinal cord." But this is all the attention that either of these authors pays to this subject.

Strümpell (*Speciellen Pathologie und Therapie*) has a little more to say: Traumatic neuritis, he asserts, occurs only from open wounds, stabs, cuts, and gunshots; moreover, it is only from such wounds that ascending neuritis results, and he quotes the experiments of Rosenbach and Kast to prove that perfectly aseptic wounds never cause spreading nerve-inflammation, and that subcutaneous injuries, as by pressure, blows, or luxations, cause simply a mechanical disturbance of the nerve-elements, from which follow secondary degeneration, overgrowth of connective tissue, and final regeneration.

Other authors have held that an open wound is a necessary precedent condition for the occurrence of *all* traumatic neuritis, but the position is one not easily defended. Still, much may be said for this theory of the causation of spreading neuritis, and a case like XLIII. offers a strong argument for the presence of some special toxic cause. The difference between a general neuritis following an injury of a nerve-trunk and limited to that branch, and a migrating inflammation, cannot lie merely in the severity of the case. Numbers 2 and 3 in *Injuries of Nerves* are examples of the severest form of neural inflammation, beginning with chills and furious pain, and passing into the subacute form, but with no spread of the disease beyond the area first attacked. The original injury and the first neuritis were of slight character, but the later disease was of a very violent kind, though at neither time was there any open wound.

The argument for a special toxic cause is a strong one. Probably a special adaptability of soil for the first planting of the seed is needed, and, should this be present,

then under favoring conditions it may germinate anew in less suitable ground or reach it by simple extension. The several epidemic varieties of nerve-inflammation (beri-beri and cerebro-spinal meningitis, for example), and those which occur in the course of infectious diseases (such as leprosy, malaria, and diphtheria), furnish additional arguments for the possibility of such causation.

The facts that some time always intervenes between the reception of the injury and the commencement of the neuritis, and that a rigor signalizes the invasion, seem also to show the presence of an infectious cause.

The manner of appearance of the peculiar ulcerative disorders in XLIII. greatly resembled the course of some local infection, as has already been said. Beginning at first in a region strictly within the territory of the affected nerve, and for some time confined to it, they extended some months later into adjoining regions, and finally appeared in quite distant and unrelated parts. Cultivations from these ulcers failed to show anything more than the ordinary pus cocci, but should another such opportunity occur I would certainly make more elaborate efforts by cultivation and inoculation-experiments to produce neuritis. A most interesting field of research would be opened should this prove possible.

There is no record among these surgical cases of any acute neuritis ascending rapidly and invading the spinal cord, nor even any well-recorded and clearly stated history of death from ascending neuritis, either acute or chronic. A very interesting series of five deaths from rapid ascending neuritis has recently been reported by Dr. J. Ferguson,[1] of Toronto. In two the starting-point seems

[1] Medical News, Philadelphia, January 6, 1894.

to have been injury to filaments from the brachial plexus during the extirpation of the axillary glands for carcinoma of the breast. The cancerous disease may have had a share in the causation. Of the others, one was a sequela of an attack of epidemic influenza, one of diphtheria; the fifth patient's trouble began from cold, with rheumatic pains in the legs, and recalls the account given by Graves, of chronic ascending neural inflammation from repeated exposure to damp cold—the first report, I think, of any form of this disease. Death occurred in all Dr. Ferguson's patients with remarkable suddenness, and only a few hours after the onset of serious symptoms. In three of the cases post-mortem examinations were made, and all showed neuritis; it had affected the intestinal nerves, and the sympathetic ganglia showed congestion in one; in two there was neuritis of the brachial plexus, and in one of these the spinal roots from the sixth cervical to the second dorsal were found inflamed.

The demonstration of the mode of death in these instances is nearly perfect. A neuritis running up the main trunk attacks the spine, and when it reaches the origin of the nerves supplying the heart, which spring mainly from the first and second dorsal roots, the control of the heart is first weakened and then lost, just as any muscle is affected when the nerve governing it becomes inflamed.

If a large number of cases could be collectively examined, some valuable general conclusions might result. The number offered here is too small to be more than a contribution to such a study; yet the following inferences will, I believe, be found borne out by more extended observations.

1. Pressure, however brought about, whether by in-

flammatory exudate, external injury by blow or weight, may be looked upon as a frequent factor, though not a constant one, in the production of spreading nerve-inflammation; but the presence of inflammation in the surrounding tissues, even in direct contact with the nerves, exerts, curiously, little bad influence.

2. The larger nerve-trunks are more prone to present the phenomena of spreading inflammation after injury than small ones.

3. Neuritis may spread either centrifugally or centripetally, the latter, in traumatic cases, being much the more common form.

Of the cases quoted in *Gunshot Wounds* there is one in which alcohol played so strong a part as to forbid us accepting the case as a typical example, since we know that alcohol alone is capable of producing neuritis. Another (Case 17, *Gunshot Wounds*) was perfectly typical in character, and was discharged when recovering, although not completely well. I have, unfortunately, not been able to trace the later history of this man. A third instance is given in which there was a paralysis of the muscles above the cut nerve, as well as below, a paralysis which the authors attribute to the ascent of the neuritis, but which may, perhaps, be looked upon as having more of the character of a reflex palsy than of a disability resulting from nerve-inflammation.

Among the old army cases which I have personally examined or received trustworthy histories of, no instance of spreading neuritis has been found, except those at the end of this chapter. It is, of course, to be remembered that it might have occurred and been fatal in the intervening years. Still, it must be a rare complication, as during some years of service at the Infirmary for Nervous

Diseases it has been very seldom under my observation. Yet this possibility of the ascent or descent of neuritis must be remembered in the treatment of nerve-traumatisms, and promptest measures taken upon its appearance.

What the possibilities of treatment are will have to be considered in the chapter upon the therapeutics of nerve-injury. That they are, so far as our present means go, very unsatisfactory, is seen in the report of one of the cases at the end of this chapter, Mrs. J., XXXIX., where, in spite of every medical interference, the spread of the inflammation was never checked at all.

When the extension stops it stops of itself; but why it should stop when it does, is as little within our present knowledge as why it should be present at all. It may be both ascending and descending in the same case, as happened in XLIII., where the pressure of a scar had something to do with its causation.

The three cases which are quoted from the Pension Bureau's Reports are not so elaborately related as one would like them to be to afford a firm foundation for an opinion upon the presence of ascending neuritis involving the cord. The best of them is XL., about which such widely different diagnoses were made by the various examining boards; but in all three, taking them as they stand, similar phenomena were present. There was slow ascent of the difficulties in two up the nerves of the leg, and consequent myelitis; in XL., up the nerve of the arm, finally attacking the cord, and apparently crossing and descending upon the corresponding nerve of the other side. This very rare and interesting form is sufficiently commented upon in the remarks attached to the cases. It may be noted that in two of these the injury was an open

wound; in XLI. from gangrene, in XL. from the missile, but in XLII. there was no exposure of subcutaneous tissues, nor in XXXIX., except the wound of twenty-two years before.

The following five cases are illustrative of various degrees and forms of spreading neural inflammation:

Case XXXIX. *Neuritis ascending from old nerve-wound in hand; affection of whole arm; unsuccessful treatment; stretching of brachial plexus, of ulnar nerve; excision of portion of ulnar; no improvement.*—Mrs. A. J., aged forty years, born in England, came to the Dispensary of the Infirmary for Nervous Diseases, July 13, 1892. The patient was a sewing-woman, and had worked excessively hard for many years, especially the last year or more before the present trouble began.

She stated that nine months prior to admission the right ring-finger began to give pain in the second joint, and grew very tender, with pain on use extending to the shoulder. There was exquisite tenderness to touch, which followed the course of the ulnar nerve and of the median up to the shoulder, and which was made worse by any exertion. Nevertheless, it was not until quite recently that she gave up full use of her arm for some hours daily.

There was no pain on the ulnar side of the middle finger. The tenderness in the hand lay between the metacarpal bones of the middle and ring fingers. The second joint of the ring-finger was slightly swollen, slightly red, and excessively tender.

"An old scar, pale but well marked, crosses the dorsal aspect of the metacarpal spaces of the index and middle fingers in their distal third. It is said to be the result of an operation performed in London twenty-two years ago for the injury received from an accidental stab-wound in the hand. A part of the nerve is said to have been removed at that time. This may account for the partial lack of sensitiveness in the median distribution."

She was ordered a blister in front of the shoulder, and to carry the arm in a sling. Improvement resulted for a short time, when the hand began to be worse, and the hand itself was blistered repeatedly. After each blister there was some relief, but her condition continued so troublesome that she was admitted to the house on August 24th. The following notes were made at that time:

(*Abstract.*) "The patient is a small, slight woman, and very anæmic. The right hand appears to be more elongated and flattened out than the left. The nails are somewhat longer on its fingers, and although the patient said she had not noticed any difference in their rate of growth, it was observed in the hospital that the nails on the right (the affected) hand grew somewhat *faster*. The right forearm was slightly wasted. A splint was put on and the arm made immovable, and a very great improvement followed for two or three weeks, when the splint was removed. Blisters were used repeatedly for a month, and then the actual cautery was applied in the painful spots along the course of the ulnar nerve.

"Although these measures somewhat relieved the pain, no permanent bettering took place. The hand continued to present the glossy appearance so common from nerve-injuries, and always sweated excessively.

"On September 21st, the patient suffered from pain in the middle and ring fingers and in the nerves of the axilla. There was also pain in the right spinal gutter from the second to the sixth dorsal vertebra. The right scapula was observed to turn slightly outward, and there was some wasting of the muscles over its surface.

"The continued use of absolute splint-rest of the arm, and general measures for the improvement of the patient's health, having done but little good, dry cold was applied in December; but the ice-bags caused great pain, and could not be kept on more than about an hour. Their continuous use was promptly followed by a very severe attack of pain requiring hypodermics of morphia.

"The temperature of the arms as taken at this time was as follows: Surface temperature of the right forearm,

93⅗° F.; of left forearm, 94⅕° F. Two days later: Right forearm, 96°; left, 94°. By this time the whole arm had acquired a peculiar glazed appearance, and the slightest touch on the fingers caused a shooting pain running up the shoulder, not apparently following the course of any one nerve, but more severe upon the inner side of the arm. There was remarkable tenderness to slight pressure both above and below the right clavicle.

"After the ice-bag had failed, hot, wet compresses were tried, which gave instant relief. In spite of all these difficulties the patient was found in December to have gained thirteen pounds during her stay in the hospital. Late in the month of December the observation was made, contrary to the first note, that the nails of the right hand grew much more slowly than those of the left. At the same time it was found that touching the radial side of the middle finger caused pain to run up the arm and along the ulnar side—a somewhat unexpected result, possibly due to an unusual distribution of the nerves. A touch over the median nerve in the forearm caused pain up the inner side, and also downward to the ring and middle fingers. In January a general consultation was held, and the operation of nerve-stretching decided upon."

Operation, January 16, 1893, by Prof. W. W. Keen. Dr. Keen's line of incision was from the outer margin of the right sterno-cleido-mastoid, nearly to the end of the clavicle, parallel to and above that bone. Two large veins were exposed and tied, one at the posterior border of the sterno-cleido-mastoid muscle and one at the anterior border of the trapezius. The omo-hyoid muscle was pushed aside, and further dissection made in the small triangle thus exposed with the Allis dissector and with the fingers. The scalenus anticus muscle was thus brought into view, and the several nerve-cords found imbedded in fatty tissue. When this was carefully separated the subclavian artery was discovered and five nerves lying in close apposition slightly external and above it. One of these nerves divided into two smaller cords in the wound. A Horsley saddle-shaped stretcher was put under the

severed nerves, and traction was made on each one separately, beginning with the innermost. Dr. Keen endeavored, so far as the limited space exposed would allow, to apply the force from the circumference toward the spine, in order to avoid undue pulling at the nerves at their origin, and possible evil results to the cord. This was done by fixing the nerve upon the instrument by pressure with the thumb. As much force as seemed wise was applied and repeated three times with each trunk, until the nerve was distinctly drawn out in its sheath, so that when slackened each trunk formed a loop an inch long. While pulling at the two innermost nerves a slight twitch of the thumb toward flexion was observed. The force applied was sufficient to move the whole arm and hand slightly upward. Lastly, the whole plexus was lifted together and stretched in the same way, this time with a little centrifugal traction.

None of the trunks exposed presented any changes obvious to the eye or touch. There was no trouble with bleeding, only one or two small superficial arteries requiring ligation. A few strands of catgut were laid in as a drainage-tube, and the wound was washed out with bichloride and closed by sutures.

After the operation, in order to measure as nearly as might be the force applied, Dr. Keen used what he thought a similar pull, with his eyes closed and the hands in the same position, on a spring steelyard, registering just 14, 15, and 20 pounds on three separate trials.

January 18th. There is no pain on touching the hand or forearm, except that the lightest touch causes "prickling" throughout the arm. All the fingers can be moved a little in abduction; to do so gives the same prickling sensation in the whole arm. There is some vague "soreness" about the elbow, perhaps from the uncomfortable, immovable position of the bandaged arm, as well as from the nerve-stretching. The shoulder is still painful. She distinguishes a touch easily on any finger, and can separate two points at three-eighths of an inch on all fingers. At about one-fourth of an inch they appear to

merge into one. The wound has not yet been dressed or examined. She has no fever.

Ten days after the operation passive motion was begun. The arm was less painful, much less hyperæsthetic, and the patient generally a good deal more comfortable, although she said she had still pain from the elbow up to the shoulder. Sensation was good all over the arm, and the patient could distinguish two points one-eighth of an inch apart on the tips of all her right fingers. The pain which remained, although constant, was of a different character from the sharp, stabbing pain of the previous complaints, and was described as "throbbing" and "bursting."

The improvement was so slight that stretching of the ulnar nerve was decided upon, and accordingly, on February 4th, an incision was made over the ulnar nerve from the lower border of the pectoralis major down the inside of the arm four inches long, and carefully dissected until the nerve was reached. The large brachial vein was seen alongside the ulnar nerve, with the arteries on the inner side; the circumflex, median, and musculospiral were well seen behind and beside it.

The ulnar nerve was stretched with a Horsley hook attached to a steelyard so as to ascertain the exact amount of pull. Ten pounds were applied, the nerve being pulled out of the wound about two inches in a loop, just lifting the arm from the table.

The next day the patient had a tingling sensation in the little and middle fingers of the right hand. There was no pain on touching any of the fingers and no swelling. Sometimes in addition to this tingling there was a subjective sensation of cold running from the little and ring fingers up to the elbow and stopping there. Heat, cold, and touch were appreciated accurately and quickly.

By the end of April the pain was again growing troublesome and was unrelieved by any treatment, although the use of the actual cautery over the ulnar nerve at the elbow and over the circumflex nerve improved it somewhat, but so little that at the end of May another opera-

tion was attempted in the somewhat desperate hope that excision of a part of the ulnar might stop the process from extending further.

The incision was made in nearly the same situation as the previous operation; the ulnar nerve exposed, tested by the faradic current, and three and one-eighth inches of it removed. A like portion of the internal cutaneous nerve was resected. The ulnar nerve was found to come off unusually high, and this was the chief reason for excising it and the internal cutaneous nerve, rather than the internal cord.

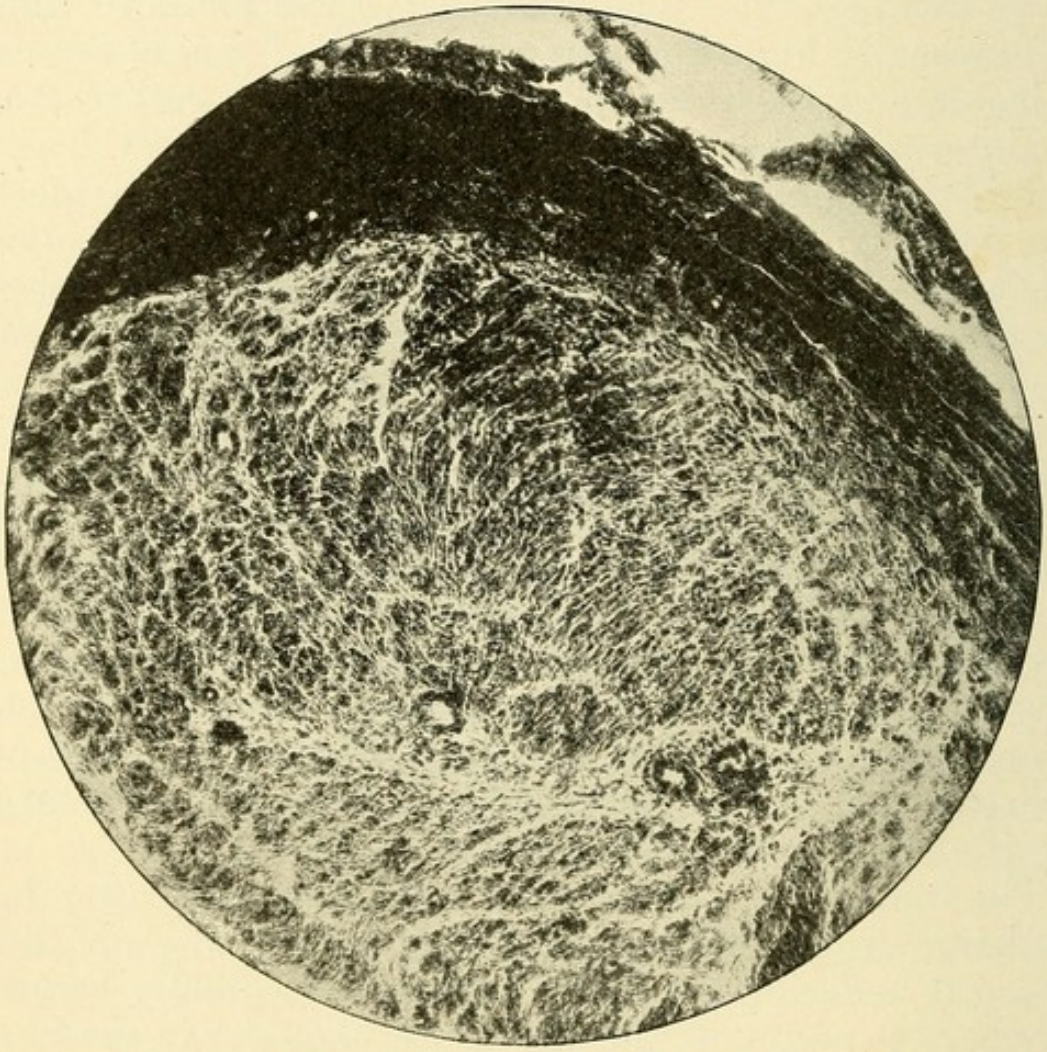
Two days after the operation a small area of anæsthesia was found on the palmar and dorsal surface of the ulnar side of the hand from the wrist to the little finger, and on the ulnar side of the ring-finger. There was no anæsthesia above this.

Considerable pain continued for several days, but the wound healed perfectly, the last stitches being removed on June 3d. At the end of June the patient was in about the same general condition, but had evidently suffered more pain since the operation than before, and daily injections of morphia had been necessary. In the last few days hypodermics of sodium sulphate were substituted for the morphia, with almost equally good effect, and on June 26th the patient went home with the intention of returning if the arm should become worse.

The woman for a time grew somewhat better after her discharge from the hospital, but in the spring of 1894 returned suffering as much as ever, and it finally became necessary to amputate the arm at the shoulder in the hope of relieving the pain. The condition at this time was most wretched; the chief site of pain was in the ulnar distribution; the axilla, the whole outer aspect of arm and forearm, especially about the olecranon and at the lower extremity of the ulna, were agonizingly sensitive and constantly painful. The rest of the arm was the seat of a constant, dull ache, and was hyperæsthetic in the highest degree. The limb was generally wasted as from disuse, an atrophy shared by the deltoid and supra- and infra-spinatus muscles.

The patient complained of pain in the arm and hand after the amputation, which was done through the shoulder-joint, saying she felt as if it had been roughly handled and rubbed. This was exactly what had happened, for the disinfection and preparation of the arm for operation

FIG. 7.



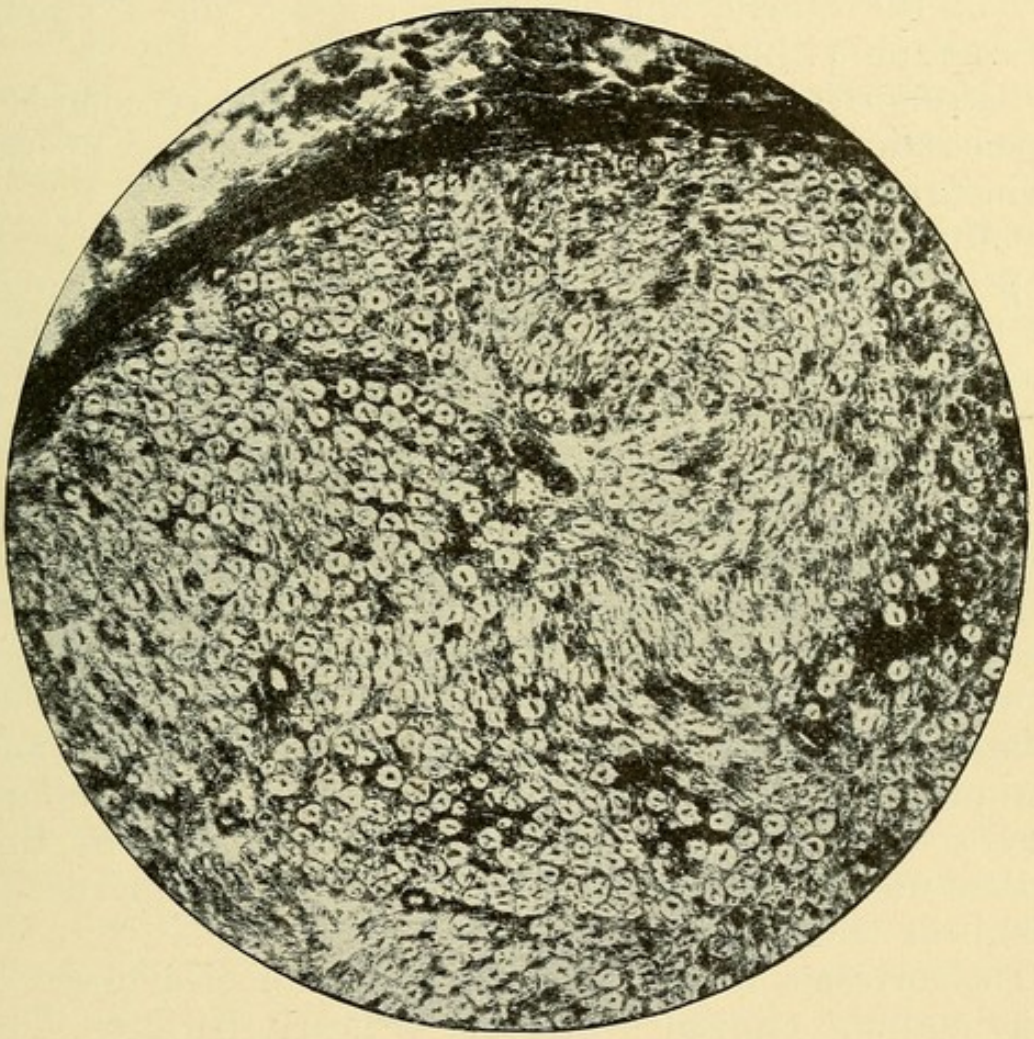
Mrs. A. J. Case XXXIX. Section from ulnar nerve at elbow. Complete degeneration of fibres: great increase of connective tissue. (From photo-micrograph by Dr. W M. GRAY.)

had to be done after anæsthetization, so great was the sensitiveness to touch.

All the muscular tissues of the arm were much wasted, especially the forearm and the ulnar muscles, though the subcutaneous fat was abundant. The digits were pointed, the nails curved and longitudinally and transversely

ridged, those of the little and index fingers most markedly. The ulnar nerve appeared unusually small. From the median nerve a small branch penetrated the middle of the brachialis anticus muscle; one inch and a quarter lower another larger trunk separated from the median.

FIG. 8.



Mrs. A. J. Case XXXIX. Section from musculo-spiral nerve: no increase of connective tissue: little degeneration of fibres. (From photomicrograph by Dr. W. M. GRAY.)

Specimens taken from various parts of the amputated limb were sent to the Surgeon-General's Office for examination. Dr. William M. Gray reported upon them as follows:

"*Ulnar nerve from lower forearm.* Palmar and dorsal branches show complete degeneration of fibres and a great

increase of the connective tissue of the perineurium and endoneurium.

"*Ulnar nerve at elbow.* Almost complete degeneration of the fibres and an enormous increase of the connective tissues of the perineurium and endoneurium; here and there may be seen a fibre which is not degenerated. This nerve at this locality is more profoundly changed than any of the others, and has been selected for a photomicrographic illustration.

"*Median nerve, upper third.* Shows almost complete degeneration of the fibres and no thickening of the perineurium.

"*Musculo-spiral nerve.* Practically normal; no increase of perineurium and very slight, if any, degeneration of the fibres. A photomicrograph of this section is selected to contrast with the one made from the ulnar nerve.

"*Radial nerve.* Slight degenerative change, although the fibres have not disappeared as in the ulnar.

"*Internal and lesser cutaneous nerves.* Almost complete degeneration of fibres, but no increase of perineurium."

The specimens were several weeks in Müller's fluid, then stained in mass in sodium carminate, and imbedded. One-half of the sections after cutting were soaked in potassium bichromate solution for twenty-four hours, and then put through the ordinary Weigert stain for medullary nerves. The fact that the fibres failed to stain by this process was due to their degenerated condition and not to a fault of technique.

The correspondence between these pathological observations and the clinical symptoms is nearly perfect. The lessened change in the nerve-trunks from the parts nearer the body is notable. The most complete alterations were in the nerves of the forearm, while the internal and lesser cutaneous were affected to a far slighter degree, and the musculo-spiral scarcely at all.

Remarks. The spontaneous occurrence of acute neuritis in patients whose history contains nothing to cause a suspicion of alcoholic excess, of syphilitic infection, or of rheumatism, is of very great rarity.

In the case of Mrs. J. there was found, as stated in the notes, an old scar upon the median side of the hand, which was said to have been the mark of an operation done twenty-two years previously for a wound of the hand. The woman was sure that a portion of nerve had been removed at that time. But the disease for which she had applied at the Infirmary had begun upon the other side of the hand, affecting first the ring-finger and extending from it up the arm. The march of the neuritis was checked but little by various plans of treatment, and although the somewhat desperate resort of surgical interference was tried, first, by stretching the brachial plexus, then the ulnar nerve, then by performing neurectomy upon the latter trunk, and finally by amputating the whole arm, nothing except the last availed to stop the progress of the inflammation, which at the date of the patient's first discharge from the Infirmary had already affected the spinal cord, at least this may be inferred from the tenderness of the nerve-roots upon the affected side of the spine. A sclerosis, or more likely a myelitis, will probably follow the further affection of the cord. But in this, as in every case of long-continued nerve-inflammation, an element of hysteria is to be reckoned with, and some allowance must be made for this factor, both in the acceptance of the description of pain and in the prognosis.

A question is suggested by such rapid returns of functional power in a nerve as took place after the resection in this instance. After such surgical operations as neurotomy and neurectomy we sometimes see a restoration of irritability and conductivity far too prompt to have been the result of an ordinary regenerative process. Has an inflamed nerve a power of more rapid repair? Is it, perhaps, even helped by the unusual amount of its blood-supply to quicker recovery? A less fantastic but still unsatisfactory explanation of the swift reappearance of the sensibility is that the communicating nerves, other than the operated one, are, from the inflammatory irritation, in a state of exalted excitability—hyperæsthetic, in fact—so that a false idea of their activity is given. Such a condi-

tion would be paralled to the over-sensibility in nerves arising below a transverse myelitis in the cord.[1]

CASE XL. *Wound of left ulnar nerve; atrophy of forearm; lasting pain; sweating of little finger; ascending neuritis affecting spine and finally involving right arm.* (From Pension Office Reports.)—N. N., Co. A, 134th New York.

A description of the wound received in service appears in the certificate of disability upon which N. N. was discharged, January 14, 1863. It is as follows:

"Incapable of performing the duties of a soldier because of the accidental discharge of a rifle, the ball entering the palm of the left hand, passing through the wrist-joint, running nearly parallel with the ulnar, and making its exit near the inner condyle of the humerus, rendering the arm at present nearly useless." Similar statements were made on subsequent examinations by Dr. John S. Delavan, July, 1863, and others.

"In 1873 Dr. D. W. Hazelton reported that adhesion had taken place between the tendons and their sheaths, so that flexion of the fingers was very imperfect and the grasping of objects very difficult."

A certificate of examination by the Board of Surgeons, Boston, Mass., dated December 17, 1884, says: "All motion of hand and forearm is so weak that they are of no use for work. The parts are atrophied and the ulnar nerve the seat of neuralgia from involvement in cicatrix. Claimant states to Board: "Hand is not only of no use, but he has to nurse it constantly with the other. The little finger sweats so that he is obliged to keep a handkerchief about it. Suffers the most exquisite pain."

Certificate of examination by Board of Surgeons at Cleveland, Ohio, dated March 14, 1888: "Ulnar was not fractured. Motion of all joints of left arm are normal, but very much weakened in power. Has no use of hand in feeding himself. Gait unsteady. Cannot walk without pain. Patellar tendon reflexes absent. Ankle-clonus absent. No

[1] At the last report (November, 1894) this patient was much better, the pain having steadily lessened since the amputation.

tender points of spine. General intelligence impaired. In our opinion the left ulnar nerve was injured by the course of the ball."

Certificate of examination by Board of Surgeons at Elyria, Ohio, dated October 17, 1888 : " The left forearm and fingers and thumb lie lifelessly by his side. Can do nothing with them. The wrist, elbow and shoulder-joint are partially ankylosed from disuse. Spine tender in its whole length. Right upper limb partially paralyzed. No use of left lower limb. Left facial paralysis. Left arm about one inch less in circumference than the right. Has locomotor ataxia. Deep reflexes deficient. Knee-jerk absent and no ankle-clonus. When standing with eyes closed immediately falls to the left. It is our opinion that the whole disability of claimant originates from the wound destroying the ulnar nerve extending to brachial plexus and spinal nerves, producing locomotor ataxia. He is a physical wreck, incapable of even dressing or undressing, or fastening a button with either hand."

Applicant was examined by the Fifth Street Board of Surgeons, Washington, March 21, 1890. In certificate the Board says : " There is contraction of flexor muscles of the forearm, flexing hand upon wrist, and of flexors of arm flexing the forearm at nearly right-angle to humerus. Muscular atrophy of entire left arm. Atrophy of muscles of left shoulder, with tendency to angel-wing deformity. We find locomotor ataxia well marked—whether or not from the gunshot-wound we are unable to say."

The examination in 1890 is thus reported : " The limb is cool and partially anæsthetic. The upper extremity is useless and hangs like a log at his side. He says that 'it feels like a ton of coal.' There is a like condition beginning in right arm. It is anæsthetic, but he has good motion of the joints and makes good use of the arm. When walking without his crutch he leans to the left, and turns in that direction when walking whether with eyes opened or closed. There is no more staggering with eyes closed than with them open. There is anæsthesia of skin of back and chest The spine is straight, and there is no tenderness on

pressure. The reflexes are normal in both patellar tendons, and sensation and motion are normal. There is no hemiatrophy of the face or drawing of the mouth. No facial paralysis. The case is manifestly obscure, but the man is just as manifestly disabled. As to the diagnosis, we can better tell what it is not than what it is. First, it is not locomotor ataxia. There is no pain in the head or spine, no lightning or girdle pains are complained of. The reflexes are normal—exaggerated, if anything. The gait is not ataxic. The heel is not brought down first, but the foot is brought down naturally. The walk is rather a reel or roll, and his movements are rather those necessary to preserve equilibrium. He is merely unsteady in his walk, and the volitional control is in marked contrast to the lack of control displayed in ataxia. Second, it is not hemiplegia. There is no facial paralysis. No difficulty in speech or deglutition. No loss of control over rectum or bladder, and the movements and power of one leg are as good as those of the other. There is no ptosis or drawing of the mouth, and the tongue comes out straight. Third, it is not paraplegia, as when sitting he has full control of lower limbs, and functions of bladder and rectum are normal. Fourth, the clearness of mental processes, the absence of pain, of affections of tongue or speech and of swelling exclude cerebral tumor. If we were to express our opinion of the case, it would be as follows: Ascending neuritis, beginning in left ulnar nerve and ascending the spinal cord, and now affecting the cerebellum, with sympathetic affection of the right arm. The diagnosis of cerebellar disease is made upon the peculiar unsteadiness of the movements, which is, in this case, almost typical. Whatever the disease may be, the man is seriously affected now, and the prognosis is grave."

On May 12th, the following was added to this certificate: "A short time after the Board had adjourned one of its members saw the claimant on F Street. The man was walking by the aid of a crutch under the right arm. His gait was very unsteady and he had the same tendency to turn to the left. When he had walked ten or twelve steps he would be so far to the left that he would have to stop and

turn squarely to the right in order to get into his course again. Claimant was, of course unaware that he was being watched. His head was drooped to the left and his left arm hung limp."

Remarks. It is difficult to comment on this most remarkable case. The patient was examined at different times by a large number of competent physicians, and radical differences of opinion as to his condition existed. Several surgeons of Boards of Examiners other than those quoted studied his symptoms, and while some of the earlier examiners were certain he had locomotor ataxia, the later reports do not bear this out. It seems pretty clear that there was ascending neuritis finally attacking the cord, and cases of this form are exceedingly rare. It is to be noted that syphilis is nowhere excluded, or even mentioned, but if it were included the history would not be different.

Cases of general neuritis, toxic or other, not due to trauma, sometimes present this phenomenon of an ascent, usually of the slowest progress, lasting ten or twelve years before attacking the cord, appearing or disappearing in the territories of certain nerves, and always, as here, with much myositis. Finally, there are wasting, high temperature, and death after great suffering. In the cases of ascending traumatic neuritis the centres are usually affected before the end of the disease. Its course is slow, years elapsing before the cord is affected, and fever is never present.

CASE XLI. *Gunshot-wound causing compound fracture of tibia; gangrene; extensive adhesions; weakness of leg and pain on using it; late paralysis of injured leg and subsequent paralysis of other side and of sphincters; possible ascending neuritis.* (From Pension Office Reports.)—W. H. L., Jr., Company L, 19th Maine Volunteers, was discharged from the service in April, 1865, because of permanent contraction and adhesion to the flexor muscles of the left foot from gunshot-wound, fracturing the tibia.

He was first examined August 30, 1865, when it was

stated that he had received a compound fracture of the left tibia which had not healed, and that pieces of bone were continually working out.

He was again examined June 2, 1871, when it was stated that the wound had become gangrenous while in hospital, causing adhesions of the soft parts as recovery took place, and on account of these adhesions the use of the limb causes some pain, followed by numbness, which lasts a considerable time after the limb is at rest. New bone did not form sufficiently to supply the loss, which results in a feeling of weakness and want of firmness in walking. His habits are good.

In 1873 the examining surgeon found a large adherent callous cicatrix on middle third and front of tibia. Probably necrosis of the bone exists, as there is sometimes an open ulcer on the scar. After labor his left leg becomes painful.

He was again examined in 1875, when it was found that the wound had entirely healed and that the bone had been well filled in and consolidated.

It appears from the further evidence filed in the case that about November, 1883, paralysis began in the foot of the wounded limb and extended up the leg and thigh to the lumbar region; that in a short time thereafter the other leg became affected so that complete paralysis was established, which has continued up to the present time. There was paralysis also of the sphincters of bladder and rectum. There is no evidence of syphilitic affection. There is no cerebral lesion; no spinal lesion to be detected; no curvature, caries, necrosis, or even tenderness.

Remarks. This case, from the records of the Pension Office, needs further details before a satisfactory conclusion can be reached. It is possible that an ascending neuritis occurred from pressure upon the nerves in the extensive scar-tissue, but there is a lack of evidence for it. The statement that there was "no spinal lesion to be detected" probably was intended to mean that there was no spinal caries. A lesion of the cord there must have been, but in the absence of all examination into the states

of sensation, electrical contractility, and the reflexes, it is mere guesswork to say what this lesion was, and this report is included with some other imperfect ones, because taken together they may help to indicate something about the way in which we should look for ascending neuritis.

CASE XLII. *Fracture of the fibula, no sign of nerve-injury; increasing lameness, final paralysis, first of injured leg and later of other leg; involvement of spine; sphincter ani paralyzed; arms weakened; possible ascending neuritis.* (From Pension Office Reports.)—R. P., Company A, 96th Illinois Infantry. This man was injured in November, 1863, while in the service, by a tree falling on his right leg, which fractured the fibula in two places. He was examined in 1866, 1873, and in 1875. At the last date he weighed 150 pounds; normal pulse and respiration. It was stated that after the fracture, the bone not being properly kept in place, "a protuberance in instep which caused lameness" was left. There was considerable swelling of ankle-joint.

He was again examined in 1884; weight, 147 pounds; normal pulse and respiration. The surgeon stated that he found the soldier had sustained a fracture of right fibula near ankle-joint and probably partial dislocation at the same time. The joint was somewhat enlarged and foot everted; it measured one inch more over instep of right than left foot, and the man walked quite lame. Movements of joint imperfect, with some contraction of tendons. The disability was increasing; could not stand or use leg as well as formerly; was confined to his room for six weeks in 1883 from reasonable use of this leg.

He was examined in 1885, when he complained that the disability of the leg had increased; that he was unable to walk more than half a mile a day; that very little standing or walking occasioned aching and distress of injured limb, so that he could not sleep. Ankle of right leg measures one-half inch more than left. Calf is one inch less. Muscles soft and flabby. Walks quite lame,

and is obliged to use cane. General health and appearance fair.

In 1887 he was worse than at the last examination. Leg was weaker and exertion caused more pain and distress at night. Leg cold much of the time, and quite numb after exercise. Joint somewhat enlarged, foot everted and motion much impaired. Flexion and extension very limited. Very little sensation in foot, and circulation imperfect. Considerable atrophy of muscles below knee. Walked very lame and dragged his foot. The man stated that he could not lift foot in going up stairs, but was obliged to crawl. In standing did not use right foot, but rested wholly upon left. Every step caused pain from foot to hip-joint, seemingly in the muscles.

He was again examined in 1888. Surgeon states that physical examination does not reveal any lesion of heart or lungs, nor any disease of spinal cord; right ankle-joint enlarged and ankylosed, and entire limb paralyzed from hip-joint; he is not able to walk or to move limb; has total loss of sensation from foot of right side to the hip-joint; middle of right thigh measures 16½ inches around; left, 17½; right ankle-joint measures 13½ inches; left, 10 inches.

He was examined in November, 1890, when the examining surgeon stated that there was paralysis of *both* legs, partial paralysis of left arm and partial paralysis of bowels; complete paralysis of sphincter ani. The brain seems to be normal, and also all parts of the body supplied from cranial nerves. The surgeon believed "that the origin of the paralysis lay in the fracture of the right leg, causing degeneration of nervous tissue resulting in peripheral paralysis, which has steadily progressed up to the present time, until now he is absolutely helpless, and requires a constant attendant to assist him in dressing, undressing, eating, attending calls of nature, etc."

Remarks. This case, from the records of the Pension Office, is insufficiently reported, and no details as to sensibility, nail-growth, pain, reflexes, etc., are given.

The gradual changes noted between the several examinations look like progressive ascending neuritis from an injury to a nerve, but nothing in the original statement of the case indicates this. Finally, there must have been grave spinal alterations.

This case illustrates the difficulties made by time and insufficient early examinations. It is included here with some doubt as to its value. The want of care to exclude syphilis as a factor is fatally seen in many of these pension cases. Despite the man's belief and statements, it is not possible with certainty to relate the loss of power to the original injury.

CASE XLIII. *Traumatic neuritis of ulnar from stab-wound; neurotic œdema; ulcerative dermatitis; descending neuritis; operation and relief; return of trouble from cicatrix-pressure; second operation and relief; return of pain and modified form of disease.*—Miss L. S. F., aged twenty-one years, single; patient of Dr. William Browning, of Brooklyn. The patient's previous health had been unusually good, except for a serious case of pertussis in the summer of 1889, and a displacement of the left ovary, which was successfully treated by replacement. She was perfectly well at the time of the accident.

On November 17, 1890, while stepping from a stair with the right arm bent at a right-angle and lifted shoulder-high, she brought the arm heavily on to the fine tip of an oil-can used to feed a sewing-machine. It entered the outer side of the arm about one inch below elbow. The pain was sharp, as if the "crazy bone" had been struck. The tip entering deeply must have transfixed the ulnar nerve. She re-entered the house from the yard where this happened, and found then the tip still in the arm. A smart pull was needed to draw it out. There was no paralysis, but ache in the ulnar territory; nevertheless she crocheted and swept rooms for two days, but spared the fourth and fifth fingers, since to use them gave pain.

On the third day she consulted Dr. McNaughton. The little wound was open and was kept open six weeks,

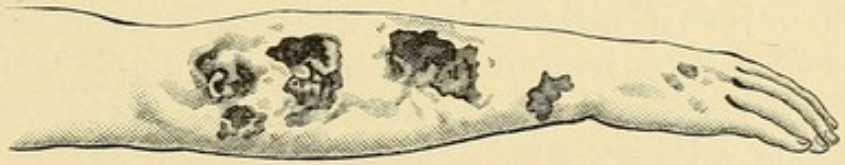
poultices being used. Meanwhile the pain increased and the elbow region and half-way to the wrist swelled enormously—a false phlegmon, so common in nerve-injuries and so sure to deceive even the best surgeons. In two weeks it was opened, but no pus escaped; and then, the wound closing, the anguish along the nerve-track and to the fourth and fifth finger-ends became excessive, but was borne without opiates. The fourth digit suffered most, but the hand seemed to ache also beyond the ulnar territory. The anæsthesia as to touch and pressure was complete in the ulnar region below the wound; and still touch and pressure caused pain referred to the seat of wound. Elsewhere in the hand, perhaps from general swelling and disturbed nutrition, touch was imperfect. Heat and cold were imperfectly felt as such, but cold caused pain. Heat was agreeable, but, as in other cases, a comparatively low heat would scald in the ulnar region, as it did not on the median side or on the other hand. The arm was held semi-flexed and guarded with sedulous care from contacts

About January 1, 1891, there broke out, first around the wound, and then below it, fiery red patches, varying in size from a pin-head to two or three inches in irregular diameter. At first these were only in the ulnar regions; after some months they extended on the back of the hand into the median territory, and much later (and this is of great interest) were found in other localities; one, a large patch, inside and above knee. At first the wrist and dorsum of hand alone suffered. Each outbreak was signalled by precedent increase of pain, a not very rare sequence in these cases. The red areas were sensitive. In a few days they grew darker and began to show points of superficial ulceration, which in some instances was deeper about the centre.

Miss F. says the red patches were apt to be covered with blisters (bullæ), which breaking left a spot of raw or ulcerated skin. Some of these ulcers were one-quarter of an inch in depth. For the first three months no water could be used on the arm, since every touch was torment.

During this time, and later, while things were at their worst, the hair of the arm became lighter in tint than on the sound arm. On neither arm was there much hair in health. At the period mentioned, and in a less degree of late, there has been an abnormal increase in the amount and length of the hair on the diseased arm. The growth was so abundant as to darken the whole ulnar territory down on to the fingers, and to this nerve-distribution it was strictly limited. The hair was in places one-third of an inch long or more. This growth was thickest around the patches of ulcerated skin. Even now, close around the edges of the sole remaining ragged area of dermatitis dotted with ulcers, the long hairs are seen like miniature reeds about a boggy marsh. When at last able to wash, the hair came out with the least friction; so that, save as above stated, there is no more hair on the right arm than on the left. Miss F. insists that all this while, indeed for six months, the nails did not grow either in median or ulnar distributions. All the ulcers except that mentioned were healed in May, 1891, and a week after Miss F. was seen here the only remaining open ulcer also closed. The remotest ulcer was seen October, 1891, above the right knee. There was redness, bullæ formed, and an ulcer resulted about one inch in diameter. Near by were several spots in which there was redness only. Faint brown stains still indicate the seat of all these lesions; occasionally they become darker and threaten to inflame anew. Dr. Browning writes that later (May 17, 1892) an ulcer appeared at the lower end of the operation-scar.

FIG. 9.



L. S. F. Case XLIII. Ulcers of forearm from stab-wound of ulnar nerve.

From the second week until now the muscles have twitched at times, causing frequent and severe pain. She

insists with much emphasis on the peculiar fact that objects clasped by the thumb and second and third fingers of the diseased hand convey to her the sensation of being smaller than when held in the left hand. The illustration, from a small photograph by Dr. Slee (see Fig. 9), represents the ulcers about the second month.

Drs. Browning and McNaughton and the patient all agree that there never was glossy or atrophied skin, distorted nails or ulcers of the matrix, nor was there a sign of joint-lesion.

The skin was, as stated, only sensitive in a peculiar way, with pain-reference centred in the wound, but the muscles were all sensitive to pressure.

The general health suffered little. She constantly refused all opiates. Her appetite and digestion were not much impaired, and, with all other functions healthy, menstruation continued regular and painless.

July 22, 1891. Dr. McNaughton cut down on the nerve at the seat of injury, and found a bridle of tough fibrous tissue crossing the nerve and visibly constricting it. This was divided and the nerve released. The œdema at once grew less, the ulcers began to heal, and for a few weeks lessening pain promised entire ease. Unfortunately, as is so apt to be the case in nerve-injuries subjected to operative procedure, the wound did not heal well, so that suppurative union left a contracting scar over the original site of hurt. As it healed all the old troubles became worse, and the patient insisted on a second operation, which was done October 10, 1891. No new trouble was found at the seat of wound; but to protect the nerve from cicatricial pressure the tissues about it were freed, and two halves of a decalcified chicken-bone placed around the nerve. The wound healed by primary union. A second and remarkable gain has been followed by a second less serious relapse.

Such was the history of the case up to April, 1892, when she was sent by Dr. Browning to consult Dr. Weir Mitchell. I had the opportunity of seeing her with Dr. Mitchell, and the notes of her condition were made at that time.

After the examination was completed, Dr. de Schweinitz made a study of the eye-grounds and the form and color-fields, with especial reference to the changes sometimes found in sequence and appreciation of color in hysterical patients, but reported both perception and color-fields normal, except that the lines of blue and red ran very close together, and sometimes were even coincident.

Dr. Mitchell's advice was to give the nerve the most complete rest possible by bandaging the whole arm and putting it on an internal angular splint from axilla to finger-tips, permitting no motion, day or night, except passive movements of the joints once daily; if this, continued for a month, brought no marked gain, then to operate, excising a portion of the nerve or simply cutting it, as might at the time seem best.

The patient did not greatly improve.

In June an eruption of the same character as those which had appeared on the arm broke out on the abdomen, to the right of the umbilicus. This patch, about three inches across, was very painful and healed slowly. Cultures, at the suggestion of Dr. Mitchell, were made from this and from the patches on the arm, by Dr. Slee, of the Hoagland Laboratory, but no peculiar organisms were found other than the usual pus cocci.

On June 25th Dr. McNaughton operated again, dividing the ulnar nerve two inches above the elbow. The nerve, which was thought on exposure to be rather too white, but presented no other marked alteration, was simply divided. The two ends were approximated and left in relation, without suturing.

At first there was a good deal of pain in the wound above the elbow, while the pain disappeared from the former spot lower down. This soon lessened and the wound healed well. There was, however, some twitching at the upper part of the wound, due to irritation of some fibres of the triceps muscle. As is common in such cases the nerve-track just above the incision was tender. The ulcers healed quickly, and there was relative ease of the whole arm for four months after the section. Unfortun-

ately, no very full study of sensation was made after the operation, but it is certain that all sensation was lost in the ulnar distribution, and all motion of the muscles ordinarily supplied by it. Motion was at once better in the median muscles after the division of the nerve. Whatever pain remained was, of course, referred to the ulnar area, and the fact that there was more or less suffering indicated that the nerve above the seat of the wound made by operation was still affected

For several months there has been occasional pain in the left forearm in the ulnar distribution. This is brought on quite promptly by the use of the left hand in writing, and she is soon obliged to give up the task. Of late there has been some occipital ache, especially if she is tired. She is also more nervous than she used to be, and more irritable.

Since October 1, 1892, it has been manifest that there has been complete reunion of the nerve-ends. So good a restoration so soon (three months) is rare in the history of nerve-wounds, especially when no suture is applied. It is probable that it would have been wiser to exsect a portion of the nerve, and thus have prolonged the time for repair. Since October, also, there has been increased pain in the right arm, and numerous bullæ with sequent ulcers have formed in the region of the hand, not only in the ulnar, but also to a certain extent in the median territory. There is red serum in the bullæ, which either dry up or, when opened, leave ulcers. These ulcers are not confined to the ulnar areas ; as before there are several small groups in the median region. There is no increase in the growth of hair surrounding them.

She was again carefully examined by Dr. Weir Mitchell, assisted by Dr. Browning, her attendant, December 17, 1892, when the above notes were taken. At this time it was quite clear that the ulnar movements had been regained with such perfectness as is unusual in these cases. She abducted, closed, and opened all the ulnar digits, and abduction of the thumb was stronger than just after the operation. Now, the movements are again somewhat

limited by the amount of pain they cause. She refers nearly all sensations perfectly, but the compass-points trouble her, and represent both touch and a sensation close to pain. There is now more pain in the ulnar region of the arm along the tract of the nerve than in the hand, and over the elbow region and forearm touch gives rise to a most unpleasant prickly sensation. She insists that since the operation there has been absence of all growth of the fourth and fifth nails; all the others grow as usual, and they appear to show evidence of the truth of this statement.

Her general condition is certainly much better since the operation. The soreness and pain in the arm, shoulder, and on the line of the brachial plexus have almost passed away.

It was agreed to give her cod-liver oil and iron, and to have gentle massage with oil of the hand and arm; also, if there were no great gain in the course of a month, then the nerve should be again divided, and an exsection of a large portion made.

Remarks. Evidently this was a neuritis with a tendency to ascend. Whether it is possible to refer the pain in the left arm to a direct transmission of organic trouble seems more than doubtful. Probably it is one of the numerous hysterical complications which arise to obscure such cases and to increase the difficulty of treatment. There is constant presence of pain in one arm. To write with the left hand proves wearisome, and the hysterical mind soon suggests and realizes left-sided states like those on the right. The decision for a second operation would rest upon the fact of a still constantly shown tendency of the neuritis to ascend.

CHAPTER V.

MISCELLANEOUS CASES—WOUND OF THE SYMPATHETIC NERVE—SPASMODIC AFFECTIONS OF AMPUTATION-STUMPS, ETC.

THERE is grouped together here for reference a collection of somewhat miscellaneous cases, to a few of which allusion has already been made in previous chapters. The others illustrate points to be hereafter discussed.

Several may be classed as medical curiosities merely, and are sufficiently commented upon in the remarks attached to each. Such are the possible wound of the sympathetic nerve (XLVI.), the extraordinary series of injuries to the brachial plexus in Mr. K.'s case (XLIV.), and XLV., which is interesting from the fact that a wound so severe and with such exhausting and torturing sequelæ was compatible with continued existence for so many years.

Besides these, a very interesting group of instances of spasmodic movement in the stumps of amputated limbs is found in XLVII., XLVIII. and XLIX. In Dr. Weir Mitchell's comments on Col. P.'s case (XLVII.) as reported in the *Sanitary Commission Memoir* and in *Injuries of Nerves*, the movements are called choreoid, for want, as is there said, of a better name. But in both the two new cases which are here added the movement was much more regular and constant than that seen in chorea—clonic, in fact. Like the spasmodic movements of that disease, the twitchings are made worse by emotion or attention; but,

unlike them, they are controlled by any attempt at co-ordinate voluntary movement, though they cannot be held in check by volition merely. It is remarkable, too, that the affection of the nerve-centres is so deep that tremor continues even in sleep. It is somewhat less active then; perhaps if the patient were closely watched it might be found that it ceased entirely during the hours of deepest slumber. In all of them the trembling ceased, momentarily at least, when the attention was diverted from it.

The question of the existence of spreading neuritis is discussed in the individual cases; but, although it is clear that a spinal affection existed in XLVIII. and XLIX., it is by no means clearly shown that there was an ascending sclerotic change. Some signs of it appear more evidently in the former; others in the latter. In XLIX., while the patella-reflex was exaggerated upon both sides there was no ankle-clonus; ankle-clonus was slight in XLVIII., also with exaggeration of the knee-jerk. XLIX. had the very serious symptoms of objective vertigo and of slight motor difficulty and hesitation in speech, but no other brain symptoms of sufficient importance to justify the supposition that the cerebrum was affected by the sclerotic process.

The starting-point of the tremor in XLVIII. obviously lay in the cut end of the nerve in the thumb-stump; in XLIX. in an irritation of the nerves from the suppurative and inflammatory processes which recurred in his wound; in XLVII. the cause is more obscure; but several instances of like disease have been observed, usually, as in the cases of Langstaff and Charcot, accompanied with neuralgic (neuritic?) pains.

Many sufferers from various forms of spasmodic movements, some painful, some painless, were observed in the

U. S. A. Hospital, but I have not succeeded in tracing the subsequent history of any of the other men.

Case XLIV. *Violent stretching of brachial plexus; contusion by sub-luxation of humerus; rupture of axillary artery; ligation of cord of brachial plexus in mistake for vessel; complete paralysis of motion and sensation from clavicle downward; undue effect of moderate heat; improvement.*—G. W. K., aged nineteen years, was in good health until April 20, 1889, when a horse fell with him and threw him violently. He struck upon his back and left side, falling with the left arm extended so that it was forced upward, stretching and straining the axillary space, and bruising severely the whole inner aspect of the upper arm and the side of the chest. He rose immediately, and while a companion was helping to remove his coat felt a slip and heard something snap in the shoulder. He pluckily remounted, though there was not a trace of power or sensibility in the arm, and rode three miles home. There was instant numbness from the top of the left shoulder to the extremities of the fingers, but no severe pain. There was still sensibility over the deltoid, but it was lost everywhere below this.

The pain grew intense in two or three hours after the accident. The shoulder and back were swollen, and soon became deeply discolored, but the skin was not broken. The arm was freely movable in its socket. A hard round swelling as large as an egg was noticed in the axilla immediately after the injury, and on the second day this had increased and become so hard as to suggest a sub-glenoid dislocation. An attempt to reduce this was made, but it does not appear that much force was applied, though traction with a heel in the axilla was used. The patient states this was done without any violent effort.

In the following weeks the general swelling gradually lessened, but the axillary tumor increased; nor was there the faintest return of motion or sensation, while the pain was so great that large doses of morphia and chloral were constantly required.

At the end of three weeks the axillary tumor was opened by a superficial incision an inch outside of the line of the axillary artery. No pus was found, but a mass of blood-clots as far as the finger could reach. There was constant slight oozing from this wound, but nothing further was attempted until a sudden, violent, and profuse hemorrhage occurred two days later. It is said that a quart of blood was lost. The flow was temporarily stopped by digital compression, and later by a compress and fixation of the arm. The next day, May 15, 1889, it was decided to tie the subclavian artery, as it was evident that the axillary artery had been ruptured, and might at any moment bleed again. When this was done it was thought that the axillary vessel could be exposed with safety, the space thoroughly explored, and a ligature applied at the seat of the injury.

The operation was a long and trying one, and made worse by the patient's feebleness from the previous hemorrhages. For the same reason the operator, Dr. E. S. Garner, found the discovery of the sought-for vessel most difficult, as the pulsation of the arteries was so feeble as to be of no service as a guide to their situation and identification. A structure was presently found and tied, with the approval of the physicians present, but in a few minutes a renewed gush of blood took place. Dr. Garner thinks that what was thus tied was a cord of the brachial plexus. On further search the artery was found pursuing an anomalous course, and was tied successfully after two attempts at ligation had failed from the breaking of the ligatures. By this time the patient's condition was alarming, and in the hurry of attending to it the first ligature was forgotten and left where it had been placed. The patient was under the anæsthetic more than three hours. Immediately upon the return of consciousness sensation was found to be lost over the deltoid muscle, where formerly it had persisted. In other ways there appears to have been no change in the nervous and nutritive phenomena after the operation.

The patient consulted Dr. Weir Mitchell November 16,

1889, and was carefully studied at the Infirmary for Nervous Diseases at many different times in the ensuing four months by the assistants in the clinic, Dr. Guy Hinsdale, Dr. F. P. Willets, Professor J. McK. Cattell, and myself, and from the notes taken during this period the following history is compiled:

November 16, 1889. General health excellent, ruddy color and well nourished.

Nutrition. There is considerable wasting of the shoulder-girdle muscles and of the whole upper extremity, the hand included. The nails are transversely ridged, and grow more slowly than on the right. It is said their growth was entirely arrested for three months. There has never been any shining, varnished appearance of the skin of the hand or arm, nor any puffiness. There are partial ankylosis and grating in all the joints, an arthritis partly from the nerve-injury, partly from disuse, though some of the lack of motion is due to contracted muscles. When chilled or when long dependent the arm and hand become cold and blue.

Measurements. Biceps, right, 9.75 inches; left, 9; forearm, right, 9.75; left, 7.75.

Sensibility. Some touch-sense remains on the inner side of the arm down to five inches above the internal condyle, but on the outer aspect it ceases just below the acromion. Pain is not now a troublesome symptom. There is pain in the hand at times, and when the forearm is strongly grasped he can just feel it. The upper part of the arm is slightly sensible of pain when firmly grasped, but the pain is not distinctly localized.

Electric examination. Galvanism (15 milliampères) produces no result in the hand-muscles or in the extensors of the hand. The same current induces a slight response in the anterior forearm muscles. KCC and ACC apparently equal. Faint action to galvanism in biceps, triceps, deltoid, and spinati muscles.

No response to faradism. The pectoral muscles react normally.

The general temperature of the paralyzed arm is usually below that of the sound side.

Knee-jerk normal, both sides.

Station normal.

The patient was ordered galvanism from the shoulder through the arm and hand, interrupted faradic currents to the paralyzed muscles, and daily massage.

Frequent examinations of the case were made and a constant watch kept on the condition of the affected muscles.

The arm, in three or four weeks, began to show signs of slightly improved nutrition and to appear less like a mere vegetable growth. The nails had become a little more pink, the muscles a shade plumper and less flabby, when the treatment was interrupted by what seemed at the moment an unfortunate accident, but which resulted not unfavorably, and, perhaps, had some good effect.

Up to this time no careful study had been made of the perception of heat and cold. The hand was tested for heat-sense by dipping it in hot water. Much to the dismay of the patient and to the chagrin of the physicians who were present, water which was not hot enough to injure the patient's right hand or to hurt the hand which Dr. Mitchell immersed in it, instantly scalded the paralyzed hand of Mr. K.

The epidermis at once showed the characteristic appearance of a scald, becoming white, loosening from the derm and shrivelling. There was a sense, both objective and subjective, of added heat in the part. The scald occurred at 1.30 P.M. At 1.35 P.M. cosmoline was applied. Temperature under the tongue, 99.8° F. At 1.46 P.M. pain began.

Surface temperature: dorsum of right hand, 95.2°; dorsum of left hand, 95.2°. At 2.10 mouth temperature was 99.4°.

Large blebs were forming, three inches long on the third finger, and two inches on the mid-finger. Color, pink in finger. Little pain present at 2.15 P.M. Serum ran freely for several days, not less than a pint in all draining from the blisters, which rose in a few hours, and in a day or two covered the whole of the hand and fingers.

On the day following the accident the surface temperature of the hand was 95° ; that of the body, 99.1°. The progress was slow at first, but after a week the skin healed more rapidly.

On December 20th (thirteenth day) surface temperature of the hand at 2 P.M. was 98.8°. December 21st, 98.8° at 10 A.M., and the same in the P.M. December 27th (twentieth day), 98.2° at 2 P.M. By this date the skin had entirely re-formed and the dressings were discontinued.

December 21*st.* There is still evident a condition of myositis which renders the deeper tissues sensitive to pressure. It is decidedly in the muscles, not at all in the skin. The atrophy of the deltoid seems to be increasing, and there is a general brawny hardness of the muscles of the arm, most marked in the triceps and deltoid.

Mr. K.'s blood was examined by Dr. F. P. Henry, who reported as follows:

"Red corpuscles per cubic millimetre, 6,000,000. Coloring-matter, 90 per cent.

"Comparing the appearance of the corpuscles on the sound and diseased sides, taking the blood in each case from the finger pulps, the only difference between the specimens was that in the sound side the tendency of the corpuscles to arrange themselves in rouleaux was very marked, more so than I have ever seen it; whereas on the paralyzed side this tendency was almost entirely absent. On the sound side scarcely an isolated corpuscle was seen.

"The flow of the blood on the paralyzed side was decidedly more sluggish than on the sound side, and its color of a more venous hue." "Apart from this," Dr. Henry writes : "The blood may be regarded as perfectly normal."

On January 5th, the hand being then completely healed, I repeated the examination of the blood from both hands, and studied several slides; but by this time the changes were no longer to be noticed, and rouleaux were formed in the usual way by the blood from either hand and from the arm of the injured side. There was no excess of white corpuscles, and the red ones were entirely healthy in appearance.

On the same day for the first time a very faint pulsation in the left radial artery at the wrist was observed. The pulse was taken very carefully, and during successive minutes found the same (74 to 76 beats per minute) as at the right wrist. As this was the first occasion on which the radial pulse had been detected, I counted it several times, and then examined my own, to make sure that I was not making the mistake of numbering my own beats. An endeavor was made to feel the pulsation at other points in the course of the arteries of the arm, but none could be found anywhere except at the wrist.

On January 16th Professor H. McK. Cattell examined the reaction-time with results as follows:

Reaction-time (10 *trials in each series, average time and mean variation in thousandths of a second*).

	Right hand.	Left hand (injured).	Left hand, excess.
Sound . . .	149 (6)	228 (17)	79
Light . . .	139 (17)	218 (10)	79

June 17*th*. The patient states that he has often a feeling of the active presence of the injured hand, and frequently dreams that he can use it.

The growth of the nails for a time was totally arrested by the scald, but the new growth is now not only progressing, but is much better in color and smoothness than the older one. Motion is much impaired. The arm can be raised to an angle of about 40° with the vertical line of the trunk, and the forearm can be flexed to half the natural extent. This is a great bettering since December.

General touch-sensibility on the arm is described by Mr. K. as notably better, and this is confirmed by Dr. Cattell's examination above. The area of good sensation on inner side of arm and over the shoulder is unchanged.

There is decidedly less tenderness to pressure over the upper arm than at former examinations.

Drs. Morris J. Lewis and John Madison Taylor confirmed the presence of the radial pulse at the wrist. No

pulse can be detected at the bend of the elbow or elsewhere in the arm.

March 13th. Progress steady. Wrist pulse slightly better felt. Brawniness about deltoid is lessening.

Motion. Great gain in biceps. No movement in forearm.

Sensibility has also improved. Touch felt on outside of arm well, less well on inside, and both two-thirds way to wrist. Above this the muscles are all still sore to pressure.

Nutrition. The nails show a deep groove marking their arrest at the time of the burn, but below this are all growing well. The thumb-nail is much less grooved than those of the fingers. The thumb was less scalded.

March 17th. Shaved the hair on both hands to observe its rate of growth. On the 29th it was clearly longer on the left side. Sensibility is gradually creeping downward.

Reaction-time, April 16th.

	Right.	Left.	Left excess.
Sound . .	139 (3)	246 (22)	107 (19)
Light . .	135 (7)	221 (19)	86 (12)

While power of movement and deep sensation, including pain, have improved, the area of cutaneous anæsthesia remains the same.

Cold (60° F.) is always felt with more difficulty than a relatively greater degree of heat (120° F.).

Professor Cattell thought this observation important, as it showed the skin to be sensitive to temperature when not sensitive to touch.

The perception of pain on deep pressure has reached the hand, so that to squeeze the ball of the thumb hurts; but surface sensation is unimproved, and there is no motion below the elbow. The muscles' nerves of sensation seem to have been repaired before those of the skin.

Letter from Mr. K., December 23, 1891:

"I took the treatment every week, consisting of the application of the galvanic and faradic currents alternately. I also took care to have the arm and shoulder rubbed

every day. The most important change to be noted is the development of the biceps muscle. This muscle has become quite strong, enabling me to support a weight of fifty pounds suspended from the forearm with the elbow bent. Of the other muscles not one seems to have gained at all, although I can notice no progression of atrophy. The triceps and deltoid muscles are totally inert. When I flex the elbow-joint, only the natural force of gravity enables me to straighten it again. The joints of the shoulder, elbow, and wrist are more pliable, the tendons being contracted much less than when you saw me.

"I remember you once spoke to me about my being conscious of the presence of my arm. Now that I have more use of it involuntarily, as one would move a sound member, I sometimes (especially if at all excited) seek to grasp an object with my hand; I can raise the hand to my face without much effort.

"The wrist, like the elbow, I can flex, but cannot extend except by relaxing it and allowing it to fall. The arm used to be what you called supersensitive. It is not nearly so much so now, and the sensation produced by rubbing and pinching is more natural and less painful. I have not noticed it to be invariably the case, but sometimes, when any part of the surface of the body on the left side over the side, back and shoulder and breast be disturbed, as by tickling, I have a strange tingling sensation pass through the entire length of the arm to the end of the fingers.

"I think the circulation is also improving, although no pulse can be detected.

"The color of the skin is better, the blood not seeming to stagnate in the hand so as to give it the black-and-blue appearance it used to assume when allowed to hang at my side. Perhaps you will not be displeased to hear that the successive parboilings you inflicted have left no scars."

The following extracts from another letter received in October, 1893, give the condition of the arm to that date:

"The condition differs little from that described nearly two years ago, except in this respect, that there is an im-

provement in the circulation, which I think must account for the skin's assuming its natural color, the cessation of atrophy, the muscles becoming soft, and no longer seeming to adhere to the bone. A few months ago it was thought that pulsation could be detected at the wrist, but as the possibility of such a thing has always been so doubtful I am bound to believe that it was a mistake.

"Rubbing of the arm is not so painful as formerly; the arm is not unnaturally sensitive to low temperature, and I have no difficulty in keeping it warm. When, however, it is suddenly immersed in water, when I draw it from my pocket and it meets the outer air, when I am preoccupied and a particle, ever so small and light, of sufficient substance to disturb the position of a hair, drops upon it, I am clearly conscious of each of these changes.

"So far as I am able to judge, the nails grow as rapidly as those upon the other hand.

"There is no motion in the wrist or finger other than an occasional involuntary twitching of the thumb or of a single finger; never two at a time. There is no rotary motion of the elbow, which, when bent, can only be extended by relaxing the biceps, its own gravitation bearing it down.

"The biceps has grown quite large and strong, but the deltoid gains not at all."

Remarks. Etzold[1] has reported six cases of division of portions of the brachial plexus in the axilla by sword-thrusts; in all of them primary sutures were applied. The course of their improvement was very slow, as in the present patient; and all of them, like Mr. K., followed the usual course of gradual bettering from above downward, the triceps muscle first showing return of motion.

To the ligation by mistake of a cord of the plexus was added the effect of the original violent stretching and contusion when he fell. It is not improbable that a partial rupture of the nerves took place at the same time that the artery was torn. Judging from his description of the accident, it may be thought that an incomplete luxation

[1] For details of these cases see p. 219.

of the humerus was also brought about by the fall, which reduced itself as he arose to his feet, or else the shock which he felt, "like a snap," may have been actually the rupturing of the artery and the pouring forth of its contents.

If the former supposition be true, the dislocation might have bruised the plexus, in which event he was suffering from stretching, laceration, and contusion of the nerve-cords; to these slow compression by the clot and, later, sudden compression by the ligature were added.

More serious injuries could hardly happen. No pressure-palsies (with the single exception of crutch-palsy)[1] make very good recoveries. The ones which do worst are those in which pressure, not necessarily severe, has been continuous for some hours, as in the case of wrist-drop from a drunkard's sleeping on his arm, or hanging it over some sharp edge which compresses the nerves.

Several cases have been reported of accidents bearing some resemblance to this. An interesting one, though somewhat incomplete, is that given by Mr. Mitchell Banks.[2]

The patient, a sailor, fell upon his shoulder down a hatchway. Two months afterward, when he was seen, there was complete loss of motion from the shoulder downward, wasting of the muscles of the shoulder and upper arm, and no pulse in the ulnar, radial, brachial, or axillary arteries.

An exploratory operation was made, and the plexus was found "torn away bodily from the spinal column and dragged downward below the axilla, with the exception of one small cord, which appeared to supply the deltoid and pectoralis major." The axillary artery had been injured, and was found at the operation entirely obliterated. The state of the eye is not mentioned.

In another case, reported by Hutchinson, like Mr. Banks's patient, a sailor, the muscles of the upper extrem-

[1] In the use of a crutch the pressure is, strictly speaking, not entirely continuous. The weight is taken off as the patient swings the crutch forward, or at least is lessened

[2] Transactions of the International Medical Congress, 1881, vol. ii. p 443.

ity, with the exception of the triceps, brachialis anticus, and coraco-brachialis, were wholly paralyzed, but the elbow could be flexed and the forearm supinated.

The muscles were atrophied, the hand was cold; but there were no other nutritive defects. The pupil on the injured side was contracted, the eyeball slightly retracted and smaller, and the opening of the eye distinctly narrowed.

Another case is minutely reported by Ross.[1] A young man, aged nineteen years, was caught by the left arm in the strap of a revolving wheel, lifted from the ground and thrown down unconscious. All the muscles of the hand, forearm and arm, and the sternal portion of the pectoralis major, were paralyzed and atrophied when Dr. Ross first saw the patient, nine months after.

The clavicular portion of the pectoralis major, the pectoralis minor, the external and internal rotators of the humerus, and the latissimus dorsi were uninjured.

The area supplied by the intercosto-humeral nerve on the inner surface of the arm, and the communicating branch from the fourth nerve to the brachial plexus, and some portions of the areas supplied by the cervical plexus, were sensitive. The left pupil was somewhat contracted, the palpebral opening diminished, and the cornea flattened.

In Mr. K., in spite of the very slow increase of power in the arm-muscles, the restored circulation and the bettered nutrition of the skin may be considered to warrant the opinion that some useful degree of motion may yet be gained in the forearm and hand, and the case teaches how persistent treatment should be, since improvement can continue even so late as has here happened.

Case XLV. *Gunshot-wound of face, nose, and neck; otorrhœa, deafness, hemiplegia, post-paralytic chorea.* (From Pension Office Reports.)—S. E. P., Co. A, 9th Maine, was wounded at Petersburg, July, 1864, in his twenty-third year, by a ball which entered beside the nose just below

[1] British Medical Journal, May 5, 1883, p 868.

the inner canthus of the left eye, and passed downward and backward to lodge deep in the right side of the neck, behind the carotid artery and about on a level with the anterior border of the upper third of the sterno-cleido-mastoid muscle. It passed through the nasal septum and the turbinated bones. A constant irritating discharge from the nose resulted, with complete right deafness, inability to turn the head to the right or to flex and extend it. There was constant pain in the head.

He was examined in September, 1875. "His respiration is 27 per minute, his pulse 105. There is a tumor over the seat of the ball as large as an English walnut, which seems to obstruct the external carotid artery, and is too tender to bear any manipulation. The nasal process of the left superior maxillary bone is carious, there is constant discharge of fetid pus from the left nostril, otorrhœa on the right side, and entire deafness in that ear. He is completely broken down by the pain and irritation, and can scarcely remember his own name. He is recovering from an attack of typhlitis."

In 1876 the patient had an attack of right-sided hemiplegia, of which no details are obtainable. When seen in that year there was no facial paralysis, the tongue protruded straight, but his utterance was thick and indistinct.

Both the leg and arm of the right side were in constant movement, very feeble and poorly controlled by the will, a post-paralytic chorea. There was much mental impairment, and the opinion was expressed that he would soon die. He was, however, still alive when the last examination was made, in August 1890, but presented a melancholy appearance. He was then forty-nine years of age, weighed 180 pounds, height 6 feet, pulse 96, temperature 98.5°, respiration 30.

"The man has a large, powerful frame, and is in the prime of life; but he is weak, tremulous, and feeble. He has an uncertain gait, and sits drooped over with both hands clasped and held between his knees to keep him from violent trembling, which is constant if his limbs are not supported. His head is fixed, slightly inclined forward,

causing him to look downward all the time. The ball is lodged against the petrous portion of the right temporal bone; from this point there is now a long sinus opening at its lower end just above the inner end of the clavicle, and discharging foul-smelling pus. There is evidently dead bone at upper end of the sinus, which for many years discharged through external meatus; but this is now closed, and all the discharge comes down the sinus. He has a very aggravated naso-pharyngeal catarrh, dependent upon the wound, and a very fetid breath. His tongue is badly coated. Lungs normal. The heart's action is rapid and irregular, but there is no valvular lesion, and the disturbance is due, in our opinion, to the injury to the nervous system. Abdominal organs normal in size and functions. Sensation in upper extremities, trunk, and lower extremities diminished one-half. Reflexes normal. Eyesight diminished: vision of right eye, 8/16; vision of left eye, 8/16, Snellen Hearing of left ear 1/36, right ear 3/36, watch-test. He protrudes his tongue in a tremulous manner; his mind is dull and slow; his speech stammering and halting; his whole appearance is that of profound dejection and indifference to external surroundings. He has no grip at all in his right hand, and in his left hand about one-third normal. He can neither dress nor undress himself."

The case is only interesting as an extraordinary example of the endurance for thirty years of conditions due to a wound such as is usually early fatal.

CASE XLVI. *Buckshot through left side of larnyx and neck; tracheotomy; late weakness of right arm; absence of sweat on right face, neck, and arm; sensitiveness to heat.*— Captain J. S., 53d Pennsylvania, aged twenty-four years, was admitted July 5, 1863, to Jarvis Hospital, Baltimore. Dr. Dewitt C. Peters, the surgeon in charge, reported the case as follows:

The patient states that on July 2, 1863, during the charge of the Second Corps through the wheat field at Gettysburg, he received a wound of the neck which bled so profusely that he had to be carried to the rear, where

simple dressings were applied. The hemorrhage continued for some time, and finally stopped of its own accord. He was sent with other wounded to Baltimore, and finally to the Jarvis Hospital.

July 5th, 9 A. M., his case was examined by the attending surgeon, who found him bright, breathing easy, pulse 96, and able to converse without difficulty. There was no excessive swelling about the neck, and the wound had closed and no emphysema existed.

The patient informed the surgeon that for two days air had escaped from the wound at each respiration, but now it had entirely closed. The wound is supposed to have been made by a single buckshot. It is located over the centre of the left plate of the thyroid cartilage. The scar is about one-quarter of an inch in length, and the course of the missile directly backward. Where the shot lodged could not be ascertained, but it must have passed through the larnyx. The patient's symptoms after admission to the hospital soon became alarming. He fell asleep in a sitting posture, and his dyspnœa was most marked. At 12 M. his pulse had increased to 116 per minute, and his breathing was most labored. The patient's chest and face were covered with a cold perspiration, and his expression was exceedingly anxious. The symptoms indicated that the officer was in a critical condition, and active steps were demanded to save his life.

The swelling and œdema around the seat of the injury, both internally and externally, were rapidly on the increase ; emphysema had set in and extended down the chest, especially on the left side, as far as the false ribs. A consultation was held, and it was decided to perform tracheotomy. A straight incision, commencing over the cricoid cartilage, was carried downward in the median line for about one and a half inches through the integument. The thyroid gland was exposed and found greatly distended and infiltrated with air and bloody serum, as indeed were all the tissues. By carefully dissecting the parts on a grooved director the lower edge of the cricoid cartilage and the upper ring of the trachea were finally

reached. A grooved tenaculum was hooked through the trachea just below the cricoid cartilage and held by an assistant, with the handle resting on the patient's chin. A narrow sharp-pointed knife guided by the groove of the tenaculum was then inserted to perforate the trachea, which, owing to its unusual thickness, caused considerable impediment at the first attempt. The length of the blade passed out of sight without accomplishing the object, and the patient uttered a complaint of too much pressure. The tenaculum was still steadily held while further dissections and enlargement of the incisions were made.

The second attempt proved less difficult, and was immediately followed by the escape of a bubble of air. The fresh wound was cleansed, and through the opening a narrow knife was passed and carried downward and forward until at least three rings of the trachea had been divided. Very little blood escaped into the trachea, and one or two explosive efforts cleared it of these small clots and a quantity of tough mucus. The patient breathed easily through the opening.

The operation was completed by introducing a large-sized Dessault's tube, which was properly retained in position in the usual manner. No ligatures were required, and the amount of blood lost was very insignificant.

The relief experienced by the patient was instantaneous, and a change for the better of all his alarming symptoms was immediately noticed. His pulse fell to 96, and he was soon enjoying a pleasant sleep.

6th. The patient's condition is much improved; the swelling is subsiding, and the wounds look healthy. The treatment consists in keeping the patient quiet, giving him flaxseed tea to drink and liquid nourishment.

9th. Improvement continued, and, as the swelling of the neck had entirely disappeared, the tube was removed. He was watched closely, and on the following day he commenced to breathe easily through the natural passages.

18th. Wounds almost healed. The patient walks about, and his voice is as strong as ever. Being anxious to return home, he was discharged cured.

Personally examined, 1890. Notes also by Dr. A. Parish, Flemington, N. J.

Measurements: Right arm at level of armpit, 12½ inches; left arm at level of armpit, 12½ inches. Eight inches from acromion process around the arm: right, 12¼ inches; left, 12½ inches. (The patient is right-handed.) Both forearms 10½ inches.

No difference noticed in the consistency of the muscles to the touch, but the grip is very feeble on the right side. Certain positions, which he could not describe, and which I was not able to find by experiment, give a sudden shock down the right arm like that from a battery. Usually these are postures in which he is leaning back, neck stretched, and head somewhat back, as, for instance, in a barber's chair. Sometimes sharp rotary movements of the head cause a similar pain.

As he moves his right arm up there is scarcely any of the usual cavity of the armpit under the right arm. From under this arm extends across the side a dark, reddish spot of a congested appearance, which he describes as permanent.

Sensation is dull to touch and pain from the origin of the deltoid down the right arm. He does not distinguish two points at one and a half inches on the arm. The back of the shoulder and of the arm is a shade worse in this respect than the front.

He differentiates heat and cold perfectly, but with a little delay on the right arm as compared with the left. The muscle-jerks are noticeably sharp and quick in the right arm and forearm. The skin, except for the reddish spot mentioned, does not differ on the two sides.

The patient states that he has never sweated on the right neck, face, and right half of head since the injury, but that he sweats excessively on the opposite half of the body, neck, and face. Sometimes, when very hot, there is a mere dampness of the surface of the right side. There is no difference in this respect between the two hands. The salivary secretion is not affected. The temperature is the same on both sides. Speech is not affected, although the

wound of the trachea has resulted in a partial stricture which causes some trouble in breathing on active exercise. Colds are apt to cause persistent hoarseness. He has a chronic pharyngitis and post-nasal catarrh. The hearing is decidedly less acute in the right ear than in the left.

No alteration of vision or unusual changes in the retinal vessels or optic nerves could be found.

Remarks. No examination of the eyes was made early, and this is of moment. Now, there is no pupillary change; but even in the most certain cases of wound of the sympathetic nerve the eye-change is apt not to be permanent. The altered physiological state as to sweating lends probability to the idea of lesion of this nerve. Yet several cases of slight nerve-injury are here reported in which loss of this secretion followed upon lesions remote from the sympathetic. The patient says the right arm was weak from the time of the wound, but gave no pain and displayed no changed sensibility. If this be so, how shall we explain the present feebleness of the right arm and its other changes? If there had been also an injury of the nerves, which at the larynx level and below it run together to make the brachial plexus, there should have been some early or immediate pain or localized loss of arm-power. None was noticed, and for a long while there was only a simple general failure of power in the right arm. It seems unlikely that this could have been a reflex from so slight an impression as a single buckshot would make; and still the case reminds one of the far graver lesion in Admiral Stembel's case related in *Injuries of Nerves*, p. 173.

The case leaves much to the imagination. The obvious suggestion in reading the history is that the sympathetic nerve was wounded. Yet this, on further examination, seems very doubtful, for how could one buckshot passing backward through the left side of the larynx injure the right sympathetic nerve? As to this point we have the minute statements of the original hospital report, and as to the later changes it should be said that the witness is a good one, and his statements entitled to absolute belief.

CASE XLVII.—*Gunshot-wound of right wrist; amputation; choreal affection of forearm and shoulder continuing many years; health otherwise perfect; insanity and death.* (Case 68, *Injuries of Nerves.*)—Colonel J. G. P., aged forty-one years, 139th Pennsylvania. The patient's family history was good, and his personal health excellent up to June 3, 1864, when he received a heavy bullet through his right wrist. "He became at once singularly excited, and felt as if he were crazed . . . . he ran along the line of his regiment, only half-conscious, until he fell senseless. . . . . Dr. Chapin, surgeon of the regiment, amputated his forearm at the junction of the lower and middle thirds. . . . The patient continued in active service while the wound healed. This process was over about September 20, 1864." At this time the spasmodic motion of the stump was first noticed, and within a month extended to all the muscles of the forearm, except the extensor group, and in another month it attacked the biceps, triceps, and deltoid. Various treatments were all unsuccessful, though for a few days after the dissecting out of a large part of the cicatrix of the stump the motion was less.

In March, 1865, the condition was as follows: "The forearm is incessantly in motion, the muscles quivering in a singular manner, night and day, whether asleep or awake. Every twenty seconds or oftener the forearm is suddenly flexed, and more rarely the arm is thrown across the chest by the pectoral group, or upward and outward by the deltoid. These movements are beginning to involve the trunk and neck muscles of the right side. They are increased by attention, and controlled during voluntary motion, as in ordinary chorea, but recur the moment the effort to stop them ceases. No fatigue is felt, the stump is in no way unhealthy, there is no tenderness in the nerve-tracks."

The patient knew of only one occasion when the arm had ceased to move, which was while, during the battle of Cedar Mountain, his regiment was cut off, when, for two or three hours of suspense and hard fighting before they made their way out, the stump hung motionless by his side.

He was severely wounded again in March, 1865, and while insensible the twitching continued as usual, but soon after the movements grew smaller, his general health improved, and though the chorea never ceased entirely, he led an active and useful life as one of the legal officers of his county after his return, upon the conclusion of the war, until 1879–80. At that time mental derangement began as the result of trouble with an estate for which he had been made assignee in bankruptcy.

The progress of the insanity was slow and gradual. He suffered from pain in the stump of the lost arm and from twitching of the muscles. He continued usually rational, but at times he threatened the lives of his family, and once attempted to commit suicide. He was admitted to an insane asylum, and the asylum physician's report made on February 1, 1880, says: "Patient has been very restless ever since his admission; on foot most of the time, walking about the room or the hall. His appetite is not good, nor does he sleep well at night. Complains of being sick, but will not say in what manner. He avoids talking and appears to be in great mental distress."

June 6, 1880. More restless; groans most of the time. Wants opium to kill himself. Shows aversion to his wife and children. General health excellent.

August 31, 1881. Gradually refused food, finally took only milk-punch, upon which he lived for several weeks. Died to-day, from exhaustion.

Remarks. The notes of the patient's state while in the asylum say nothing of the stump or of twitching in its muscles. The insanity, gradual exhaustion, and death cannot, in the absence of all physical examination, be related in any way to the original injury or to the disease of the stump. Up to the time when he was admitted to the asylum the movements of the stump continued, though less severe than at first.

CASE XLVIII. *Crush of thumb; amputation; bruise of stump; sequent tremor of right hand, forearm, arm, and of adductor muscles of right thigh, with periodic contraction*

of toes of right foot—M. Q., aged forty years, comes of long-lived ancestry, grandfather living to one hundred years of age, great-grandfather to eighty years, and grandmother to ninety-six. Father died in Cuba of yellow fever, mother of influenza; four brothers living, all large, hearty men.

Patient was married at twenty-two, and has two healthy children. His wife has had no miscarriages. He denies venereal disease other than gonorrhœa, from which there were no sequelæ. No excesses in drink, etc.

He began "braking" on a railroad at sixteen years of age, and kept it up until right thumb was split open through the ungular phalanx while coupling cars. The end of right thumb was at once amputated through articulation of the second and ungular phalanges. The wound seemed unusually painful and irritable at the time of accident, but quieted down after amputation somewhat, and he continued his work very soon. Seven weeks after the original accident, however, he struck the stump while at work. This produced much irritation. The stump became red and swollen, but did not suppurate, healing rapidly under rest and use of ung. zinci oxid. He then continued to work as a brakeman, the stump not giving him any trouble, but he says "it was a little sensitive." He was not nervous, and his general health was good.

In January, 1890, he obtained a position as policeman. In December of that year he slipped and fell, his right arm and hand being thrown back to catch himself. He states that the thumb-stump struck the ground. It was quite painful at the time, but did not swell much, remaining however tender to touch in line of scar of amputation transversely across end of dorsal surface. Did not go off duty, not being injured in any other respect. The scar remained red and congested for two or three weeks. There was no suppuration produced, the slight swelling soon disappearing. (The stump has continued more or less tender to present date of examination, March 16, 1894.)

About three weeks after the fall referred to in December, 1890, the interesting feature of the case presented itself.

The thumb-stump became the seat of a coarse tremor; not at first continuous, but made worse by any slight injury or excitement. This was not painful, and would always quiet down with rest, as when he retired at night. The stump began to have a subjective sense of warmth in its tip end. Very soon (in two or three weeks) the index-finger of right hand also became the seat of tremor (without the feeling of warmth) and influenced by like conditions of quietude, but made to shake more violently and rapidly by excitement. It seemed also that at times when the right arm hung limp by his side (*i. e.*, when volition and voluntary motion were absent), especially if he was exhausted from long work, the two digits shook more. Later a peculiar rhythmical to-and-fro rotation in supination and pronation would at times appear. This lasted a short time only. Then there came a general tremor of hand and forearm.

The patient came under the care of Dr. Guy Hinsdale, who consulted with Dr. S. Weir Mitchell in June 1891, all therapeusis having been of no avail. At this time he had been compelled to resign his position on account of the tremor in right hand and arm. He had also become generally nervous. The thumb-scar was a little tender.

On June 7, 1892, patient was admitted to the Surgical Ward of Presbyterian Hospital, where Dr. H. R. Wharton excised "tissues of end of stump and resected the end of the bone." This was followed by marked diminution in the hand-tremor for a few weeks only, the tremor again increasing, and on July 12, 1892, Dr. Wharton stretched the median and ulnar nerves in the right forearm above the wrist. After this operation the tremor entirely disappeared for some time, but gradually returned, and has increased in extent ever since. Some two months after he was discharged from the ward after this second operation he began to notice a tremulous condition of the adductor muscles of the right thigh, especially when sitting quiet. He observed soon after this that when he was about to bring his right foot forward in walking the toes would be drawn down in tonic flexion, at first slight, but gradually assum-

ing more of spastic "hammer-toe" position. This symptom would also develop when reaching upward, as to a shelf. There was no tenderness of spine nor along any nerve-trunks, and he had no pain.

The symptoms have made slow progress since. The man is now keeping a small grocery-store, and does ordinary chores, using the left hand mostly for fine work (on account of tremor in right), although he is quite as strong in right arm as in left one. Movements in the right are, of course, less well co-ordinated.

Status præsens. Fairly good physique, dark hair and eyes. Rather nervous, depressed countenance. Sexual powers preserved. There is no tenderness or deformity of spine, and no tenderness anywhere excepting over old stump-scar, which is slightly sensitive to external stimuli. The cicatrices of the old amputation of thumb, of the subsequent excisions, and of the nerve-stretchings appear healthy. Sensation to touch, pain, and thermal sense same as in left hand, and normal. Little hyperæsthesia over scars. No neuroma found. There is a fine tremor of all fingers of right hand, probably a little more in thumb-stump. The forearm is also, but to a less degree, tremulous. No involuntary supination or pronation movements are now observed. The right upper arm trembles a little. To held the right arm out horizontally in front, then slowly abduct it, causes a more choreiform spastic movement of right forearm, as though the ulnar nerve was thus stretched and irritated; but it is not made worse by pressing over the right ulnar nerve at elbow. He uses a cane when walking, with either hand indiscriminately.

Circumference of arm around biceps: R., 11½ inches; L., 11½ inches. Circumference of forearms: R., 11 inches; L., 12 inches. Circumference at wrists: R., 7 inches; L., 7 inches. Grasp good, both sides about equal.

There is some deltoid wasting. Can move arm in all directions, but there is some inco-ordination, and it soon tires. No tremor of deltoid or trunk muscles seen. Tongue protruded straight and not tremulous. Trunk-muscles are quiet.

His gait is curious : he throws spinal column far back in effort to bring right foot forward. There is a tendency to relaxation of the anterior group of the right leg and thigh, with the opposite condition (of tonicity) in the posterior group of muscles. Gait is very slow. Tires easily. While sitting there can be seen and felt a fine tremor of the adductor muscles of the right thigh. Station is good. Knee-jerk + on both sides, more on right, where there is also an attempt at clonus. No sensory disturbance anywhere. No tremor on left side of body. Circumference of right thigh at gluteal fold, 22 inches ; left, 22½ inches.

Muscle jerks + on right arm and leg. Elbow jerk + on right. All organs seem normal.

Pupils respond normally to light and accommodation. The patient states that except for the spastic difficulty with the leg he is in every way improved in the last two or three months.

Remarks. While the evidence of ascending neuritis in this case is by no means complete, yet the supposition of its presence is more permissible than in the next case. The repeated injuries of the stump, its tenderness, the improvement which resulted first from excision of the end of the stump, and then from nerve-stretching, all point to neural inflammation. The change is probably of the slowest sclerotic kind, and has finally affected slightly the spinal cord, apparently progressing down the spine and not up. The extent of disease in the cord in this case must have been very slight, as the knee-jerk is very little affected ; there is no ankle-clonus, and the movements of the leg are perfect with the exception of the slight spastic tendency in the right leg.

A case in which, seven years after amputation, choreic motion began in the stump of the amputated leg, gradually spreading upward until the arm of the same side was affected, I know only as quoted by Nepveu in *Revue de Chirurgie*, 1881. It is said to have followed upon neuralgia of the stump. Perhaps for neuralgia we may read neuritis. The patient is reported to have died as a result of exhaustion from generalized convulsions.

CASE XLIX. *Long-suppurating gunshot-wound of forearm; final amputation of member; generalized tremor, worst in shoulder-stump; also a less-marked general tremor.* —J. D., aged fifty-three years, 61st Pennsylvania. First reported at Dr. S. Weir Mitchell's clinic at the Infirmary for Nervous Diseases, June 5, 1891, when the following notes were made: His family history was negative. He is a widower; two children. Denies syphilis. Wife never had a miscarriage, but developed locomotor ataxia, and was treated for a time at this clinic, dying in 1886. Patient has always been a temperate man, and never had any serious illness up to time of onset of present trouble. In April, 1862, during service in the Peninsular campaign, he was wounded in the right forearm, two inches below the elbow. Wound closed and reopened at intervals, discharging pus and pieces of bone, for over twenty years. Finally the arm became so painful and utterly useless it was amputated through the anatomical neck of the humerus by Dr. John Ashhurst, Jr., at the University Hospital, in 1886.

About eight months after amputation he began to have a coarse tremor of the stump, which has progressively increased. Previously there had been occasional attacks of twitching, but not long continued. The movement, at first jerky, became steadily more clonic in its character; in the beginning it resulted usually from any excitement, after a few minutes affecting the whole right side of the body, but in a less degree than the stump and shoulder-muscles. During the continuance of these paroxysms of twitching a pricking sensation was felt in the arm. The right leg in turn became weakened after one specially severe paroxysm. (The patient's first statement was that the tremor had begun long before the amputation, and that even the face had shared in the movement; but he afterward corrected this to the above history, saying that he had made a mistake in the time and order of the symptoms.)

This state has continued, with remissions and exacerba-

tions, up to the present time (June, 1891). He complains, also, of tremor of head, body, left arm, and right leg, all of the characteristic type of Parkinson's disease. Excitement greatly increases all movements. He says bromides formerly quieted them. Has pain in stump at change of weather; worse at night. Is losing the sense of presence of fingers, which was very vivid for several years after amputation. Says the stump feels numb. Irritation of the cicatrix increases the coarse tremor.

Examination, 1891. On removing artificial arm the right shoulder and stump are seen in rapid clonic movement, easily controlled by firm pressure. Cannot stop it by volition. Striking pectoral muscle of right side sets up the clonic movement. The clonus seems mainly confined to the pectorals, but there is motion in the rhomboid and latissimus dorsi. The scapular muscles are wasted on this side. Elbow-jerk left side, ++. Knee-jerk ++; no ankle-clonus. Striking for knee-jerk also increases clonic arm-movement. When ordered to do a co-ordinate act with left hand, the tremor momentarily ceases, but simple physical effort increases it. The slight head, arm, and leg tremors are not much affected by local stimulus of the parts. No tremor of tongue can be detected.

Patient was not seen again until two and a half years later, when the following was noted, February 23, 1894: The man is thin. There is general tremor of head, left arm, and lower extremities, very much interfering with locomotion. In addition the stump is in violent clonic tremor, the region of the pectoralis major muscle of the right side being specially active, pulling the stump and shoulder forward at each contraction. The tremor ceases almost entirely for a brief time when the mind is diverted. There is no corresponding tremor of opposite side. The stump's motion cannot be controlled by volition. When in bed and lying on the stump the tremor ceases a little. The head becomes quiet by rest in bed, but the right leg trembles about the same as when up. There is a numb feeling on the whole right side of body; none on left side. There is a burning in the lost arm, from which the right-sided

paræsthesia seems to radiate, and where the injury existed there is a sensation "as of the crawling of worms over part."

Percussion on the parts about the stump increases the tremor. Sensation is impaired all over the body. Patellar reflex exaggerated both right and left. No ankle-clonus. The muscles are greatly wasted on right chest and shoulder. There is no wasting in right leg, the part next most involved.

In addition the man complains of vertigo; "things seem to move away from him." There is occasional pain in the right temporal region, during exacerbations of which vertigo is worse. Appetite capricious. Feels generally miserable and bruised, as though he had been flogged.

Remarks. A number of cases are recorded of tremor following amputation, and some have been noted in which the spasmodic movements extended to other parts, as here and in XLVIII. It is remarkable that there is not in this, as there is in the latter case, any evidence of the presence of a neuritis. The possibility of a neuritis ascending from the nerve in the stump and affecting the spinal cord is to be considered in such cases, but the most careful examination of the man does not indicate any such trouble; the difficulty has a more obscure origin. Indeed, there has not even been neuralgia of the stump; and although the wound, by repeated suppuration, became a factor in depressing the man's general condition, it was never excessively painful in the way that a neuritis would have been painful.

CASE L. *Liquefactive necrosis of soft parts and bones of the fingers as a late result of section of the median nerve; amputation; entire absence of nerve elements from the remnant of the median trunk.*—The following very interesting and extraordinary case is abstracted from a paper in the *Journal of Pathology and Bacteriology*, by Dr. Joseph Griffiths, of the University of Cambridge. The patient, an Essex laborer, fifteen years before he was seen by Dr. Griffiths, had his left arm caught above the elbow in a

chaff-cutting machine, and cut into the bone on the inner side. The hand became at once numbed and useless, and after five months the fingers, hand, thumb, and forearm were still powerless. About one year after the accident a slight degree of feeling had returned to the skin of the hand. Three years after the accident the tip of the middle finger began to fester and ulcerate, the nail dropping off and the end of the finger disappearing bit by bit without the coming away of the end of the bone or any obvious sloughing of the soft parts. The same process followed later in the index-finger. The activity of the ulceration was much worse in the cold season, and seemed to cease completely during warm weather.

A painless necrosis of soft parts, tendons, and bones finally removed the distal portions of both index and middle fingers. Flexion of the ring and little fingers began six or seven years after the accident, and gradually increased with some pain. The end of the thumb began to ulcerate thirteen years after the accident, and continued to do so up to the time of examination. He suffered so much from pain in the ring and little fingers and from the ulcerations, and the hand was so useless, that it was, at his own request, removed in his seventy-third year by Sir George Humphry.

The hand and forearm were much wasted, the muscles being greatly atrophied. The ring and little fingers showed beginning ulceration on the extensor surfaces of the terminal joints. The pulp and a small portion of the terminal phalanx of the thumb were also destroyed, and the nail had thickened and curved over the end. The skin of the whole hand was thin and shiny. There were limited flexion and extension at the wrist, slight flexion, extension, and adduction of the thumb. Sensation was defective over the whole hand, but there was no complete anæsthesia nor any very definite limitations of sensation. The scar of the original injury was just above the inner condyle of the humerus, and two to three inches in length. The brachial artery could be traced above the scar, but could not be felt below.

On examination of the member when removed the bones

were found very little changed, except where they had been affected by the ulceration. The second phalanges of the index and middle fingers were represented by cones of about one-third of an inch in length, with perfectly smooth and well-healed surfaces. The terminal phalanges had entirely disappeared and the greater part of the second ones. The phalanges of the ring and little fingers were more delicate than natural. The remainder of the bones were healthy. The median nerve measured but one-sixth of an inch in diameter at the wrist. The fine, glistening surface of the normal nerve had entirely disappeared, and it looked like a firm, whitish cord. The microscope showed no trace of medullated or non-medullated fibres, the nerve-trunk apparently consisting of nothing but fibrous connective tissue. The ulnar nerve was about of a natural size, surrounded by fat, like the median, and had lost its smooth and glistening surface. The peri- and endo-neurium were found much increased upon microscopic examination, dense, fibrous, and the nerve-fibres were in various stages of atrophy, many having quite disappeared.

In the skin of the hand the changes noted microscopically were interesting. Where the skin was thin and tightly adherent the subcutaneous adipose tissue had entirely disappeared and was replaced by fibrous connective and yellow elastic tissue. The true skin was thickened, and also contained an unusual number of yellow elastic fibres. The epidermis was thinner than natural, but presented no morbid changes. The muscles showed different degrees of atrophy; the abductor, opponens, and the median half of the flexor brevis pollicis were very pale, tough, and fibrous. The muscles supplied by the ulnar nerve were wasted also, but to a less degree. Microscopic study of one of the median muscles proved the muscle-fibres to have been largely substituted by dense, wavy, fibrous connective tissue. There was no evidence of fatty disintegration.

Remarks. This very curious case is quoted as illustrative of some points of importance, and it is interesting to compare the changes in the two nerves of the involved

region. The median, which had been separated in the accident, and had, of course, never reunited, had no semblance of nervous tissue left in its substance. The ulnar, on the other hand, had apparently suffered a sclerotic change; the connective tissue of the trunk was much increased at the expense of the fibres. It seems to have been difficult to obtain from the patient any accurate account of the state of sensation in the hand, and a degree of loss of sensation existed which could by no means be accounted for by the division of the median nerve alone. The nutritive changes could not have been, as Mr. Bowlby has suggested for his case,[1] the result of the extensive injuries to which a surface lacking sensitiveness is so greatly exposed; indeed, even in the case which Mr. Bowlby reports with this suggestion, he says that the ulceration continued no matter how carefully the hand was protected. The kind of destructive process is interesting—a "liquefactive necrosis," as Dr. Griffiths calls it, not accompanied by much inflammation, but preceded by transformation of the connective tissues, including the tendon and bone, into granular tissue, which gradually liquefied and escaped as a serous, semi-purulent, bloody fluid. Nothing is said of the state of the arteries supplying the hand; but no process of slow gangrene from stoppage of an artery could have pursued such a course as this, and the determining factor in the trouble may reasonably be supposed to be the withdrawal of all trophic control, since there appears to have been no injury, no suspicion of gangrene, and nothing like frostbite or other exciting causes.

CASE LI. *Glass-cut of branches of median nerve in palm; anæsthesia of thumb, forefinger, and part of middle finger, gradually lessening; neurotomy; neurectomy; hyperæsthesia of cicatrix, anæsthesia of forefinger; atrophy of tissues of finger; trophic changes; great improvement.* (*Trans. of College of Physicians of Phila.*, 1876.)—Bella H., aged seventeen years, applied at Dr. Wharton Sinkler's clinic,

[1] Bowlby on Injuries of Nerves.

in the Orthopedic Hospital and Infirmary for Nervous Diseases, April 23, 1876, giving the following history: On February 11, 1876, she fell with a bottle in her hand, breaking the bottle and running one of the fragments into the palm of her right hand. Free hemorrhage followed. She perceived a numbness in the hand at once, and noticed that the dressing of the wound gave no pain. The hand and arm ached for two days, movement or touch caused sharp pain in all the fingers, but this gradually became confined to the thumb, index and middle fingers. For one week there was complete anæsthesia of the thumb, index and radial side of middle finger, but the thumb and middle finger soon improved in this respect. The only loss of motion was of flexion of the forefinger.

The wound was treated by Dr. C. B. Nancrede at the Episcopal Hospital and healed readily. One week after complete cicatrization a "water blister" appeared on the forefinger, and involved the whole of it, except the dorsum of the first phalanx. She says the finger looked as if it had been dipped in boiling water. The epidermis was removed, and the nail being found loose was mostly removed also. The raw surface healed very badly, and it was five or six weeks before the skin was re-formed.

The cicatrix of the cut became extremely sensitive to touch, and there was great pain on movement.

Examined, April 23, 1876. A cicatrix runs obliquely upward and outward across the palm, beginning one and one-half inches from the middle of the first metacarpal bone. The forefinger on the injured side tapers unusually toward the end. The skin of this finger is shiny and of a mottled purplish hue. The nail is shorter than that of the other side, ridgy, thickened, and partially detached from the end of the finger. The skin on the radial side of the middle finger is mottled and discolored in the same way, although to a less degree.

Motion. The movements of the last three fingers are perfect. In the index-finger extension is good; the first phalanx can be partly flexed, but the last two not at all. The thumb is somewhat drawn across the palm, and, although

it can be flexed and extended, these movements are limited by the pain which they cause. The median thumb-muscles respond to electrical stimulation of the main nerve in the forearm.

Sensation. Slight pressure over the median nerve at the wrist, or at the bend of the elbow, causes pain in the cicatrix. At the wrist deep pressure causes pain as far as the first joint of the index-finger, but not in the thumb. There is seldom much pain in the hand while at rest. If the thumb is handled or moved, there is great pain. The scar on the palm is exquisitely sensitive. Sensation is entirely lost in the forefinger. On the radial side of the middle finger and on the ulnar side of the thumb there is no loss of pain-sense, and only slight loss of touch-sense.

From this time on pain steadily increased to a torturing degree, in spite of every treatment. It was always confined to the hand, affecting the index, middle finger, and thumb. At the end of three months from the time of the injury a section of the median nerve three inches above the wrist was made by Dr. T. G. Morton, in order to relieve the unbearable agony of the palmar neuritis.

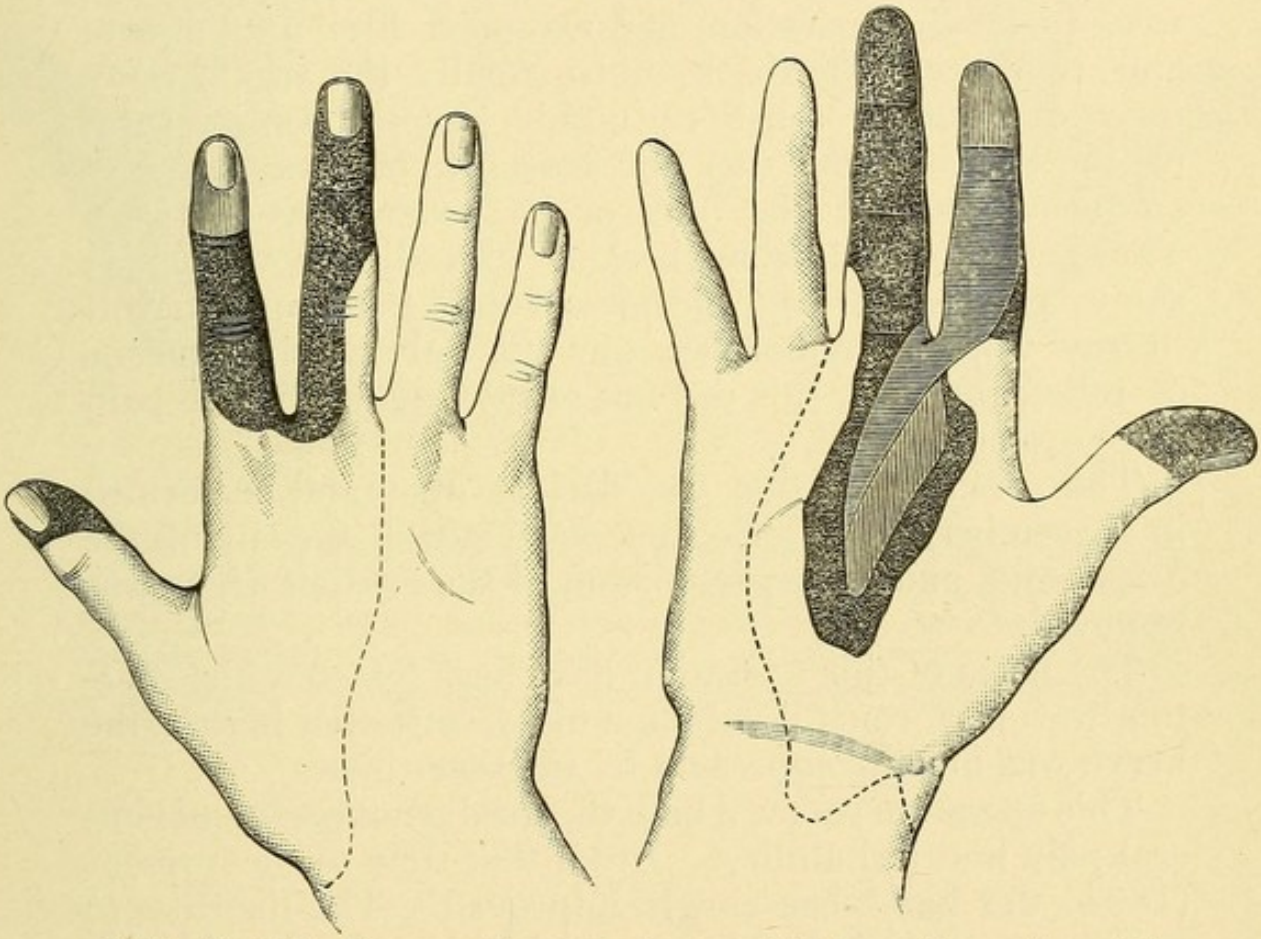
On the eighth day after the operation the hand was minutely examined, and the diagrams[1] made by Dr. Morris Lewis at that time show better than a description in words can the character of the changes in sensation. (Fig. 10.) Between the dotted lines and the continuous line sense of touch to a slight stimulation was lessened ; the area, it will be observed, was much greater than that usually described as the median distribution. This may not mean that the median territory was in this case unusually large, for such a defect might be due to a "reflex disturbance of the central perceptivity owing to the influence of the section." The dark areas, much more extensive again on the dorsum than the usual median distribution, presented loss of sense of touch, pain, and temperature. It will be observed that this distribution is a very unusual one and

[1] From "Some of the Lessons of Neurotomy," by S. Weir Mitchell, M.D.; Brain, 1878.

difficult to reconcile with the supposition of injury of the median or, indeed, of any single nerve-branch.

The territory which is marked by lines running parallel to the axis of the limb, including a small area in the palm at the base of the index and middle fingers and the tip of the index-finger, both on the dorsal and palmar aspects, was entirely without touch-sense, but a slight pinch or a decided

FIG. 10.



B. H. Case LI. Diagram of sensory changes eight days after section of the median nerve. The stippled areas have no touch, pain, or temperature sense. Area marked by lines parallel to axis of limb has no touch-sense, but is hyperæsthetic to pinch or pressure; area transversely lined is hyperæsthetic to deep pressure. Fair localization in both areas.

pressure caused agonizing, sharp pain. The area upon the index-finger and lying between its metacarpal bone and that of the middle finger in the palm, which is marked by transverse lines, was insensible to anything but a firm pressure, and this caused pain, which was fairly well localized.

From these conditions some curious conclusions may be drawn. First, while superficial sensory perception was lost, there was extreme hyperæsthesia to deeper stimulations, and with this some power to localize the seat of this pain. It was the opinion of Dr. Mitchell at the time of his study of this case that the only possible explanation was the presence of recurrent nerve-fibres, such as Bernard, Arloing, and Tripier have shown the existence of.

General pain and tenderness began to return about six weeks after the operation, and extended, first up the arm and then into the back, until finally the whole body became intensely sensitive. This general sensitiveness of the entire frame was not constant, but was brought on by any use of the limb or by general over-fatigue. The patient's condition became exceedingly wretched; she was hysterical and sleepless, could not apply herself to any work, and morphia was the only possible means of relief, and even this did not always succeed if the pain were extreme.

The second operation was decided upon and performed in November, 1877. Section was made at the site of the old wound, and a larger portion of the median nerve was removed.

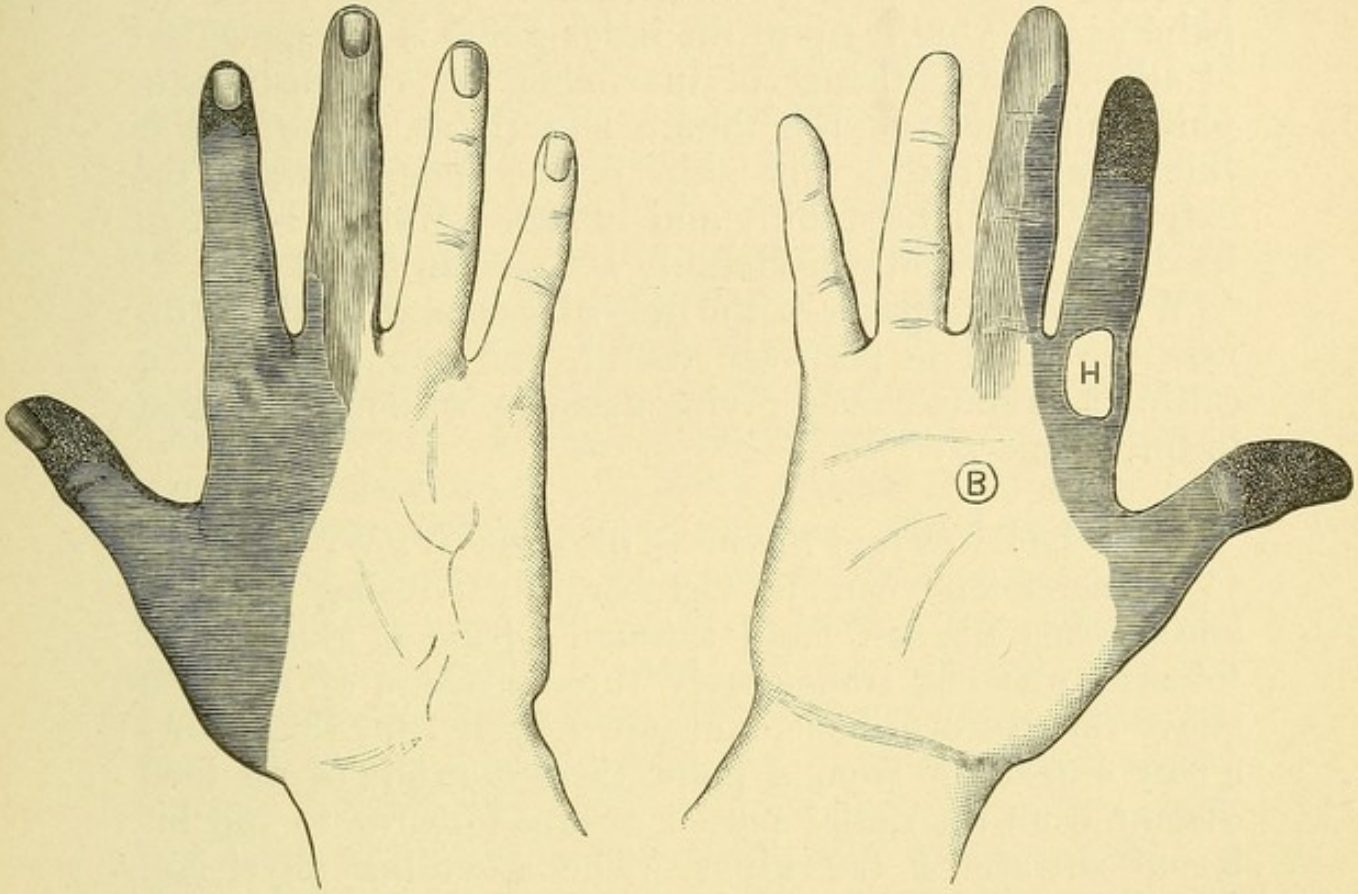
The notes of this operation have been lost, but Dr. Morton, who performed it, tells me his recollection is that the nerve was much compressed by the scar-tissue.

This operation relieved both the local tenderness and general pain and irritability. From that time to the present (1894) the hand has slowly improved. The liability to pain has never wholly disappeared. An occasional acute pain occurs in the palm. Some formication is constant, rather vaguely referred to the central part of the palm.

Localization is much impaired on the palmar aspect of the index, thumb, and adjoining palmar surface. (See diagram. Fig. 11.) A substantially similar condition is present on the dorsal surface, except that all forms of sensation are somewhat better.

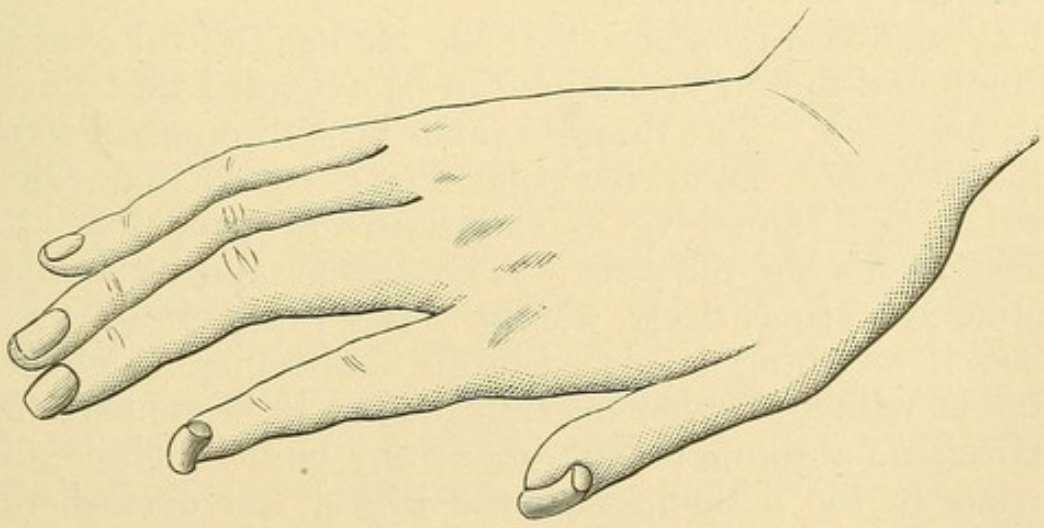
A deep pressure on index-finger below first joint (marked H in diagram), and especially near the metacarpal articu-

FIG. 11.



B. H. Case LI. Sensory changes seventeen years after median neurectomy. Touch everywhere felt except on stippled areas. Pain-sense imperfect everywhere, absent in stippled areas. Localization confused or imperfect in area of transverse lines; better, but not good, in area of lines parallel to axis of limb. Deep pressure is better localized than touch. Temperature-sense fair everywhere, except where touch and pain sense are both lost.

FIG. 12.



B. H. Case LI. Present condition of hand; atrophy of thumb, index, and middle fingers; curved and thickened nails. From sketch by Dr. J. M. TAYLOR.

lation, is felt as pain and referred to the middle of the palm at B. On the tip of the index touch is not perceived at all. All the tissues of the finger are curiously atrophied, and those of the thumb slightly so. The nail is thick and curved. The skin of the index toward the extremity is slightly shiny and bluish. Motion is lost in its distal joint and considerably lessened in the others.

With the exception of the difficulty caused by this stiffness the hand is perfectly useful, and she pursues her calling as a nurse, even giving massage, without any great inconvenience.

CASE LII. (From the notes of Prof. W. W. Keen.)—C. D., aged ten years, in October, 1891, losing his balance, thrust his left hand through a pane of glass. His forearm was cut transversely three-quarters of an inch above the pisiform bone, and now (April 19, 1892) shows a scar extending from a point three-quarters of an inch distant from the radial border of the forearm to the internal surface of the ulnar. The attending physician, Dr. Horton, of Peekskill, N. Y., states that the cuts extended completely down to the bone, severing all the tendons in the median and ulnar portions of the forearm and dividing the median nerve and the ulnar nerve and artery. The artery was, of course, ligated, and Dr. Horton desired to suture the tendons and nerves at the time of the accident, but was overruled.

Present condition, April, 1892. He has control over the thumb and forefinger, which can be extended and flexed, but are weak. The thumb cannot be well opposed to the other fingers. The three ulnar fingers are all in a state of flexion and cannot be extended, except partially, upon strongly flexing the wrist. The thenar and hypothenar eminences are entirely wasted. His grasp, however, is good if anything is placed in his flexed fingers. Sensation is with difficulty ascertained, but it is evident that there is no absolute anæsthesia at any point. The radial surface of the little finger is the dullest, but even there a light touch is perceived, though not sharply. Secondary

suture was decided upon and performed by Prof. Keen (April 21, 1892), who has kindly allowed me to use his own notes of the operation: "A longitudinal incision was made over the ulnar nerve, the incision finally being extended down over the hypothenar eminence one and a half inches below the wrist and three and one-half inches above the wrist. The upper bulbous extremity of the ulnar nerve was then seen. The nerve lost itself in a mass of connective tissue. In order to discover the distal end the cut was prolonged, as stated, over the hypothenar eminence. The ulnar nerve was here found not wasted, but about the normal size, its upper end being directly continuous with one of the superficial flexor tendons. Both ends of the nerve were loosened and resected, and both were stretched, especially the upper end. With some little tension the two extremities could be brought together and were sutured with one fine silk suture. The median nerve was next found with some difficulty. At the level of the cicatrix the two ends had united, and at the same point another tendon had joined them in a bulbous mass. I debated for some time whether to excise this mass and attach the two ends of the nerve together after stretching, but finally decided to sever the connection of the tendon with the mass, free it from its fibrous attachments, and let it alone. Should the nerve require it a later operation could be done. A rabbit had been provided, so that in case the two nerve-ends could not be approximated transplantation of nerve might be done; but, fortunately, it was not necessary. The tendons I found in one general cicatricial mass. As it was impossible to differentiate the individual tendons, I contented myself with elongating the deep flexors by the method of tenotomy described in my paper in the *Transactions of the College of Physicians.*[1] The superficial flexors I severed obliquely and attached them at a distance by several strands of catgut suture. The gap between the ends was three-fourths of an inch. The fingers were then placed in extension on a splint with the usual antiseptic dressing.

[1] Transactions of Coll. of Phys. of Phila., 1891.

"25*th*. As his hand has been dressed but once since the operation the only opportunity for testing sensation has been by touching the last two joints of the fingers where exposed on the splint. These have shown that the ring and little fingers have been devoid of sensation, the ring finger not only on the ulnar but also on the radial side. The sides of the other two fingers and of the thumb have shown sensation. To-day he perceived a prick over the ulnar fingers for the first time."

June 2, 1892. Dr. Horton reports circulation nearly normal; motions of wrist, thumb, and forefinger normal, with the exception of extreme extension of the wrist. Sensation of the three fingers is not very acute, but is returning. Blueness of the nails is going off rapidly. There is some slight contraction of the ligament of the wrist, which keeps the fingers slightly bent. The boy will not co-operate in the efforts to get movement in the fingers.

November 25, 1892. The general condition of the hand is good. The ring and little fingers are a little purplish, and also a little cold, but to nothing like the same degree as before the operation. Sensation exists in all parts of the hand. He can even feel when a single hair is drawn across any part of the hand, excepting the ring and little fingers, and over these two fingers he can feel and localize a pencil-point. Motion in the thumb and middle and index fingers is excellent, and he can seize objects, although he cannot grasp with great strength. Flexion in the last two fingers is limited to the last two phalanges, there being no flexion in the knuckles yet, although there is in the other fingers of the hand.

April 9, 1893. His hand has improved immensely with the massage and electricity. He can touch the tip and the base of each finger with his thumb, and can make a fist, the fingers being in almost complete flexion, and has a good grip. Only seeing him for a few moments, and not in my office, I could not test him by the dynamometer; but judging by his grip, there seemed to be but little difference in the grasp on the two sides. He

can also move each finger independently of the others, the motion of the ring and little fingers being nearly normal, and the others quite so. His sensation also is perfect. A large part of this improvement he owes to the intelligent daily treatment of his hand and arm by Dr. Horton, who has applied electricity, etc.

New York, April 10, 1894. The lad's father writes as follows: "As for Charley's hand, it has been gaining steadily, and he has got very fair use of it. The entire hand, as to grip, is very strong. He can use all the fingers collectively with a strong hold. Individually the second and fourth fingers are fairly strong and he can use them. The third finger is weaker and has a feeble motion individually, but nothing like as strong as the others. The palm of the hand, which had lost all nourishment and become so thin that you could look through it, now receives full nourishment, and is as fully developed as the right hand, and he is taking lessons on the piano again. This is being done with the attempt to teach him the piano without the use of the third finger. The operation on C.'s hand we deem a great success, and he has virtually the use of his hand."

CHAPTER VI.

DEGENERATION AND REGENERATION OF SEVERED NERVES.

As degeneration takes place wherever a nerve-trunk has been destroyed, by whatever means, it is proper to begin the consideration of the special symptoms resulting from these injuries by an examination of the clinical aspects of degenerative neural alterations.

The literature of the subject is of enormous extent; a vast amount of experimental work has been done upon the physiological and pathological sides. Much of this is very well known, though not so thoroughly applied to everyday treatment and diagnosis as it should be. One of the latest, most complete and conclusive presentations of the course, physiology, and histology of degenerative and regenerative change in nerves separated from their centres is the paper,[1] already referred to several times, of Drs. Howell and Huber, with whose conclusions from the standpoint of experimental pathology my own deductions from clinical observation almost absolutely agree. But it is not my intention here to attempt an exhaustive study or to discuss other than the clinical bearing of the matter.

Histological study and pathological experiment both

[1] "A Physiological, Histological, and Clinical Study of the Degeneration and Regeneration in Peripheral Nerve-fibres after Severance of their Connection with the Nerve-centres." By W. H. Howell, Ph.D., M.D., and G. C. Huber, M. D. Journal of Physiology, vol. xiii., No. 5; vol. xiv., No. 1.

agree with bedside experience in the conclusions that degeneration always takes place when the continuity of a nerve is destroyed. Many surgeons believe in the possibility of primary or immediate union "by first intention" in nerves sutured directly after section; but the evidence adduced for the very early passage of nerve-influence does not bear close examination, and physiologists are all agreed against this possibility. Insufficiently observed cases cannot be used to contradict utterly the evidence of careful physiological experiments; and the only argument against their results is that the regenerative powers of the animals used may be different from those of the human being. Admitting this, it is nevertheless a strong point that, although the physiological experimenter upon nerve-sections has everything in his favor, having the control of the extent and character of the injury entirely in his hands, yet no one of them has ever secured undoubted primary union.

Though pathologists dispute as to the manner in which degeneration affects the individual fibres and the various tissues constituting the nerve-trunks, there is a substantial agreement that the change once begun will involve the entire trunk and its branches below the injury, and probably is nearly simultaneous in its occurrence throughout the whole of the distal portion. Degeneration in the proximal extremity takes place to a much more limited extent, probably not further than the second node of Ranvier above the wound. In what one may call "normal cases," where the wound is and remains in a healthy condition, and no neuritis follows, it is probable that the alteration never passes this point.

The conclusions drawn from gunshot-wounds received in war, as has already been so often repeated, have ele-

ments of doubt and uncertainty in them which are not present in even extremely severe wounds of civil life. The contusion, concussion, and general shattering of tissues from the passage of a bullet are very great; the extent of the resulting lesion of the nerve is often far wider than would happen from a cut, a bruise, or even a bad crush, such as are seen daily in our hospitals. Then, too, a better chance for recovery is given to the latter forms of injury by the greater promptness of surgical assistance, the early cleansing and closure of the wound, etc.

The progress of the degenerative process is shown not only by loss of motion and sensation, but, after a few days, by the appearance of the reaction of degeneration in the muscles supplied by the cut nerve. Where union of the separated parts of the nerves has been effected, either by the aid of an operation or by the unassisted efforts of nature, new nerve-fibres are constructed, the process of regeneration proceeds centrifugally, and after a period varying very widely in different cases, even under seemingly similar conditions, there is a return, first, of sensation, which usually attains to a certain degree of completeness before motion begins to be regained. On the other hand, motion may return in some form and sensation remain impaired. This less common result was seen in XV., XVI., and XXV. Sometimes motion never returns, even though sensation may have become nearly perfect. (See XVIII. and XXI.)

Howell and Huber suggest for this a very reasonable explanation: "The first stage of regeneration, the embryonic fibre, possesses a low degree of irritability and conductivity; and once union is made at the wound, a way is opened for the passage of sensory impulses before complete regeneration of the peripheral end is accomplished.

For the motor fibres, on the other hand, the peripheral regeneration must have progressed as far as the muscles, and must, in addition, have involved the reproduction of connections with the muscle-fibres. In the clinical cases sensibility was, of course, tested in the skin; but there is, perhaps, still a possibility that if the regeneration of the motor and sensory fibres have made equal progress to that point, the sensory fibres first show evidence of a return of function, because there is less to be accomplished in their case in the way of making peripheral connections. Of course, this is a mere suggestion, which can have no special value unless verified by actual observations."

In *Gunshot Wounds* an additional possible reason is given for the early return of sensation: "When a function is partially paralyzed its continued exercise is one of the conditions of its ultimate return to full activity so soon as the neural injury has become repaired. Now, the sense of touch is in constant automatic use, so to speak, every contact being a continuous stimulus to its activity, and the very fact of deficient feelings subjects the part to rough and unusual irritation. . . . . This may explain, in part at least, the early disappearance of sensory paralysis in cases where the function of sensation seems to be as much affected at the outset as that of motility. . . . . The skin is all the time stimulated, whether we will or not. The muscles which volition has ceased to move with ease have no such incidental stimulus. Accident and position do for the skin what artificial agencies must do for the muscles, if we desire to sustain their nutrition and restore their power."

As to the time which these processes may take, degeneration of a cut nerve-trunk is usually complete in about thirty days; but it would seem from the history of some

of our cases that no lapse of years is sufficient to forbid the possibility of improvement. Decided bettering of motion took place in several more than twenty years subsequent to the injury, after the condition of the part had remained at a perfect standstill for a long interval.

Gradual improvement in sensation, no matter how slight, makes the prognosis for the ultimate return of motion better. The regeneration, as physiological experiment has repeatedly shown, begins in the neighborhood of the injury and gradually extends peripherally. During the early part of this process some disturbance in the performance of the functions of a nerve in process of recreation might be expected and does occur. A mis-reference of touch-sensation is a common symptom of this stage, and is probably an incidental condition of the return of functional activity to a nerve. For instance, XVII. (section of brachial plexus) referred touches upon his fingers upward, sometimes mistaking a contact with a finger-tip for a touch at the elbow. But usually his perception was not further wrong than from finger-tip to wrist, often not so far as this. A touch to the third finger's palmar surface he referred to the middle of the palm; on the back of the same finger he made a precisely equal mistake. A plausible theory might be framed to account for such misconceptions as these; but it would be hard to make it explain the fact that he always perceived a touch anywhere about the elbow, as in the hand, while on the rest of the forearm tactile sense was fairly accurate. XXIII. had received a more limited and less severe injury, a division of the musculo-spiral nerve. He made constant similar mistakes in perception of touch upon the fingers, always referring the contact upward, but only half an inch or so. The notes in XXVI. are based

upon the man's own statement, and describe imperfectly the original injury; but it does not seem probable that there was at first serious lesion of the median nerve, which later began to give him pain. Touch-sense was impaired, and where it was best the contact was consistently referred *downward.*

In spite of these exceptional and confusing examples, the rule clearly is that tact is perceived as if nearer the trunk than its real point. That is, the mis-reference is usually toward a region of more distinct sensation. This offers another proof that regeneration of the nerve progresses centrifugally. It may be, too, that an impulse peripherally received is reinforced in its movement toward the brain. The parts nearest the centres carry sensation earlier than the portions further removed. In XLIV. the improvement of motility distinctly proceeded centrifugally, as in Etzold's cases.

If a nerve is regenerated perfectly, this faulty translation of contact-sensations gradually disappears; but if, as happened with XVII., improvement ceases, the mis-reference will persist, with only so much of improvement in accuracy as is gained by education of the perceiving-sense; the brain in time may learn to interpret the message rightly.

Upward reference of touch was first thus described in *Gunshot Wounds* as a symptom of regenerating nerve-tissues, and was there stated to be the only mis-reference made in such cases; but, in view of the several different conditions here described in XVII., XXIII., and XXVI., the statement will have to be modified somewhat.

The difficult problems presented for our solution by these mis-references seemed so interesting that I requested

the opinions of Prof. W. H. Howell, of Johns Hopkins (to whose most valuable paper I have already mentioned my indebtedness), and of Prof. H. Münsterberg, of Harvard, on this subject. The replies which they were kind enough to make to these queries will be found in the Appendix.

When any form of injury has caused a solution of continuity in a nerve the break may be filled up by the renewal of the nerve, and perfect motion and sensation be regained without surgical aid. This tendency to regeneration is our chief reliance in cases of nerve-suture, and every surgeon has seen it happen in operations for relief of facial neuralgia when, after a certain time, usually a year or more, a second operation is called for by the return of the pain, and the branches upon which neurotomy had been performed are found completely regenerated and supplying the same territory as before their section. A considerable distance intervening between the cut ends does not seem to be any bar to this growth. The inferior dental branch of the trigeminal nerve is peculiarly favorably situated for the occurrence of such a regeneration; the canal in which the nerve lies supplies it with a guide, so that the regenerating fibres have but to continue their growth, not feeling their way, as in the soft tissues they must, through masses of cicatrix; and it has happened upon at least two occasions within my personal observation, that an extent of two inches of this trunk has been thus renewed.

That in gunshot-wounds this so seldom occurs is due in part to the nature of such wounds. The extensive destruction of surrounding tissues by the passage of the projectile results in the formation upon healing of a large and firm cicatrix, through which regenerating fibres cannot reach to rejoin their peripheral extremity.

In the accounts of cases where regeneration after suture has seemed to occur with extraordinary rapidity it will usually be found upon careful examination of the histories that the symptoms have been very imperfectly studied. It is rare to find any report of the electrical condition of the muscles, either before or after suture. Such an omission before the attempt at repair is easy to understand; in presence of the immediate necessity for closing the wound and leaving it undisturbed when dressed it could scarcely be expected of the surgeon to make this minute examination; but when such a case is reported to have shown evidences of return of sensation,—and it will be observed that the reappearance of motion is rarely noted as happening so early,—it certainly would be but a wise precaution to make a complete electrical study of the conditions of the muscles and nerves whose functions are supposed to have been interfered with before proclaiming these remarkable results. On examination of such cases where details are given two things will at once strike an observer who has had much experience of neural surgery: First, that a majority of these rapid improvements have occurred in the median nerve; second, that the site of the injury was nearly always low down in this nerve, near the wrist.

The hand is so elaborately supplied with nerves arising from the three trunks of the median, radial, and ulnar, that, except for the little finger, it is impossible to destroy sensation completely in any part of the hand by section of a single one of these nerves. The muscles of the hand and forearm act largely in groups. These groups are supplied by all the different nerves of the forearm. For instance, the forearm is flexed by the combined action of the biceps and brachialis anticus, the pronator radii teres and supinator longus sharing in the action in certain posi-

tions. These four muscles receive their innervation from three nerves: the biceps from the external cutaneous (musculo-cutaneous), the brachialis from the external cutaneous and the musculo-spiral, the pronator from the median, and the supinator from the musculo-spiral nerve. The two latter muscles act as flexors only under certain conditions: when pronation is complete the further contraction of the pronator radii teres assists in flexion of the forearm; when the limb is in supination the continued action of the supinator longus flexes the forearm. Thus, although the external cutaneous supplies one of these muscles entirely and one in part, its section would not wholly remove the power of feeble flexing. If the musculo-spiral and median nerves were both destroyed, the external cutaneous would still supply muscles sufficient to perform the movement. Indeed, the only groups of hand-muscles exclusively governed by one nerve are the extensors, which receive their impulses from the musculo-spiral, and the interossei, supplied by the ulnar. The complicated movements of the thumb, largely directed by the median, may yet be performed with some approach to completeness by muscles innervated from other trunks. The whole subject has been so thoroughly treated by Létièvant and others that it would seem unnecessary to discuss it at any length here, but the notes of LI. may usefully be examined for an illustration of some of these points.

The prompt renewal of sensation after section of a nerve is even less good an evidence of completed union. In the first place, sensation may be suspended for a time after the reception of a wound by shock, and with the disappearance of this cause functional power rapidly returns. Again, it is even more widely true that sensation may be taken up by other than the nerves ordinarily supposed to be con-

cerned in the sensory supply of a part, than that motor power may thus be substituted from new sources. In fact, a collateral nervous communication by anastomosing fibres may be made, fairly comparable to the collateral circulation which is so soon established after the ligation of an artery. It will probably be found that deep sensibility, such as the perception of pressure, returns before superficial sensation. This happened in XLIV., where, although the whole brachial plexus had been overstretched and sustained the several other injuries described, deep pressure was somehow felt when no return of superficial sensation had taken place; and in LI., although superficial sensation is lost, deep pressure is still felt as acute pain. When a mixed nerve is divided the motor is always greater than the sensory loss, or at least it is more persistent. Much not very profitable argument has been spent upon this question. Either sensory fibres can conduct an impulse in some sort of fashion when they are in an injured or imperfect condition, or their recovery is much more rapid and ready than that of motor fibres. Again, there is the constant stimulation to which they are subject (as suggested in a former quotation from *Injuries of Nerves*), and another fact is also to be remembered, that in the hand, the nerves of which have furnished the largest number of examples of rapid return of sensation after section, the anastomoses are more numerous than in any other part of the body, and supplementary sensation correspondingly more perfect. Possibly, too, the stimulation of a sensory nerve may be felt by the brain even when very imperfectly transmitted to it, when the coarser apparatus of muscular motion is not in condition, either because of the damaged state of the efferent nerves or of the end-plates, to transmit or translate into action the message returned from the centre;

and, lastly, there must be a large element of individual difference in patients, for after injuries that seem to an examiner precisely alike one patient will be found to retain sensation while another has completely lost it.

One of the few instances of primary suture very thoroughly reported is Monod's,[1] and it alone is sufficient to answer the argument on the other side from a number of less thoroughly studied cases. The median nerve was divided by a razor in the lower part of the forearm, with loss of sensation in the territory of the ulnar as well as in that of the injured nerve. The ulnar was, however, not at all hurt, and the sharp instrument used could not have bruised or compressed it. By the next day sensibility was perfect in the ulnar region and greatly improved in the median. In less than three weeks those movements of the thumb which are supposed to be governed by the median nerve had begun to improve, but when an electrical examination of these muscles was made it was found that those innervated by the median were still completely paralyzed, and that the movements were performed by the substituted action of the muscles governed by the ulnar and musculo-spiral nerves.

Besides the testimony of the electrical examination, additional evidence may be drawn from a minute examination of the sensibility. The most important sign of the perfect return of sensation, as Tripier has insisted, is the ability to discriminate the points of the æsthesiometer as two when but moderately separated. No matter how good common sensation may be, if this localizing-sense is imperfect the nerve is not regenerated to the point of doing its full duty.

[1] Bulletin et Mém. de la Société de Chirurgie, 1886, xii. p. 933.

In point is Baudens' case, quoted by Paulet,[1] in which the median, ulnar, and other branches of the brachial plexus were severed by a sword-cut in the axilla. Suture was performed, and eight days after the patient died of hemorrhage. During this time sensation in the territories of the injured nerves was never wholly lost, but at the post-mortem examination the ends were found, not only not united, but not even in contact.

Etzold[2] cites from various authors other like cases. Several causes enter into the question, making it excessively difficult to decide with absolute certainty the question of the intact condition of nerves when judged by the presence of sensibility alone. Létièvant, Weir Mitchell, and others have insisted upon the source of error caused by what the former calls "collateral dispersion" of touch. Again, no one can see many operations upon superficial nerves without noticing the frequency of variation in the areas applied by skin nerves from the usual descriptions of the books.[3]

An instance of very excellent recovery after a severe

[1] Mém. de la Soc. de Chirurgie, 1869, t. vii.

[2] Deutsche Zeitsch. für Chirurgie, xxix. p. 430.

[3] We are accustomed to regard the nerve-supplies of the hand as varying but little from the distribution ordinarily given in the anatomical books, and perhaps we are right in this; there are not often very gross or very marked differences in this respect. But we do not sufficiently remember how varied the possibilities of motion in the hand are, and to what an extent the action of one muscle may be substituted for that of another. The median nerve ordinarily supplies in the hand the opponens pollicis, the abductor pollicis, the outer head of the flexor brevis pollicis, and the two outer lumbricales; but the abductor has also a twig from the radial, and the third and sometimes even the fourth lumbricalis are now and then found supplied by the median. While the interossei are all governed by the ulnar, the paralysis which results from destruction of that nerve may easily be covered by the supplementary action of these median muscles. To a less degree the reverse is also true, for the ulnar supplies, in conjunction with the median, the flexor digitorum profundus, the abductor pollicis, and the inner head of the flexor brevis pollicis, as well as the whole of the little finger.

accidental injury of the forearm, with complete section of both the median and radial nerves, and of nine muscles in the forearm, seven of which were sutured, is XXVII. This patient, under industrious and long-continued treatment, regained nearly perfect motion and sensation. The ultimate prognosis in cases of primary suture may be considered as very good; better, like other nerve-injuries, the younger the patient. Perhaps, too, the chance of recovery where only one nerve has suffered is better than where two or more are involved in the wound.

Etzold, already quoted, has given very elaborate details of six cases of division of the cords of the brachial plexus by sword-thrusts in the axilla. All of them were in University students between twenty and twenty-three years of age. The results were, of course, less favorable than if a smaller number of nerves had been divided, but there was decided improvement in four out of the six. Distinct regeneration could not be made out in the first case until after six years. In the second case marked improvement was manifested at the end of over four years, and in the third case in over three. In the fifth, in which all of the motor nerves of the arm were sutured, good evidence of regeneration in the radial territory appeared after six months. The author especially notes that in these cases improvement clearly proceeded from above downward.

Into the final condition of parts cut off from their nerve-supply other elements besides the loss of nervous control of motion enter. The impairment of nutrition, due to the absence of the trophic government of the part by its nerves, entails a further loss of motor power, sometimes so great as to interfere with perfect recovery, even when neural conductivity has been re-established.

Disuse alone is not sufficient to cause the muscular atrophy which is seen after nerve-wounds. If the nervous influence is not withdrawn, and the part merely loses the power of movement, as in cases of hemiplegia, the muscles soften and lose their tone, but in most instances do not greatly waste. Where the trophic control has been wholly removed by section of the nerve, not only does great muscular atrophy result, but muscular contractions sometimes appear, most commonly, however, in the groups opposed to those whose supply is derived from the wounded trunk.

For the real cause of these contractions we search in vain. They occur in some cases; in others equally bad in every respect they do not, though some fault of early treatment may be at the base of the trouble. A state of slight tension is the normal condition of a muscle; when this is not balanced and hindered by a similar tonus in the group performing contrary functions a shortening of the unopposed muscles occurs, and once established is with great difficulty and pain overcome, especially as it is very often associated with joint-stiffening. The muscles may have an extraordinary persistence in this contraction, which not uncommonly remains unrelaxed for years. An obstinate insistance on treatment by manipulations, however painful, and on frequent breaking up of the adhesions, may help. Assuredly, without these, time will not. But these evils may all be avoided by proper early management, and should never occur in civil cases, where the patient comes at once into the surgeon's hands.

Again, that disuse cannot be the only factor in the production of the extreme nutritive changes appearing in limbs whose neural supply is withdrawn, is shown by such trophic alterations as the aberrant growth of the nails,

the skin affections, bullæ, ulcers, etc., which occur, and by the occasional arthritic complications arising. These are not all or always neurotic in their causation. The results of absolute inactivity of the part, such as we have when an arm has been for an unreasonable time upon a splint (IX.), closely resemble them.

It may be that as motion is one condition of normal life of joints and muscles, immobilization by splint or by paralysis may be an assisting factor in causing joint-lesions, atrophy and contractions. Certainly trauma may be. Thus in Goodwin's case, an accident to the shoulder-joint at the time of paralysis served to determine an arthritis of extreme severity, probably begotten of two parents, the direct injury and the palsied condition of the limb, for every other articulation in the left arm also became diseased in time; but the trouble in the shoulder-joint occurred too early to be probably only neural in its origin.

Brown-Séquard's opinion was adopted by Charcot, namely, that trophic alterations were more common after contusion, puncture, or incomplete section, than after entire division of a nerve-trunk; that is to say, after such traumas as most commonly produce neuritis or neuralgia, his view being that "trophic irritation" resulted. It is more reasonable to suppose that the loss of trophic control is the real cause, and, though their separate existence is still a disputed point, there is yet strong evidence, clinical, physiological, and pathological, for the presence of trophic nerves.

CHAPTER VII.

TREATMENT.

In all cases where injury of a nerve is suspected the first indication is to discover exactly the extent of the neural lesion, for upon this the next step in the treatment must rest. A simple slight contusion, stab, or partial division of a nerve, if not complicated with much bruising or destruction, calls for no special treatment beyond the careful closing of the external wound and the taking of unusual pains to avoid inflammation, leaving the rest to natural processes of repair. The member should, if possible, be placed upon a splint, and in such a position as to enforce relaxation of the hurt trunk.

It is of the highest importance, where the parts in the neighborhood of the nerve are injured, to secure healing with the smallest possible quantity of cicatricial tissue, as the density and amount of the scar-formation may seriously interfere with regeneration, or may cause secondary pressure upon the nerve. It has, too, been pointed out that some authors contend that neuritis occurs only in open wounds, and, although this cannot be said to be a proven fact, yet it has sufficient authority to cause the taking of extra precautions to secure thorough asepsis. The surgeon of to-day has great advantages in this respect over his colleague of thirty years ago, for an aseptic wound is practically not an open wound in the sense of the elder surgical definition.

Of the utmost consequence for the repair of wounded nerves is absolute rest of the part involved, which must be secured by position, by splints, and by strict injunctions to the patient. If, after healing is apparently complete, there should still be pain present or increasing, scar-pressure may be suspected; if these symptoms be severe, surgical interference need not be delayed; but it is often found that time is the one thing needful for cure of these lesser pains, which disappear as the parts grow accustomed to their new relations. Thorough, but not hard, massage is a great help in the removal of small degrees of compression from the cicatrix, promoting the softening of hard and the absorption of soft exudate, and thus releasing the nerves from pressure and advancing their recovery. If a reasonable time elapse and improvement still does not result from this line of treatment, an operation for the exploration of the wound should be undertaken, and if the nerve be found caught or compressed, it should be released. Successful instances of such interference are related in the second operations upon XLIII. and LI., and a typical case where such help should be rendered is VI.

Next, to take up in order the treatment of the different varieties of nerve-lesions, we may first consider contusions. Contusions, as has been said in the chapter devoted to hurts of that character, are apt to have serious possibilities quite out of proportion to the apparent extent or severity of the original damage, no doubt from the displacement of myeline by the blow or by concussion. In contusions, as in all other forms of neural injuries, the first indication is for perfect rest, a means which, like more active therapeutic measures, should be used with watchful care, lest in the effort to help we overdo, and by too prolonged inaction impair the functional ability of joints and muscles.

To some extent this may be avoided by passive movements and light massage; the latter properly applied will do good even if neuritis be present. For the details of this manipulation reference must be made to such special treatises as those by Kleen[1] and Graham.[2] It should be borne in mind that the intelligent and trained masseur can handle tender nerves to advantage even at a very early period, and sensibly reduce the pain and hyperæsthesia by his manipulation. Even in inflammatory states the later occurrence of trophic disturbances may be minimized or prevented, the products of inflammation removed, and a much more favorable course promoted by these means.

It is not necessary to distinguish between the treatment of contusions and that of compression of nerve-trunks. Should neuritis result from either of these causes the treatment must be directed to that complication, a subject of sufficient importance to demand separate consideration later.

When complete section of the nerve is certain and can be verified by direct examination, no time need be lost in applying sutures to bring the cut ends into apposition, after which the wound may be closed with the same precautions to secure absence of tension and early healing that have been already recommended. Should any doubt exist as to the character or extent of the injury, so very little harm can arise from twenty-four to forty-eight hours' delay that this much time may well be given to observation of the condition of the part, remembering the numerous recorded cases in which there was at first a loss of power or of sensory ability so great as apparently to make certain that there had been destruction of a nerve, which yet within

[1] Handbook of Massage.

[2] Treatise on Massage.

a day or two gave evidence that motility and sensibility had returned, making necessary the conclusion that the injury had been no more than a shock, with the addition of what Létièvant calls "local torpor" from it. If uncertainty as to the extent of damage should still continue at the end of this period of waiting, a direct inspection may be made, if necessary by enlarging the wound, and treatment may then be suited to the condition discovered. So far as the union of the nerve is concerned, primary suture will give no better ultimate result than an operation at an interval of a month or six weeks; but it is of course preferable, should suture be required, to perform it at once, that a second wound may not have to undergo healing.

If the conclusions of the previous chapter as to the impossibility of immediate union in severed nerve-trunks be correct, primary suture has no great advantage over secondary, since regeneration cannot take place in either until degeneration has occurred. I think it will be found, if cases equally favorable are chosen, and are minutely examined, that movement and sensation appear sooner after the operation in cases of secondary than in cases of primary suture; and Professor John Ashhurst, Jr., stated to me that he could confirm this from his own observation. The reason is obvious. In the primary suture, before the conductivity of the nerve can be restored, degenerative changes occupying some weeks must be undergone, and subsequently regeneration has to take place. In the case of secondary suture, degeneration is already complete, possibly regeneration has begun, and the interval is thus shortened.

On the whole, the results of suture are so successful that it would perhaps be proper advice to say, "If in doubt, suture," and this is the conservative course in any com-

plete section of the nerve, for while a nerve may reunite with perfect return of motility and sensibility without the surgeon's interference, yet its chances are surely better if the ends are placed and held in apposition. Whether the injury is recent or old makes no difference in this respect; but in those of long standing the condition of the nerve must be more carefully looked at before suture. If, as is usually the case in stumps of old amputations, the nerve extremities are found bulbous, or if they have been crushed by a projectile in the wound, or much stretched by the blow of a dull cutting-instrument so that the sheath is torn, the proper course would be the removal of the injured portion, taking, of course, as little as possible from the nerve, and then suturing. Should it be necessary to cut off so much of the nerve that the extremities cannot be readily brought together by relaxing the parts, the nerve may be gently stretched without serious damage resulting. In the arm-nerves about an inch may be gained in this way. If the loss of substance, whether by the injury or by the ablation of bruised or bulbous parts of the nerve, be so great that stretching will not bring the ends into approximation, one of the several operations of splicing or grafting may be attempted, either by making flaps from the nerve itself, as has been done by Létièvant, Beach, and others, or by the actual insertion of a portion of a nerve from another person, or from an animal, into the gap between the extremities. Hitherto no great success has attended these latter operations. Mr. Atkinson, of Leeds, has reported[1] several cases of his own and his colleagues, Mr. Mayo Robson and Mr. Ward. The first of Mr. Robson's is described as a success, although this is hardly warranted by the description of the after-

[1] British Medical Journal, September, 1891.

condition, and the case seems to have passed from view at far too early a period to be sure of its ultimate fate. Mr. Ward's case gave no sign of improvement seventeen months after the operation. Mr. Atkinson's own, in which he transplanted a nerve from a rabbit in the place of two and a half inches of lost ulnar nerve, appears to have been rather happier in its results.

Mr. Mansell Moullin[1] has reported another case of nerve-transplantation in which the description of the case, both before and after treatment, is much more satisfactorily full in its details than the ones just quoted. The original injury was a compound fracture of the left humerus, at the juncture of the middle and lower thirds, as well as a simple fracture about the middle of the radius. The muscles around the humerus were very badly torn, the triceps almost severed. The fracture of the humerus did not unite, and two years and a half after the accident an attempt was made to secure union by stripping the periosteum from the bone and wiring the ends. The musculospiral nerve was not seen in this operation. Three months after the operation the patient began to notice some loss of power in the extensors of the wrist and fingers, which grew rapidly worse. An exploratory incision was made, in the hope that the nerve might be found compressed in the callus, but it could not be discovered, and nothing was done. About three years after the operation an attempt at transplantation to supply the place of the musculospiral nerve was made. The nerve was found much bound down by adhesions; it was dissected out and about two inches of it removed. A sciatic nerve freshly taken from a young rabbit was inserted in its place and sutured at each end. The wound healed perfectly, and the day fol-

[1] Lancet, vol. i, 1893, p. 1516.

lowing the operation sensibility was described as follows: At the root of the thumb there was an area of almost complete anæsthesia, extending on to the back of the hand. On the back of the thumb the skin was a little more sensitive. On the back of the two first fingers a scratch from the point of a pin could be felt, but not a touch with its head; and on the third day after the operation hyperæsthesia was noticed over the proximal phalanges of the index and middle fingers; two days later this had disappeared, and, so far as the fingers were concerned, the sense of touch was almost normal. The patient could feel and localize the contact of a wisp of wool. The area of anæsthesia on the back of the hand contracted until it was limited to a small patch the size of a shilling at the metacarpo-phalangeal joint of the index-finger. The muscles were galvanized for ten days. They reacted well to strong faradic currents, but, although treatment was continued for some months, "voluntary power was not regained, and the wasting eventually became extreme;" that is to say, no general improvement resulted from the operation, which was indeed postponed so late as to make a cure most improbable. The sensibility, evidently at first lessened by the operation, was afterward replaced, as has been seen in some of the other cases, by the supplementary action of surrounding nerves. Any minute examination of sensibility, beyond the brief statement quoted above, does not appear to have been made before operating.

Mr. Moullin's remarks upon this case apply to almost all such instances. He says very truly that it is difficult to judge of the results of such operations owing to the incomplete character of the published reports. On his own case he comments that, as frequently happens when a nerve is divided, sensibility was never absolutely lost.

"The rapid improvement which took place after the operation, and which began almost at once, was probably due to the increased attention the patient paid, and to the experience he had gained as to what was wanted of him. The gradual contraction of the anæsthetic area can only have been caused by the vicarious activity of the other nerves, those especially which enter into such free anastomosis with the terminal filaments of the radial nerve;" and he finally proceeds to emphasize what has been here insisted upon several times, namely, that it seems advisable that the test of restored sensibility should be dropped altogether, and only those cases considered successful in which the motor points of the separate muscles have been systematically examined electrically. Judged by this standard we should see but few fortunate cases. I cannot say that any have fallen under my notice in which transplantation has been a success.

Still less favorable have been the results of the attempt to provide a passage for the regenerating trunk by the use of a tube of decalcified bone in the wound, and it does not appear to be an operation which can be recommended, although, as in XLIII., it may be useful for the protection of sutured nerve-ends.

A species of grafting of which very little proof has been made upon human subjects, but which, according to the physiological experimenters, should have possible usefulness, is the attaching of the peripheral end of one nerve to the proximal end of another where the proximal extremity of the first is not available for any reason. The central trunk soon learns to transmit messages to its new graft in a proper manner.[1]

[1] Després.

The treatment of the various consequences of nerve injuries may be taken up under the following heads: Disturbances of sensibility and motility; of nutrition, including contractions and arthritic complications; and, finally, neuritis. Much has already been said incidentally to suggest the proper ways of handling the interferences with sensation and motion which result from neural wounds. While the nerve is undergoing its inevitable process of degeneration, every effort should be made to keep the muscles in the best possible condition, so that there will be less ground to gain when regeneration shall have taken place. As has already been said, the muscles may be exercised by massage and passive movements, and by the use of electricity.

At first, at any rate, they will be found to retain their excitability to faradism; but if they lose this, as they will in the course of the degeneration, galvanism may be used instead; in fact, in these conditions, as in all others where we wish to use this agent, the rule may be formulated briefly by saying: Apply that current which will produce the most motion with the least pain. If at first the muscles do not react even to galvanism, the application should nevertheless be daily repeated, and it will often be found that after several treatments the sensibility to this form of stimulation will return. The only contra-indication would be the presence of neuritis with consequent pain upon movement. Alternate hot and cold spongings or douches will also be found useful by promoting the circulation, and the water used should be as hot and as cold as can be borne, and be applied for two or three minutes of the one and then an equal time for the other, repeating each about thrice.

By massage is meant a very different operation from mere rubbing. It should be deep enough to affect all the

tissues of the part, to stimulate the movement of the blood in the deepest-lying vessels,[1] and, when once the nerve is able to bear handling, this should be thoroughly carried out, no matter what pain it may cause to stiffened and disused joints and muscles. Should it be desired to treat the loss of sensation, electricity may be used as a stimulant, with a wire brush upon the dry skin, and here, too, the alternate hot and cold douching is useful, and superficial massage, especially pinching of the skin. Counter-irritation by very strong stimulating liniments, such as hot turpentine, is likewise of service.

It is sometimes found after incomplete section or punctures, even when there is no evidence of neuritis, that there is much pain. Formerly the only means of relieving this would have been by the use of a general anodyne, such as morphine, by the mouth or hypodermatically; but cocaine by hypodermatic injection will often serve as well for the relief of such pains and without the bad systemic effects of the opiates. Besides this, we may use for the neuralgias consequent upon wounds local abstraction of blood by leeches, counter-irritation and dry cold applied by means of ice-bags; in fact, the treatment of traumatic neuralgia differs but little from the treatment of neuritis, and measures for the relief of the one may equally serve for the other, the distinction being rather of degree than of kind of suffering.

There was lately under my care a patient with a subacute neuritis of the whole arm. It did not appear to be more clearly localized in one nerve than in another; it

[1] The extraordinary general increase in the corpuscular elements of the blood which may be brought about by thorough general massage is also to be borne in mind. This is discussed at length in a paper by the author in the American Journal of the Medical Sciences, May, 1894.

reached no very high degree in any of them, but all the trunks of the forearm and hand were tender, and this tenderness ran up the median, diminishing as it ascended, so that the neighborhood of the plexus was not at all hyperæsthetic. It was never severe enough to call for the use of morphine, except in rare occasional exacerbations, and even then the patient strongly objected to being put under the influence of an opiate, so that of necessity every other means in turn was tried for the relief of the suffering. The application of ice, usually a very satisfactory method of diminishing the irritation in a slightly inflamed trunk, was excessively disagreeable to the patient, and a few days' use of it evidently made the pain much worse; but this increase was almost instantly relieved by the use of moist heat, enveloping the whole arm in cloths wrung out in hot water and covered with oiled silk. She found, however, nothing which so soon and so steadily relieved her as repeated superficial cauterization; the Paquelin cautery must have been used in all hundreds of times over the course of the forearm nerves, and always with benefit, so that she would disappear for a time when improved, and in a few weeks, having had a slight relapse, turn up again, begging to have the cautery used; but in spite of every care and attention, no permanent bettering has resulted, nor, on the other hand, has there been any spread of the inflammation or any great increase in the amount of suffering, and the case remains, after about two years of treatment, much where it was at first.

The most difficult and unsatisfactory of all the sequelæ of nerve-section to treat are the contractions which sometimes appear, especially where it has been necessary to keep the limb long immobilized, and the arthritic troubles which develop in occasional cases without any very evi-

dent reason. They sometimes occur very early, one case being reported in *Injuries of Nerves*, in which the joints of the fingers swelled upon the third day after a ball-wound of the brachial plexus. Much more commonly, however, the joint inflammation is a late consequence and follows a secondary neuritis. Examples of this disabling and deforming affection are seen in XVII. and XVIII. In cases like the former, where this was a very large part of the trouble, but little improvement has resulted with lapse of years. In the earlier and less severe instances some good may be done by insisting upon passive movement and even breaking up the adhesions under ether. Tenotomy in extreme cases may at least lessen the inconvenience, and, with thorough-going and persistent after-treatment, restore some degree of usefulness. Where the contracture has not lasted so long as to have caused adhesions, injections of atropine into the body of the affected muscles, to the limit of physiological effect, have a proven usefulness.

The treatment is less unsatisfactory when these lesions have been caused or increased by long-continued rest in one position; but whether they are due to neural injury or to disuse, or to both combined, their presence decidedly lessens the chances of usefully complete recovery. In Chapter III. the difficulty of distinguishing between ankylosis from nerve disease and stiffening from lack of functional activity or enforced rest has been discussed. Nothing in the condition of the joints will tell us which is the acting cause in any particular case. Only minute observation of all the circumstances of the injury, the subsequent history, the electro-muscular contractility, the tactile and other sensibility of the patient, will aid in this determination. Any great degree of impairment of motion in a

joint is unfavorable, good motion seldom returning with whatever care the patient is handled, and persistence in the necessarily painful manipulation of the affected joints is the one hope for recovery.

In neuritis the first symptom which needs attention is the furious pain. For this anodynes must be used, at least for a time. Where cocaine relieves, its injection should be frequently repeated. Nothing is to be gained in the administration of morphine by its hypodermatic use in the neighborhood of the seat of pain; but with cocaine it is necessary that the needle should be inserted as near the tender nerve as may safely be. A combination of cocaine and morphine is occasionally of more value than either of these drugs alone.

If the neuritis last long, causalgia will often appear, though less common in civil cases than in the exhausted patients of whom so many were seen in hospital during the Rebellion. No treatment better than that suggested in *Injuries of Nerves* has been added to our knowledge in late years. For the burning pain water-dressings unceasingly renewed seem to be the most satisfactory means, other than the hypodermatic use of morphine. This form of pain makes an exception to the rule as to the locality in which morphine should be used. An injection affords much greater relief when given in the tissues in the neighborhood of the pain. Ice, an application of great value in the less acute forms of neuritis, cannot usually be borne when causalgia is present or during the active stage of the inflammation, and repeated blisters or cauterization are the only things which seem greatly to help the torture. No general treatment, except what individual indications may call for in the way of tonics, is of any value. If, in spite of every treatment, the neuritis persist,

nerve-section should be resorted to. A simple neurotomy may be enough, if the general health is good and the inflammation not very severe or very extensive, giving time to the nerve to recover, and having, of course, no further influence than the removal of a source of pain by cutting off the central connection. If the inflammation be widespread or very intense, probably an operation which will give longer rest than this will be necessary, and here we may try the effect of a resection of part of the nerve. In this, as in neurotomy, the first point is to make sure that the operation is done sufficiently high to get above any diseased tissue. Then in large nerves a portion of an inch or more may be removed, with an eye to the future possibility of a secondary reunion of the divided nerve by suture after the four weeks necessary for degeneration have elapsed. Perhaps, as an operation less radical than neurotomy, nerve-stretching may be recommended for the slighter cases.

APPENDIX.

THE questions asked in the circular addressed to former patients of the Turner's Lane and Christian Street United States Army Hospitals were as follows:

I. How are you as to the sensation of touch in the parts injured? How do you feel heat and cold? How strongly do you feel a touch, and do you feel it as a pinch or a prick? Be as exact as possible, please.

II. How much movement have you in the part injured, and what powers have you lost and regained?

III. To what extent is the limb shrunken?

IV. What changes, if any, are there in the odor of the secretions from the injured part?

V. What changes are there in the character of the hair upon the injured part?

VI. What changes are there in the nails; do they grow as fast as upon the other side?

VII. If the injury is upon the neck or face, what changes have taken place there?

If you have any difficulty in answering these questions, show some physician this letter, and ask him to go carefully over your case.

The letters of Dr. Münsterberg and Dr. Howell on the questions raised by the confusing varieties of mis-reference of touch, referred to in Chapter VI., are given here in full as possessing interest and suggestiveness both for the clinician and psychologist.

HARVARD UNIVERSITY PSYCHOLOGICAL LABORATORY,
CAMBRIDGE, MASS., Dec. 16, 1893.

I have thought much about the matter, but I feel myself unable to bring out a theory which is well based. In any case, I should think on the connection between centripetal and centrifugal nerve-currents. The localization of a touch-sensation is the connection of a sensation with a special motor impulse; from the psychological standpoint the localization is the association of a touch-sensation with a sensation of movement; the system of our movement-sensations is psychologically our tactual space. If now, during a long period of illness, a new habit of movement, and new motor reflex has to be developed, this new centrifugal tendency must control the localization of the centrifugal stimulus; and it may be by accidental reasons that this new habit makes use of the higher or of the lower parts of the organ. To be sure, the regenerated nerve may change the quality and intensity of the stimulation brought to the brain, and the result must be also a change of the motor reaction, and this second change, the change of the motor impulse, seems to me the direct reason for the local mis-reference. Every normal person makes such mis-reference under abnormal motor conditions: does not know, for instance, what finger is touched if all ten fingers are brought together in abnormal artificial position. I should think, therefore, the main attention has to be given to the relation of these sensorial disturbances to the motor variations of the patients. The differences of the motor ability may perhaps explain the differences of dislocalization.

Very sincerely yours,

HUGO MÜNSTERBERG.

JOHNS HOPKINS UNIVERSITY,
BALTIMORE, Oct. 23, 1893.

DEAR DOCTOR: I feel some hesitation in complying with your request to suggest a theory to explain the curious cases of mis-reference of sensations which you describe in your letter. While it is not difficult to suggest a possible explanation, I should want to know all the details of the cases, to be satisfied in my own mind that anything I might offer really met the conditions.

As this thing presents itself to my mind, with the limited knowledge I possess of the details, the underlying cause of the phe-

nomenon is to be found in an abnormal union and distribution of the sensory fibres of the region involved. Localization of sensations, in the long run, depends upon some distinctive difference in the qualities of the sensations from different regions, a difference to which the appropriate name of "local sign" has been given; and that we are able to distinguish a sensation aroused by stimulation of one part of the skin from that originating in some other part depends, then, upon the fact that the local signs of these sensations are different, and that by experience we have learned to recognize the local sign for each region. If now the mis-reference you speak of has an anatomical basis, which we can scarcely doubt, it must be sought either in an escape of impulse in the cortical centres, or in an abnormal distribution of the sensory fibres occurring during the act of regeneration. The former explanation is not probable, as it involves double or associated sensations; the latter, on the contrary, is to my mind quite possible. During the act of regeneration, when the fibres of the regenerated peripheral end have made actual connections with the fibres of the central stump, the axis-cylinders of the latter grow down into the newly formed peripheral fibres. In some way most of these downgrowths reach their proper terminations; but it seems very probable that some of the bundles from the central end might take a wrong route and reach a wrong termination: that, for instance, the axis-cylinders belonging to the group of sensory fibres in the central stump which formerly supplied the elbow might grow down into the peripheral fibres which end at the wrist, or *vice versa*. This would be more likely to happen, I suppose, if the apposition of the ends in the suture had been unfortunate. Granting that such a thing had happened, then the impulses aroused by stimulation of the peripheral endings would call forth sensations which previous experience had localized in a different region; and this mis-reference of sensation might or might not be overcome by future training, depending somewhat on the location of the false sensations (*i. e.*, the skin region involved), and upon the nature and vocation of the individual.

As far as I can see, the same explanation would hold if we adopted the hypothesis that the axis-cylinders are formed in the regenerated peripheral fibres, and are not downgrowths from the central stump, as there would be a possibility in this case also of

a similar malposition of fibres when functional union with the fibres of the central stump was consummated.

This explanation does not apply to your spinal cord case;[1] I cannot imagine any anatomical explanation of that.

Sincerely yours,

W. H. Howell.

Information is desired of the present condition or addresses of the following:

Anz, Martin, 68th New York.

Barnum, Smith D., 141st New York.

Emory, Morgan, 9th New York Cavalry.

Kaiser, Charles, 14th New York State Militia.

Mooney, Edward, 110th Pennsylvania.

Seymour, William, said to have been formerly in naval service. Record of regiment lost. Wounded in the Wilderness, May 5, 1864.

Sylvester, Wm. S., 7th Wisconsin, Company D.

[1] Case XXXVIII.

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