Notes on Military Orthopaedics.

II. ON SUTURE OF NERVES, AND ALTERNATIVE METHODS OF TREATMENT BY TRANSPLANTATION OF TENDON.

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THERE are few problems more urgently needing solution at the present moment than those involved in the treatment of limbs disabled by injuries involving nerves. The conditions vary and are often very complex. The nerve may be irretrievably injured beyond all hope of suture; it may be entangled in cicatricial tissue; one or more of the muscles it supplies may have suffered grave lesions, varying from partial to complete destruction; the tendons or muscles themselves may be bound down by adhesions, or the joint or joints the muscles govern may be stiff or ankylosed, or held in a deformed position by a skin cicatrix, or more than one of these hampering conditions may be present. The simple condition, where the nerve or some of its fibres receive a clean severance, is exceptional.

If once these facts are realized it will require no argument to establish the proposition that certain orthopaedic problems must be mastered in connexion with the suture of nerves if proper restoration of motor function and of the normal efferent and afferent connexion between muscle and the central nervous system are to be secured. In certain fortunate cases the conductivity of the nerve is restored and good muscular function may result. In other instances, although the conductivity is restored, the function of the muscles and joint may not be regained because certain fundamental principles have been neglected. There are other cases in which the conducting power of the nerve is not properly restored, and yet others in which, owing to extensive destruction of the nerve, any attempt at suture would be futile. We must therefore be prepared with alternative methods in order to secure for the patient a satisfactory limb.

LATE SUTURE OF NERVE.

With regard, however, in the first place, to late suture of the nerve, certain general principles must be borne in mind. These are:

1. The correction of contractures of skin or muscle and all the anatomical constituents, from skin to bone, on the concave aspect—that is to say, on the side of the abnormal direction the contracture takes.
2. When possible, the freeing of joints from all adhesions and the restoration of the mobility of the joint in all cases where ankylosis is threatened.
3. The maintenance of the paralysed muscles in a position of relaxation throughout the period of recovery.
4. The practice of massage during the recovery, but without once allowing the relaxed muscles to be stretched.

In short, the principles and their application coincide with those I have so often emphasized in the treatment of poliomyelitis.¹

1. Freeing the Muscles.

In the first place, it is necessary to free the muscles from all mechanical obstructions to their action. If this be not done they cannot respond to stimuli sent to them through the nerve, and therefore cannot in their turn send the answering afferent impulse which is necessary to bring the apparatus into proper working order. It is essential to dwell on this point, inasmuch as many operations are being performed while the muscles and joints are stiff. This stiffness is not due to the nerve injury, but to the consequences of trauma and sepsis affecting the muscles, tendons, blood vessels, nerves and ligaments about the joint. When we realize how anaemic an unused muscle becomes, we shall not delay in giving help to prepare it for the reception of nerve impulses.

2. Mobility of Joint.

In the second place, where the joint is threatened with ankylosis, every effort should be made to restore its function.

Operation on the nerves is doomed to failure if these fundamental principles be disregarded.

3. Relaxation of Muscles.

Thirdly, the importance of keeping the partially paralysed and overstretched muscles in relaxation during treatment has been so forcibly brought home in ordinary civil practice in the treatment of residual paralyses after poliomyelitis, lead palsy, injuries of the brachial plexus and of isolated nerves, that it should be scarcely necessary for me again to call attention to it. Nevertheless, visits to wards prove that this elementary orthopaedic measure is too frequently entirely omitted by surgeons who have performed suture of injured nerves. Thus we find men who have had the musculo-spiral sutured allowed to walk about with the hand dangling in palmar flexion instead of its being kept continuously in dorsiflexion! By letting the hand hang in palmar flexion the muscles supplied by the sutured musculo-spiral, which can only recover if kept relaxed, are allowed to become stretched. The result is that the fingers and hand do not regain, can hardly be expected to regain, full normal function. A similar grave error is perpetrated often in the case of the external popliteal nerve also, with the same disappointing result in the foot. Frequently I have noticed that the foot of a patient whose popliteal nerve has been sutured is allowed to remain in an equinus position! Sometimes, indeed, the operation is even performed while the tendo Achillis is contracted. Were it not so frequently happening I should feel ashamed to refer to this matter, but as it is happening I again urge surgeons who suture nerves to insist that the affected muscles be kept in complete relaxation until power returns. The most skilful operation performed on the most suitable case will prove a fiasco unless the affected muscles are continuously kept relaxed until recovery takes place.

In some cases it will be found not only that no provision is made for the muscle to be in the most favourable condition to respond to the earliest motor impulses which come through the block in the nerve, but, further, the mechanical condition of the muscle as to function seems to be entirely neglected, and suture of the nerve is performed when the paralysed muscle or the joint on which it acts is immobilized by cicatricial adhesions. If restoration of function is to follow nerve suture, the new axis cylinders growing through a cicatrix must of course be enabled to establish some sort of normal relation as to function with the end organs in muscle. If the muscle is mechanically disabled from making any response, it is absurd to hope for good functional result, even though the physiological processes of repair of the nerve be perfect. I desire to emphasize again the fundamental principle of procedure—namely, that the restoration of the mobility of joint and muscle must precede the operation of nerve suture. It is useless to attempt it otherwise.

4. Voluntary Use and Massage.

Fourthly, for precisely similar reasons, it is important that the patient should as soon as possible exercise the limb in normal movements. In the case of the lower limb this usually means the application of some apparatus designed to prevent strain on the recovering muscles while the patient is permitted a moderately free physiological use of his limb. In order to make the foregoing observations more lucid to those who have not followed my writings, which are based on the late Mr. H. O. Thomas's theory of "muscle lengthening," I will briefly indicate their tenor.

It is well, in view of the enormous number of injuries to nerves occurring in this war, to emphasize the fact that principles applicable in poliomyelitis are applicable here. When speaking, some years ago, of the results of acute poliomyelitis, I pointed out² that, though the disease might permanently destroy motor cells in the anterior horns of the grey matter, so rendering the muscles dependent upon them for ever useless, unless nerve transplantation might at some later date come to their rescue, yet complete destruction was fortunately the rarer condition. The clinical evidence afforded by rapid and

complete recoveries from complete paralysis and the very many partial recoveries proved that the motor cells concerned had suffered from temporary injury and had not been destroyed. Something had happened to make the muscle incapable of responding to motor stimulus. Whether this was to be attributed to the absence of afferent muscle-sense stimulus, as seemed probable, or whether it was due to some other cause, it was clinically certain that the nerve cells became partially inactive, not extinct, and that with appropriate treatment of the muscle or group of muscles functional activity could be reinstated. When a muscle governed by a live cell, or rather a group of live cells, fails to act, the disability may be spoken of as functional. Of this disability the great outstanding cause is overstretching of muscle fibres. A surgeon must recognize the difference between a truly paralysed muscle and a muscle which is over-stretched, and must know how to distinguish the one condition from the other.

The first essential of treatment is that the muscle or muscular groups must be prevented from being over-stretched. If the wrist is, for instance, allowed to remain flexed the flexor muscles undergo adaptive shortening, and the extensors become over-stretched and consequently placed at a mechanical disadvantage. This point is well illustrated by dropped wrist from lead poisoning. The lesion here may be either in the cord or in the nerve trunks; in either case the muscles cease to be controlled by their nerve centres, and the patient goes about with his wrist flexed by gravity, and the extensor muscles become disabled by continuous overstretching. As the condition is usually bilateral, an interesting experiment to test my contention may be made, if the case be of some weeks' standing, by placing one of the paralysed arms on a splint to keep the hand dorsiflexed. It will be found that recovery will be much more rapid on the side on which the extensors are relieved from overstretching than on the other neglected side. When a muscle is deprived of the natural motor stimuli, its condition from the point of view of function and nutrition is the same, whether the absence of stimuli be due to inactivity of the central nerve cells or to interruption of the conducting paths along the peripheral nerves. Its motor function is suspended, its nutrition suffers, it becomes anaemic, and it may, easily be over-stretched by gravity, by the unrestrained action of the opposing muscle, or by these two forces acting in combination. If the wrist and fingers are kept in extreme dorsiflexion, the extensor muscles, thus relieved of strain, undergo adaptive shortening, and soon begin to respond to the constant stream of tonic stimuli sent to them by efferent impulses; later they come under the higher control of the voluntary centres.

Another cause of persistence of functional disability is an unequal degree of recovery in opposing muscular groups.

Deflection of Body Weight.

A most potent factor for evil is what I have called the erroneous deflection of body weight, which, for physical reasons, operates chiefly in the lower limbs. If, for example, there be weakness in the tibial group and the patient be allowed to walk, the valgoid deformity will

constantly increase, the tibial muscles will be more and more stretched, adaptive contraction will affect the peronei, and structural alteration will ensue in the tarsal bone, terminating in a troublesome flat-foot. All these untoward results may be avoided by simple treatment on sound scientific principles; a little alteration of the boot which, by raising the inside of the heel of the boot, will deviate pressure from the inner to the outer side of the foot, may suffice. When we have to deal with a group of muscles in which the power is only slightly impaired, the muscular

balance may be restored by over-developing the weaker group. If, for instance, the peronei are weak, but the foot can quite easily be placed in the everted position, then massage and exercises may reasonably be expected to succeed. But if the foot cannot be everted because of adaptive shortening of the tibial tendons, then massage and exercise of the peronei will be perfectly useless until such time as the deformity has been corrected and the over-stretched muscles kept relaxed for a sufficient period to permit them to recover by interstitial shortening.

LATE RECOVERY OF MUSCLE POWER.

But before any operations are performed affecting the mobility of a joint, every use should be made of available muscle power. No surgeon should operate on these cases until he has fully satisfied himself whether or no it be possible to restore the apparently paralysed muscle. Neglect of this precaution produces such a distressing occurrence as the unexpected recovery of muscles which were ignored because assumed to be paralysed.

For example, a patient was brought to me once with a partially ankylosed knee. The operation of arthrodesis had been performed with a view of bringing about bony ankylosis. As an arthrodesis the operation had failed, for the knee had a short range of movement. As an experiment, illustrating the principle we are discussing, it was very successful, because the quadriceps was acting with considerable strength. Prolonged fixation had relieved the quadriceps from all strain, and restoration of function resulted. This case exemplifies the mistake of taking for granted that a muscle is paralysed without first making quite certain that it is *really* paralysed. It is only possible to make quite certain by relaxing the muscle and thus putting it into the position most favourable to recovery for a sufficient length of time. Electrical tests cannot be relied upon to give this information.

Treatment to Promote This.

The first stage of treatment is the correction of existing deformity. When deformity has been corrected the limb should be kept immovable until the ligaments, muscles, and even bone have become of normal length and shape. The continuity of treatment must be maintained or a relapse will result. This point is fundamental, and neglect to observe it spells failure, as the slightest stretching of a muscle on the point of recovery disables it again. All the good work may be thwarted by a single indiscretion. I cannot emphasize this point too strongly. For instance, let us take the case of a drop-wrist which has been placed in a splint designed to dorsiflex the hand and wrist. The position must be constantly maintained. The hand must

FIG. 1.—Showing action of dorsiflexing after transplantation of tendons. Captain McMurray's case.

FIG. 2 illustrates a similar result in another of Captain McMurray's cases.

DIAGRAMS ILLUSTRATING TRANSPLANTATION OF TENDON INTO TENDON UNDER VARIOUS ANATOMICAL CONDITIONS.

FIG. 3 A.—Showing the tendon which is to be transplanted about to be passed through a tunnel in the other tendon. The tunnel is being dilated to receive the transplanted tendon.

FIG. 3 B.—Transplant in position. The angulation is dealt with as shown in Fig. 3 C.

FIG. 3 C.—In order to overcome angulation a slit is made in the upper part of the receiving tendon, which is then wrapped round the transplanted tendon.

FIG. 4 A.—Tendons about to be pulled through another tendon before suturing.

FIG. 4 B.—The divided ends of three tendons passed through another tendon in its course.

FIG. 5 A.—Showing transplanted tendon about to be passed along a tunnel in the receiving (active) tendon.

FIG. 5 B.—Tendon passed along course of active tendon.

FIG. 6.—Three tendons passed through another tendon, which has been split to receive them.

FIG. 7.—Tendons inserted into either side of active tendon.

not be allowed to flex for a single moment until recovery has occurred. Even while the patient washes, the hand must be held dorsiflexed.

The clinical test of the recoverability of a muscle, therefore, depends on an experiment. Let it be kept for a prolonged period—for at least six months—in a position of relaxation. This test should always be made before condemning any muscle, no matter how long the period for which it may apparently have been paralysed. When, therefore, one reads in textbooks statements to the effect that we are to despair of the return of power after a certain length of time, we can quite well afford to ignore the advice unless in addition to this time test there has been an uninterrupted muscular relaxation during that time.

These are views which I have without ceasing urged upon my professional brethren as applicable to infantile paralysis. They are equally applicable, with certain modifications, in the case of gunshot injuries. It is obvious that in infantile paralysis long mechanical treatment can do no harm. This is not so in the case of a soldier in whom a nerve has been injured. If suture is to give any promise of success there must be a limit to conservative methods. In any case, an exploration of the nerve is a harmless procedure.

TENDON TRANSPLANTATION IN GUNSHOT INJURIES OF NERVES.

In recommending tendon transplantation in gunshot injuries I have profited by the experience gained in anterior poliomyelitis. I have frequently performed tendon transplantation with success in the adult in cases in which isolated nerves have been destroyed. Similarly unrecorded cases have been operated upon by my friends Mr. Thelwall Thomas and Mr. Bickersteth. At the Military Orthopaedic Hospital, Liverpool, my colleague, Captain McMurray, has at this moment three successful cases in which transplantation has been done for musculo-spiral paralysis. As

I have previously indicated, the object of a transplantation is to improve or restore muscular balance. It is not justified unless it improves function. There is little satisfaction to a patient if the transplanted muscle merely responds to faradism, or even makes a feeble movement by the effort of the will. It must be, or give the promise of becoming, a substitute for the muscle it supplants. It can only be judged by its ultimate usefulness.

A tendon may be transplanted in order to restore the balance between opposing groups of muscles by helping a redistribution of power, or its attachment may be slightly altered to prevent deformity.

Recognizing that the principles involved in tendon transplantation are the same in both conditions, I will briefly describe in the second part of this communication certain transplantation operations I recommend for various injuries.

As a preliminary I give here a series of diagrams Figs. 3, 4, 5, 6, and 7, illustrating methods of transplantation of tendon into tendon applicable under various anatomical conditions.

REFERENCES.

¹ The Annual Oration, Medical Society, May 18th, 1914, on Infantile Paralysis: its Early Treatment and the Surgical Means for the Alleviation of Deformities. ² BRITISH MEDICAL JOURNAL, December 9th, 1911.

(To be continued.)

LIEUTENANT-COLONEL C. C. McCULLOCH, Medical Corps, U.S.A., Librarian of the Surgeon-General's Office, Washington, D.C., informs us that the Army Medical Museum there possesses a valuable collection of medals relating to medicine, started and fostered by the late Dr. John S. Billings. It is desired to add to this collection and complete it as far as possible. Colonel McCulloch invites the assistance and advice of physicians who are collectors of medical medals. Gifts of medals are asked for, and also copies of catalogues for sale, as the museum is in command of money for the purchase of individual medals or private collections.