THE TECHNIQUE OF NERVE SUTURE.

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The experiences of nerve surgery here related were gained while acting as surgeon in chief at the Granville Canadian Special Hospital in Ramsgate.

This series of fifty cases covered a period of eight months in 1916. I regret that I was unable, owing to the demands of the military situation, to follow up the majority of my cases, as they were invalided to Canada at varying times from six weeks to six months after operation.

I desire to point out certain details of the operative technique, and, in addition, some of the general considerations of the treatment upon which stress is being laid by the profession at the present time. It has been possible to follow a few cases till results of operation began to manifest themselves, and full reports of six cases are appended. Cases A and B are complete lesions of the musculo-spiral nerve. Case C is an incomplete lesion of the external popliteal. Case D is an example of axillary aneurysm complicated by incomplete lesions of nerves of the brachial plexus. Case E is reported to show an exaggerated form of traumatic neuritis; Case F is one of complete anterior crural paralysis, anatomically unsuitable for suture, showing the results of tendon transplantation.

Cases of peripheral nerve lesions require uninterrupted treatment for a considerable length of time. This can only be obtained in suitable institutions, fully equipped, in order to be able to carry out the various forms of treatment required. On this account nerve suture work should only be done by surgeons attached to hospitals that can hold their cases so that they may be treated to finality. Tendon transplantation is often available in cases where nerve suture has failed, and no man should be finally discharged until the question of its advisability has been debated. I have transplanted the primary flexors of the wrist to the primary extensors in several cases during the last year where nerve suture had failed or was contra-indicated, and good results were obtained.

At the outset it is necessary to emphasize the point that surgery must go hand in hand with massage, electrical and postural treatment in nerve suture cases. Any institution where nerve surgery is performed must be adequate to deal with the case in all these particulars. The break in the treatment due to cases being sent from Ramsgate to Canada is unfortunate, but at present unavoidable. It would appear that the close co-operation between a surgeon and a neurologist is of importance. I was fortunate in having Major Colin Russel of Montreal as my co-adjutor, and was much helped by his enthusiastic support in the combined treatment of these cases.

All cases of complete lesion should be sutured as soon as they are diagnosed, provided they are fit for operation.

Cases due to bullet wounds that have healed rapidly may safely be operated upon within three weeks from the time the wound is healed. Wounds due to shrapnel or high explosive require a longer period, more especially when there has been bone involvement, destruction of tissue, with consequent scar formation, or when fine metallic bodies are present. These cases often take long in healing, and it is a good working rule to wait for at least three months after the wounds have well healed. Undue haste may be followed by sepsis on account of the latent infectivity that remains for a considerable period in this type of wound. I have operated on several such cases three months after healing, and have encountered small sequestra from healed comminuted fractures, small metallic fragments, and large areas of scar tissue. If a suspicious wound be swabbed with iodine and alcohol before the nerve is dissected out, and a small cigarette drain inserted for forty-eight hours after operation, no untoward accidents should occur.

In a series of fifty cases with a maximum length of time between wound and operation of eleven months, a minimum of three months, and an average of five and a half months, all healed by first intention. This high average length of time was due to the fact that the majority were due to

shell wounds, and that all were transfers from general or convalescent hospitals in this country.

PRELIMINARY ELECTRICAL EXAMINATION.

On admission the average case is tested on three different occasions at intervals of a few days, during which time the daily conservative treatment by massage and electricity is instituted with whatever postural treatment is indicated, deformities being overcome at the earliest possible moment. The paralysed muscles are tested to faradism and galvanism, and on the nature of the response to the latter the diagnosis is usually made. It was found in a long series of cases that the results of the varying contractions produced by the anodal and cathodal opening and closing currents are somewhat variable. Great stress is laid on the sluggish reaction to galvanism and on the increased amount of current required to produce it.

Throughout the series all complete lesions, verified at the operation, displayed loss of irritability and a sluggish response to galvanism, and all cases failed to react to faradism, and the sensory disturbances were anatomically constant.

Cases showing prompt response to galvanism of some muscles and sluggish response in others supplied by the suspected nerve should be watched for improvement or otherwise, as a partial lesion combined with scar tissue infiltration may reasonably be expected to exist. Should no improvement occur within six weeks operation is indicated. The progress of such cases should be carefully watched, as the sensory disturbances vary considerably, and referred pain may occur on account of traumatic neuritis. Psychogenetic paralysis, of which a number of cases have been seen, can invariably be diagnosed by the stocking type of anaesthesia, the exaggerated deformity of the limb, combined with the brisk reaction of the alleged paralysed muscle groups to the faradic current.

CONSERVATIVE TREATMENT.

Conservative treatment is instituted at once, and must be continued without interruption—except during operative convalescence—for a long period of time, as on its persistence depends to a large extent the outcome of the case. Daily massage to the paralysed muscles is given for twenty minutes, with fifteen minutes of the galvanic current sufficiently strong to produce a fairly marked response. Should trophic conditions be present, as are constantly found in lesions of the median, ulnar, and sciatic nerves, "eau courante" or contrast baths are given as an adjunct to massage. Marked swelling and cyanosis of the fingers or toes, with sweating of the involved skin area in some cases, and friability of the nails, are the usual symptoms. Baths are contraindicated where trophic ulcers or whitlows are present.

Where marked trophic disturbances have existed for some time in combined nerve lesions—especially if complicated by osteomyelitis—conservative measures are of little avail and the question of amputation arises. This has been necessary in two cases; both showed complete lesions of median and musculo-spiral nerves, compound comminuted fracture of the radius with osteomyelitis, and discharging sinuses. Trophic ulcers of a persistent type were also present. Amputation through the forearm was done in each instance. A curious phenomenon is sometimes seen in post-operative cases of nerve lesion, generally three to six months after suture. Reactions to faradism remain negative, and reactions to galvanism become more and more difficult to obtain. Voluntary power may shortly appear in one or more of the paralysed muscles. In fact, a paradox sometimes is present, as the muscle has voluntary power but the electrical reactions are practically non-existent—no reaction to faradism and reaction to galvanism obtained with the greatest difficulty, and then, perhaps, with a small electrode only (see Case A).

POSTURAL TREATMENT.

The paralysed muscle groups must never be allowed to become overstretched by their opponents, or contractures will occur. The overstretching of a paralysed muscle, devoid of tonicity, if allowed to persist, may render the muscle incapable of contraction even after nerve conductivity is re-established.

I do not intend to describe at length the various splints devised to carry out this treatment, as they are well

known from the writings of Colonel Sir Robert Jones. In lesions of the musculo-spiral nerve the wrist and fingers should be kept hyperextended, lesions of the sciatic and popliteals require the foot to be kept at a right angle.

In cases in which there is damage to the cords of the brachial plexus or to the nerve trunks from which they are formed, individual appliances will be required to meet each case. The commonest injury that we have seen in this region is that which involves the anterior primary divisions of the fifth and sixth nerves, due to wounds in the neck. Here an appliance is required to keep the arm abducted and rotated outwards, the elbow flexed, the forearm supinated, and the wrist and fingers extended.

The long cock-up splint used for musculo-spiral lesions should have a thumb-piece to keep the thumb extended and abducted. The splint should be bent transversely in the centre of the palm to allow the hand to rest with the metacarpo-phalangeal joints flexed a little. This is to prevent the hyperextension that has been found to occur in these joints in long-standing cases, due no doubt to the hand slipping in the splint. Slight movement of the finger joints may be permitted by the masseur during the daily treatment. These movements increase the circulation in the part and prevent the formation of adhesions. Under no consideration, however, must undue stretching of the paralysed muscles be permitted at any time. Some cases of metacarpo-phalangeal stiffness have been brought to my notice presumably as the result of continued immobilization in a hyperextended position, but the alteration to the splint which was suggested by Colonel Sir Robert Jones has prevented recurrence of this complication.

OPERATIVE PROCEDURE.

Before deciding on operative interference it is necessary that contractures of joints distal to the lesion, involving muscles supplied by the paralysed nerve, be duly corrected. Remarks previously made regarding the nature of the wound are applicable here.

Analysis of Cases.

Total cases	...	...	...	50
Nerves operated on	...	...	...	53
End-to-end suture	...	...	...	40
Catgut bridge	...	...	...	2
Nerve graft	...	...	...	1
Partial and scar cases	...	...	...	15
Covering of fascia lata "sleeve"	...	...	...	44
Obtained locally	...	...	...	2

Standing orders call for preparation of the skin of the thigh of the same side, from groin to knee, as well as at the site of operation. This is for the removal of the flap of fascia lata destined to act as the "sleeve," which is described later.

Relative Frequency of Lesion to Individual Nerves.

1. Ulnar	...	...	...	23
2. Musculo-spiral	...	...	...	13
Posterior interosseous	...	...	...	4
3. External popliteal	...	...	...	8
4. Median	...	...	...	4
5. Sciatic	...	...	...	2
Internal popliteal	...	...	...	2
6. Cords of brachial plexus	...	...	...	1
Musculo-cutaneous	...	...	...	1

As will be seen, more than one nerve was injured in several cases.

It is advisable in all arm cases to use a side table so that the arm may be abducted to a right angle and remain steady in that position. Where there is marked scar tissue formation it is advisable to make the incision in the line of the nerve above and below the scar, and to pick the nerve up at the upper and lower level where it lies in its true anatomical relationship with surrounding structures. The advantage of this procedure is obvious as it is a tedious task searching for a nerve imbedded in scar tissue. These nerves are often destroyed for a distance of one to three inches, so that large dissections are required above and below the site of injury to make up shortage sufficient to give end-to-end apposition. Whenever end-to-end suture can be obtained by any means nothing should be left undone to bring it about.

A catgut bridge was used on two occasions in large gaps where other means failed to get end-to-end apposition. The gap should be joined by chromic catgut sutures, and the whole covered in by a fascial "sleeve." However carefully the sleeve covers in the gap the chance of its

becoming filled with blood clot, which organizes to form fibrous tissue, appears very considerable. If the gap is long it would seem that the operation defeats its own end. A case of reoperation where primarily, as far as one could judge, the nerve ends had been so joined showed dense scar intervening between the cut ends. In one case of lesion of the ulnar nerve in the forearm four inches were missing from the nerve when the ends were prepared. The nerve ends were grafted into the median. The result of the operation I do not know.

In dissection the nerve should be isolated above and below the fibrous tissue as before stated. The nerve should be carefully loosened from its bed at these points and a length of half-inch tape or cut gauze gently placed beneath it. Haemostats are attached to the ends of these tapes and so loops are formed on which gentle traction may be exercised while dissection of the nerve from above and below is made. This dissection will be found to be easy and without danger to surrounding structures. The use of the loops prevents the nerve being pressed on during dissection by the indiscriminate use of forceps. Where dissecting forceps need to be used a special type made by Messrs. Schaefer of Berne is useful. The end of each blade is shaped to half a circle and covered with fine rubber tubing, so that the nerve can be held without pressure. Three sizes of forceps are available.

Scar tissue should be dissected in the neighbourhood of the lesion after the nerve ends are isolated and freed. Stimulation of the nerve by means of the faradic current is now undertaken—above and below the lesion where dissection has not produced anatomical loss of continuity, below the lesion only where this loss exists. A Bristow coil with metronome interruption appears the most suitable apparatus—a pad can be placed on some part of the body away from the seat of operation. The nerve is now stimulated in the whole of its circumference by means of a single sterilized electrode—a long silver probe is advised by Mr. Bristow of the London Military Orthopaedic Hospital; I have also used a twin electrode with success. The faradic current thus applied will readily determine as to whether the lesion is complete or partial if applied to healthy nerve above the block. In the vast majority of cases no reaction is obtainable in complete lesions when the electrodes are applied below the lesion, as the lower end degenerates in a few days.

Should the lesion be complete the preparation of the ends for suture should be the next step.

If definite nerve bulbs are found these should be cut transversely at distances of one-eighth of an inch until healthy nerve tissue is encountered. The fibrous end of the nerve should be held with mouse-tooth forceps and the cross sections made with a sharp knife, almost but not quite through the nerve. This plan obviates undue handling of the nerve, which is only touched by the forceps at its fibrous end. When healthy nerve is recognized by the protrusion of the bundles, the last made section is completed. On no account should nerve sections be made with scissors, which cause crushing of the fibrils. The nerve sections are sent to the laboratory, and slides are made as a routine.

The amount of shortage in the nerve can now be gauged, and steps taken to make this good, so that end-to-end suture can be accomplished. The shortage can be overcome in four ways:

1. By flexion of intermediate joints.
2. By free dissection of the nerve for a considerable distance above and below the lesion.
3. By translation of the nerve path to a straight line.
4. By dislocation of the nerve.

The first and second only are applicable to nerves of the lower extremity; the third is applicable to the ulnar and musculo-spiral, and the fourth is referable only to the ulnar at the elbow-joint. By these various means a gap of over two inches has been readily overcome.

I have chosen the example of an ulnar nerve lesion in the forearm for the purpose of description of the closing stages of the operation as it is in this situation that the worse types of nerve shortage occur. The nerve must not be unduly pulled upon, although a certain amount of gentle traction is permissible if necessary, as there is little doubt that the sheath is shorter than the nerve fibres.

With regard to shortage in the ulnar nerve free dissections must be made to the middle of the upper arm and the nerve is dislocated from its tunnel behind the internal condyle and brought to the centre of the antecubital fossa. The nerve must be dissected high enough up the arm to enable it to be brought in a straight line from the axilla to its normal position in the forearm. The new course of the nerve causes it to lie between the superficial muscles of the forearm behind and the fascia and fat superficially. In making the dissection great care and gentleness must be exercised, and the sheath must not be injured. Careless and rough handling of the nerve is to be deprecated. The procedure is obviously not applicable to a nerve where it is giving off muscular branches.

Objections may be raised to the cutting of the nerve from its blood supply for such a distance. It has been shown clinically in cases of fracture in the region of the elbow with bone overgrowth interfering with the ulnar nerve, that the operation of free dissection with dislocation causes no ill effects as evidenced by loss in conductivity. Here the nerve must be similarly deprived of its blood supply.

The aponeurotic band between the two heads of the flexor carpi ulnaris must be divided with care as one wishes to conserve the branches to this muscle and to the ulnar head of the flexor profundus digitorum which come off at this level.

Where the lesion is below the level of the middle of the forearm it is sometimes convenient to free the nerve with a dissector beneath the muscle, and to push the upper segment upwards, bringing it out through the opening made between the two heads of the muscle. This was done on two occasions without damaging the two nerve branches before mentioned. This method is quicker and causes less trauma than the full dissection of the flexor carpi ulnaris, which is the only alternative. The bringing of the ulnar nerve superficial to the flexor carpi ulnaris in the upper half of the forearm lengthens it by more than half an inch. By these means almost any gap that is likely to be encountered in ulnar nerve lesions may be overcome, and the cut end of the nerve should now come together without tension.

A temporary stitch of fine catgut is placed through the nerve ends with a fine non-cutting needle at a distance of about half an inch from each extremity. This stitch aids the surgeon in the permanent suture. The nerve is sutured by means of the finest domestic sewing needle and the finest white sewing silk obtainable. I would advise the use of the No. 9 "calyx" self-threading needle, which is obtainable in drapery establishments. A continuous stitch is put round the nerve, involving nothing but its sheath. This will be found to be easy as, despite the protrusion of the bundles, the sheath is capable of being stretched. It is important that eversion of the sheath edges be brought about, and very fine and accurate stitching is necessary to produce this result. This eversion will minimize the risk of subsequent interstitial fibrous formation. The catgut "stay" stitch is now removed and the whole circumference of the suture examined. An autogenous graft of fascia lata is now removed from the thigh. The outer side of the thigh about its centre is opened by means of a semicircular incision involving the skin and subcutaneous fat. This flap is now turned down and the fascia lata is seen. A parallelogram of fascia is now removed, varying in size with the calibre of the nerve it is desired to cover. It is well to err on the large side, as the fascia tends to contract on separation and the "sleeve" must be easy fitting. I use the term "sleeve" advisedly to emphasize the fact that an easy fit is essential and the covering should bear the same relationship to the nerve that a sleeve does to the arm. The fascia when removed from the subjacent muscle will be found to strip quite easily on account of the areolar tissue that exists between the two. This side must be the one in contact with the nerve.

It will be found advisable to grip the corners of one long side with mosquito forceps. Two similar haemostats are placed beneath the nerve and these grip the corresponding corners of the other side of the flap. The flap is now drawn beneath the nerve and the haemostats brought into apposition at the upper and lower ends. An end-to-end suture of the long edges is done with chromic catgut, leaving long ends at the top and bottom. A tube of fascia now envelops the nerve with a length of catgut at either end. By this means the "sleeve" can be slid up or down

the nerve until its centre covers the suture line. The "sleeve" is now anchored to adjacent tissue both top and bottom with the catgut ends before mentioned.

I have emphasized this method as some such scheme will be found to save time on account of the marked propensity for curling up that the fascial flap always displays.

The reason for the preference of fascia lata over local fascial flaps is twofold, namely: (a) The amount of areolar tissue present on the inner side of the fascia lata. This appears to prevent strong fibrous union to the subjacent nerve sheath. (b) Latent infection may lurk in tissues in the region of the initial wound where suppuration has existed.

The disadvantages of a second wound appear to be slight, for if the hole in the fascia lata be well sutured with chromic catgut and the patient kept in bed for fourteen days, the risk of a quadriceps hernia is remote. I have no experience in the use of Cargile membrane as a covering. It is well spoken of by some of my colleagues. As I have had no trouble in any of my cases, I hesitate to begin using a foreign body where an autogenous graft is available.

All cases of complete nerve lesion do not show the bulbous ends previously described. After dissection, the nerve sometimes appears normal to the eye. On palpation, the fibrous block is generally recognizable, as it feels harder than normal nerve. Should faradic stimuli fail to pierce the block, it is advisable to divide the nerve at its hardest point and then to section each end until healthy nerve is reached. Where interstitial fibrosis is present one feels a grating sensation on the knife when making the section of the nerve.

Where there is much destruction of nerve and translation is not available, as in the median and sciatic, it is sometimes necessary to dissect out fibrous tissue from between the nerve bundles instead of sectioning until healthy nerve is reached. This is done in order to procure end-to-end apposition when it cannot be otherwise obtained. A fine-bladed knife, such as a von Graefe, will be found useful, and careful dissection is necessary.

Partial lesions require careful dissection, as it is probable that two or more bundles retain their conductivity. All scar tissue must be removed from the site of lesion until healthy bundles are seen. A wedge-shaped gap is now found to be present, and some dissection of the nerve from its bed will be necessary to coapt the edges of this gap without tension. When the suture is complete the nerve displays a bulge at this level. In one of the cases in the series the nerve after dissection showed that only one bundle retained conductivity, and the gap of destroyed nerve tissue was very wide. Here a complete section of the nerve with end-to-end suture was made. It was felt that on account of the wide gap strangulation of the remaining bundle would occur if the case were treated as a partial lesion.

Some cases display no damage to the nerve bundles, but nevertheless the lesion is apparently complete. When the scar tissue is removed the calibre of the nerve is much lessened, and it may even be quite flattened. Occasionally the nerve will be seen to bulge at the seat of injury immediately the constricting bands are divided (Case D). It is advisable to divide the nerve sheath longitudinally in one or more places at the site of the lesion, and to cover the area with a sleeve of fascia lata. This is to counteract adaptive contracture of the sheath that has probably occurred.

Referred pain occurs solely in partial lesions due to scar pressure from without or within the nerve sheath. Free removal of all fibrous tissue is necessary, both surrounding the nerve itself and also between the individual nerve bundles, and a fascial sleeve must be used. Case E is of interest in this respect in that it shows what occurs to the fascial flap after it has remained *in situ* for some time.

Where flexion of joints has been necessary to procure end-to-end anastomosis, six weeks should elapse before any extension is permitted, and this should be very gradually brought about.

In the suturing of small nerves a straight needle is often a disadvantage. This applies especially to the posterior interosseous, which, in my experience, is the most difficult to suture. It is possibly better practice to transplant tendons at the outset instead of suturing this nerve, especially if the damage has occurred after the supinator

brevis has been pierced. The flexor carpi radialis can be attached to the three extensor tendons of the thumb and to that of the index finger, and good results have been quickly obtained. "Calyx" needles are not made in curves, and I found it impossible to obtain self-threading, curved, non-cutting needles of sufficient fineness. Sir Edward Rigg, C.B., an authority on metallurgy, has given me great help in showing me how to make one's own curved needles.

By the careful drawing of the temper of "calyx" or other domestic needles, they may be bent to any desired curve without losing their point, strength, or resiliency. The needles are heated on a metal plate by means of a spirit lamp. The plate must be sufficiently large to prevent any of the gases of the flame coming into contact with the needles, which must be constantly kept in motion whilst being heated. The needles are heated beyond the straw stage to a light blue, and then they are rapidly transferred by forceps to a cold plate of metal. Here they immediately turn dark blue. By means of a specially made pair of pliers, whose blades are concavo-convex and graduated, any desired curve may be wrought on the needle. I mention this point in case others find the same difficulty in obtaining suitable needles.

AFTER-TREATMENT.

I wish to emphasize the fact that peripheral nerve lesions require prolonged after-treatment. This should be given in institutions suitable to the purpose at which the soldiers can attend as out-patients. The institution should be equipped with complete therapeutical establishments, and also with curative workshops. These workshops are used for functional re-education. Where needed, arrangements should be made for professional re-education, which should go hand-in-hand with the military orthopaedic treatment. The full consideration of this matter, which is provoking much discussion in military circles at the present time, does not come within the scope of this paper. The matter is being diligently and thoroughly taken up by the Pensions Minister.

Complete Lesions.

CASE A.

Capt. T. Gunshot wound through centre of upper arm (left), December, 1915.

Preliminary examination showed sluggish reaction of all muscles supplied by the musculo-spiral nerve, with the exception of the triceps; larger galvanic current required than on corresponding muscles of the other arm. No response to faradism. Treatment for six weeks by massage and galvanism, and long cock-up splint.

Operation (April 30th, 1916).—Exposure of left musculo-spiral nerve from where it perforates external intermuscular septum. Nerve found bound down on the mesial aspect; all adhesions freed. Two bulbs lying within half an inch of each other and attached together by fibrous tissue were found. The bulbs were separated and sectioned until healthy nerve fibrils appeared. End-to-end suture with fine silk. Junction covered by fascia lata "sleeve." After-treatment: Massage, "eau courante" baths, galvanism, and long cock-up splint.

November 1st. Reaction to galvanism very sluggish and difficult to obtain; strongest current and fine button electrode required—this after several attempts. No reaction to faradism. Voluntary power in supinator longus and extensor carpi radialis longior appearing.

December 5th. Voluntary power beginning in extensor carpi ulnaris; short cock-up splint substituted.

January 7th, 1917. No reaction to faradism in extensors of wrist and fingers. Reaction to galvanism so slow and weak as to be scarcely perceptible.

March 12th. Strong voluntary power in primary extensors of the wrist. Voluntary power in extensors of fingers beginning; can extend fingers with wrist slightly hyperextended. On home service at present.

CASE B.

Pte. S., Canadian Infantry. Admitted August 31st, 1916. Gunshot wound of outer side of right arm 2 in. above the elbow, emerging at back of arm midway between elbow and shoulder, on June 3rd, 1916. The humerus was not touched. Drop-wrist came on immediately; there is loss of sensation over the radial side of the dorsum of the hand. Extensors of wrist and fingers do not react to faradism, and only sluggishly to galvanism, with the exception of the extensor carpi radialis, which responds promptly.

Operation (September 25th).—A 5-inch incision over the course of the musculo-spiral nerve on the outer side of the humerus was made. The nerve was exposed, and a block of fibrous tissue found. There was no conductivity to faradism, either above or below the lesion. Nearly an-inch was removed, healthy fibrils obtained, and end-to-end suture performed. "Sleeve" of fascia lata used to cover the junction; wound closed with catgut and clips. Long cock-up splint applied.

After convalescence, conservative and postural treatment continued.

March 9th, 1917. Supinator longus and extensors of wrist and fingers do not react to faradism; reaction to galvanism slow and weak. The patient has voluntary power in supinator longus and extensor carpi radialis longior, and slight voluntary power in extensor carpi ulnaris. Treatment continues.

Incomplete Lesions.

CASE C.

Cpl. W., C.M.R. Admitted January 17th, 1916, with history of shell wound of left thigh on December 8th, 1915. Immediately after being wounded was unable to flex ankle or extend toes. Two days later phlebitis supervened. For two weeks after the injury a numb feeling was complained of all over the foot and up about the knee-cap. Wounds in thigh not healed. Foot kept at right angle with a Thomas rectangular shoe.

February 16th. Tibialis anticus and peronei react to condensed current. All muscles react to galvanism promptly, and with small current. Partial lesion of external popliteal diagnosed. Patient walks with boot and fixed posterior iron to prevent foot-drop.

May 16th. Voluntary power returning in anterior tibial group; no power in peronei.

June 14th. Peronei and extensor communis digitorum do not react to faradism. Tibialis anticus has regained voluntary power.

July 21st. No improvement.

August 7th. Voluntary power of anterior tibial group has quite gone. Muscles react poorly to galvanism. Operation advised.

Operation (August 10th).—An 8-inch longitudinal incision in mid posterior line of left thigh from level of tuber ischii. The great sciatic was isolated at the lower level of the gluteus maximus. The sciatic was found to divide into the popliteals at a high level. Both trunks were imbedded in scar tissue, especially the external one. The external popliteal was dissected from the scar tissue, but the sheath appeared intact, and palpation could discover no hard points on the nerve. Conductivity to faradism was poor but complete, much inferior to that of the internal popliteal, from around which all fibrous tissue was removed. A longitudinal incision was made in the sheath of the external nerve $1\frac{1}{2}$ in. long; a "sleeve" of fascia lata covered the nerve at this point.

September 14th. Regaining voluntary power in anterior tibial group; can voluntarily flex the ankle.

September 26th. Invalided to Canada.

February, 1917. A letter from the patient states that he has continued to improve, and is very pleased with the result.

CASE D.—Incomplete Lesion complicated by Aneurysm.

Pte. K., Canadian Infantry. Admitted April 6th, 1916, with a history of shell wound, September 22nd, 1915. A shrapnel bullet entered the posterior fold of the left axilla, and emerged through the pectorals on the right side about two inches to the mesial side of the anterior fold of the right axilla. In the left axilla there is an expansile swelling as large as a hen's egg. There is little loss of sensation in any part of the arm. There is complete wrist-drop and inability to flex and to separate the fingers. Voluntary power in the triceps; the supinator longus and extensors of wrist and fingers do not react to faradism, and but slowly to galvanism; reaction is more easily obtained by the anodal than by the cathodal closing current (ACC > CCC). The muscles of the median and ulnar distribution show marked weakness and voluntary power is all but lost; react promptly to galvanism.

Operation (April 27th).—(a) Ligation of first part of axillary artery. (b) Eight-inch incision over line of the vessel. Axillary border of pectoralis major divided and reflected. All nerves of the plexus lying anterior were found to be closely adherent to the sac and were obviously stretched. Nerves stripped from sac wall. Sac opened and clot turned out. Sharp haemorrhage checked. Sac excised with difficulty and vessel tied above and below. The musculo-spiral nerve was found in its position at the back of the sac and tacked down to it. Scar tissue removed from the nerve, which was found constricted and flattened, but on division of the constricting band expanded slightly.

May 29th. Extensors of wrist and fingers react fairly to galvanism. Voluntary power has returned in median and ulnar distribution. Circulation in arm and hand well compensated. Invalided to Canada with symptoms of musculo-spiral lesion only.

CASE E.—Incomplete Lesion of Great Sciatic Nerve with Traumatic Neuritis, Causing Great Pain, so that Patient was Bedridden for Fifteen Months.

Pte. C., Canadian Infantry. Admitted March 27th, 1916, with history of shell wound of lower third of left thigh on April 25th, 1915. Complaints of extreme constant pain in foot and leg ever since being wounded.

Previous Operations.—(1) Foreign body removed in France. In other hospitals: (2) Removal of scar tissue from sciatic nerve, June 2nd, 1915; (3) removal of scar tissue from sciatic nerve, September 6th, 1915; (4) removal of scar tissue from sciatic nerve, and nerve wrapped in saphena vein, January 1st, 1916.

No improvement in the pain followed any of these operations, and the patient has never been out of bed, as he cannot bear to have the leg touched. It is so hyperæsthetic. The leg is flexed on the thigh to 45 degrees, and there is bad foot-drop with

contracture of the tendo Achillis. Marked hyperaesthesia to cotton-wool stimulation on the sole and on the outer side of the foot.

Fifth Operation.—Division of tendo Achillis and forcible extension of the knee with the hope of stretching nerve fibres and diminishing pain. Scar was felt to stretch in the popliteal space. Slight alleviation of pain for two days, but it recurred.

Sixth Operation (May 24th).—Removal of scar, freeing nerve and fascial "sleeve." Both popliteal nerves were found surrounded by large areas of fibrous tissue. Both nerves were freed from scar as much as possible, and this extended for 3 in. above their junction. The nerves felt hard and fibrous, but to such an extent that further treatment seemed contraindicated. Fascial sheaths taken from both thighs 6 in. by 2 in.; invested both popliteals and the sciatic like a pair of trousers. All three nerves injected with 5 c.cm. normal saline above and below the "sleeves." Temporary relief was obtained for a week but the pain afterwards recurred.

June 18th. Pain as before and foot oedematous.

July 4th. As patient continues to lose weight and is very depressed it was decided to sacrifice the "sciatic" nerve. This on account of the length of time the patient has been in bed (fifteen months), although there is voluntary power in extension of the ankle.

Seventh Operation (July 6th).—Excision of sciatic nerve at the junction. Four inches removed, which included repair work of operation No. 6, with fascial covering.

July 10th. All pain gone; anaesthesia in foot.

September 19th. Patient invalided to Canada; boot and iron to prevent drop-foot.

Microscopical Report on Nerve Section.—Several large bundles of nerve separated by much dense—in places hyaline—connective tissue, in which are imbedded groups of inflammatory cells and also foci of endothelial cells laden with brown pigment; old haemorrhage. In all nerve bundles there is considerable destruction of fibrils and their sheaths, often with replacement fibrosis. In parts at the periphery of the section a layer of connective tissue is seen, in some parts separated from, and in other parts attached to, the subjacent connective tissue covering the nerve bundles. The section shows to what extent interstitial fibrosis may occur when the nerve sheath is damaged. Conversely, it shows the uselessness of dissecting the nerve from surrounding scar when on palpation the nerve feels in the least degree hard or nodular. The layer of connective tissue referred to above consists of the fascial flap that had been put in position six weeks previously. It shows that the "sleeve" does not unduly adhere to the nerve sheath.

CASE F.—Tendon Transplantation in a Case where Nerve Suture was Impossible.

Pte. L., Canadian Infantry. Admitted December 24th, 1915, with history of having been hit by a bullet in the left groin on November 16th. The bullet emerged posteriorly in the region of the left sacro-iliac joint. Wounds closed on admission.

The left thigh is markedly atrophic—two inches less in circumference than the right. Cannot extend leg on the thigh, and cannot raise the patella. The quadriceps muscle does not react to faradism, and only sluggishly to galvanism. Matted glands and adhesions causing a marked mass felt on palpation in left pelvis. Thomas's walking knee-splint applied; massage and galvanism.

May 17th, 1916. No voluntary power in quadriceps; no reaction to faradism, and only sluggishly to galvanism. Apparently a complete lesion of the anterior crural. Suture contraindicated for anatomical reasons. Tendon transplantation advised.

Operation (June 16th).—Vertical incision twelve inches long on outer side of popliteal space. Biceps isolated and separated from head of fibula. From a corresponding incision on the inner side the semitendinosus was separated from its insertion. A channel was made between the deep fascia and the aponeurosis of the vasti through a 4-inch vertical incision in the suprapatellar region. The tendons were brought through this opening to the patella from their respective sides. Each tendon was fixed to the patella by means of a tunnelling process, which fixed them subperiosteally on the anterior surface. Sutured with No. 3 chromic catgut; wounds closed.

September 16th. Walking well; full extension possible voluntarily, and 45 degrees flexion of knee permitted.

September 26th. Discharged in England.

THE June issue of the *Edinburgh Medical Journal* is entirely given up to the medical and surgical aspects of child welfare, and forms the second collective report on this subject published by our contemporary. Dr. Claude Ker deals with infectious diseases; Dr. Norman Walker and Dr. R. Cranston Low with dermatology; Mr. J. V. Paterson and Dr. H. M. Traquair with diseases of the eye; Mr. J. S. Fraser with diseases of the ear, nose, and throat; and Mr. J. H. Gibbs, who is an able exponent of the views of Dr. Sim Wallace, with the prevention of dental disease. Each of these subjects is treated from the immediate point of view of child welfare. Dr. J. Hally Meikle contributes a chapter on medical inspection and supervision of school children in Edinburgh; and Dr. and Mrs. Leslie Mackenzie write on administrative institutions and regulations, and certain legal aspects of the subject.

C

OBSERVATIONS ON CHLORAMINES AS NASAL ANTISEPTICS.*

BY

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(Report to the Medical Research Committee.)

THE valuable results obtained by Gordon and Flack¹ on the use of chloramine-T, zinc sulphate, and other antiseptics for the treatment of meningococcus carriers among soldiers, led us to undertake some experiments on the influence of certain antiseptics on the total bacterial count of the nasal secretions of apparently normal individuals. It would appear that such experiments might furnish information which could be utilized in a practical way for the treatment of certain types of carriers. On submitting our results to Colonel Gordon he expressed the opinion that they possessed some interest in relation to the carrier problem, and we are thus led to record a short account of them.

The problem of destroying pathogenic organisms in the nasal cavities and upper air passages by direct disinfection is a difficult one. There are, undoubtedly, many carriers with anatomical abnormalities of the nose, pharyngeal vault, and tonsils, precluding immediate contact with solutions used either as sprays or gargles. In such cases there is little if any prospect of any antiseptic proving effective. On the other hand, the fact that the chloramines do not cause precipitates or coagula in secretions or exudates is favourable to their acting upon micro-organisms contained in these fluids. Experiments made by Gordon and Flack on meningococcus carriers among soldiers, in which they used a solution of chloramine-T² reduced to a very fine spray with a current of superheated steam, have given decidedly encouraging results.

Our first experiments were merely modifications of those of Gordon and Flack, and were made on the normal noses of healthy individuals. A high-pressure jet of air replaced steam, and the fine spray so produced was inhaled from a double cone of celluloid, which obviated the use of a closed chamber. The coarser droplets from the spraying nozzle were caught by diaphragms and returned to the reservoir from which the antiseptic solution was drawn, thus effecting a considerable saving.

With this apparatus, using a 0.5 per cent. solution of chloramine-T and sufficient salt to make it approximately isotonic, we found it possible to secure a very considerable reduction of the bacteria in the nasal secretions, occasionally obtaining sterile agar plates with the swabs used for collection. It was necessary, however, to continue the treatment for half an hour to attain this. Such a protracted treatment militates greatly against the method; it is probable that the concentration of the antiseptic actually present at a given time is insufficient to act promptly. The use of more concentrated solutions seems unwise, because it would be likely to prove irritating in many cases. We therefore turned our attention to other means of prolonging the time of contact without increasing the concentration, and finally had recourse to the use of an oily medium.

Chloramine-T, while freely soluble in water, is practically insoluble in oils. But the corresponding dichloramine (toluene-*p*-sulphodichloramine, $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{NCl}_2$, to which we now propose to assign the abbreviated name of dichloramine-T), though very sparingly soluble in paraffin oil, is quite readily dissolved in eucalyptol. The resulting solution can be subsequently diluted with paraffin. In this way a reasonably bland oil solution, containing as much as 2 per cent. of the dichloramine, can be obtained. It is with such solutions of different strengths that our second series of experiments was made.†

* "Chloramines" are substances containing chlorine linked to nitrogen, almost all of which possess marked germicidal properties. Hitherto the most widely used member of this group is sodium-toluene-*para*-sulphochloramide, $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{Na.NCl}$, which is known under the name of chloramine-T and also a variety of trade names. The related dichloramines contain the NCl_2 group and are mostly sparingly soluble in water, but more readily soluble in organic solvents. A study of the germicidal action of these bodies will be found in the *Proc. Roy. Soc.*, B, 89, p. 232, 1916.

† It may be worth noting that Captain Sweet and Dr. Lee, at our suggestion, have investigated the use of a similar mixture containing 5 per cent. of dichloramine-T as a surgical dressing for infected wounds. The results will be published shortly and are said to be distinctly encouraging.