WAR INJURIES OF PERIPHERAL NERVES.

By HARRY PLATT, M.S., F.R.C.S.

(Professor of Orthopædic Surgery, University of Manchester.)

Introduction.

Although the mechanisation of modern armies has provided conditions in which the soldier is especially liable to accidental injury, the surgical problems thereby presented are in no way peculiar to military life. We may therefore put on one side the special consideration of types of peripheral nerve injury familiar in civil practice, such as lesions due to the penetration of sharp particles, nerve injuries associated with fractures and dislocations, and traction lesions of the brachial plexus. It is the peripheral nerve lesions resulting from gunshot injuries with which we are for the moment particularly concerned. In through and through wounds from rifle, machine-gun, or shrapnel bullets, the large nerve trunks quite frequently escape damage. Such nerve lesions as occur, tend to be localised and are often incomplete. But in wounds from high explosive missiles producing widespread destruction of soft parts and severely comminuted fractures, a nerve trunk may sustain considerable loss of substance. To the immediate damage produced by the missile there is later added the destruction wrought by suppuration, and during the final stages of healing, further obliteration of conductive elements by scar tissue, both around and in the interior of the nerve trunk. In a limb so grievously injured, a nerve lesion is not necessarily the most important factor in the sum-total of the disablement.

Diagnosis.

The presence of a nerve injury is indicated either by signs of loss of conduction (nerve block) or by the signs of disordered function. For diagnostic purposes certain distinctive syndromes are recognised:—(1) *complete* block, characterised by complete interruption of motor and sensory function, with inconspicuous vaso-motor, secretory, and trophic signs; (2) *incomplete* block; (3) *irritation*, in which, with an incomplete block, the vaso-motor, secretory and trophic signs, are predominant. The special type of severe irritation syndrome known as *causalgia* was first described in connection with gunshot wounds of the median and sciatic nerves observed during the American Civil War; (4) *recovery*, manifested in the early stage by the reappearance of tone in the wasted muscles combined with a recession of the area of protopathic sensory loss.

When a diagnosis of nerve injury has been made, the all-important question to be answered is whether the lesion is one which demands some form of operative repair. The lesions encountered at operation may be broadly classified as follows:—(a) complete division with a gap; (b) complete division without gap; and (c) an intact nerve trunk presenting a localised lesion.

When an injured nerve is open to direct inspection during the operation of wound débridement, information regarding the naked-eye extent of the lesion is at once available. But if the problem is presented to the surgeon only at a later stage when the gunshot wounds are healed, the severity of the lesion must now be assessed on clinical evidence derived from a series of motor and sensory tests made over a given period of time. Precise information may in actual fact become available only when the injured nerve is explored.

Treatment.

I. Non-operative. When it has been decided that there is a reasonable chance of regeneration occurring without recourse to operation, the essential objective is to maintain and improve the nutrition and mobility of the affected limb by carefully chosen physio-therapeutic measures. Such treatment exerts not the slightest influence on the regenerative process in the nerve trunk, but the ultimate functional value of the regeneration will clearly depend on the state of the tissues supplied by the injured nerve. Paralysed muscles which have been continuously over-stretched cannot regain full power, nor can recovering muscles function if opposed by contractures and fixed joints. The paralysed muscle group should therefore be maintained in moderate relaxation by suitable light splints, and the limb treated by warmth and light massage. At each sitting all joints should be gently mobilised through a full range. In the early stage the muscles should be regularly stimulated by the current to which they respond. At a later stage, when recovery of voluntary power has set in, the treatment comprises muscle re-education, purposive exercises, and occupational therapy. A similar programme is followed in the after-treatment of nerve operations.

II. Operative treatment. A distinction must be drawn between the primary and secondary repair of an injured nerve. *Primary* repair as practised with safety in certain civil injuries, has no place in the infected wounds of warfare. If a severely lacerated or completely divided nerve trunk is encountered in the course of the operation of wound débridement, the existence of the lesion should be duly recorded, but no attempt made to repair the damage.

Secondary nerve repair is not undertaken until the original wounds have been soundly healed for a period of at least six weeks, and the maximal nutrition and range of mobility have been restored to the limb by physical treatment and active use. In the most severe types of gunshot wound, with gross destruction of soft tissues, or in which there is delayed union or non-union in an associated fracture, the nerve operation should be postponed until all necessary skin plastic or bone grafting procedures have been completed. In such cases it may be necessary to postpone the nerve repair for many months.

(1) **Technique of exploration.** The injured nerve should be exposed through a generous skin incision and the nerve trunk displayed in an inter-muscular interval, first above and then below the level of the lesion. The presence or absence of response to direct faradic stimulation is next ascertained. It is interesting to find that a positive response may be occasionally demonstrable when before operation no such reaction could be obtained from the ordinary percutaneous method of testing. The exposure of the area of the lesion usually presents difficulties owing to the density and extent of the scar tissue around the nerve trunk. It should be assumed, until proved to the contrary, that the nerve trunk is intact. The injured segment should be freed by dissecting only in the long axis of the nerve.

Nerve suture will be called for in complete anatomical lesions with or without gap, and *neurolysis* in incomplete lesions where recovery is inhibited by the strangling effect of extraneural scar tissue.

(2) **Technique of nerve suture.** Where there is extensive scarring in the limb, the nerve trunk, proximal and distal to the lesion, should be exposed and freed as widely as possible. This is often a difficult and tedious procedure. Further mobilisation of the nerve is afforded by changing the position of the limb, by stripping up motor branches from within the proximal part of the nerve trunk, and if need be by so displacing the nerve as to shorten its course—e.g., anterior transposition of the ulnar nerve at the elbow.

After appropriate trimming of the proximal and distal stumps to expose healthy nerve bundles on the cross-section, the ends should be lightly opposed and the *nerve sheath* neatly approximated by a number of interrupted sutures of non-irritant material (thread or plain catgut of the finest calibre). The sutured nerve is then placed in a bed of healthy muscle tissue.

(3) **Technique of neurolysis.** In this procedure the nerve trunk is released from scar tissue in the neighbourhood of the lesion and a more suitable bed provided. If healthy muscle is not available, as for example when a nerve trunk is in close contact with bone, a sheet of fascia should be interposed.

In some of the severe lesions with apparent naked-eye continuity, it is difficult at first sight to decide whether resection and suture or neurolysis is the correct procedure. An attempt should be made to estimate the relative amounts of scar tissue and intact nerve bundles. When the scar tissue predominates, and especially in long standing injuries, regeneration on a large scale cannot obviously take place. Under such circumstances resection is clearly indicated. In lesions with partial loss of conductivity the choice between neurolysis and resection may also be determined by the relative importance of the motor and sensory functions subserved by the injured nerve. Thus, in the median nerve, intact motor bundles may be sacrificed if the prospects of sensory regeneration are poor. The reverse condition applies to the ulnar nerve.

III. Irreparable lesions. In severe gunshot injuries a certain number of irreparable lesions are inevitably encountered. When, despite the widest exposure and freeing of nerve trunk, the ends cannot be approximated, the choice lies between (a) bridging the gap by some form of nerve graft; or (b) in certain nerve lesions, restoring function by an appropriate tendon transplantation. Nerve grafting, which after a trial during the Great War of 1914–1918 fell into disfavour, has recently been used with striking success in facial palsy. The anatomical conditions in gunshot injuries are however much less favourable, but it remains to be seen in the future whether full calibre grafts can be successfully employed to bridge long gaps in the larger nerve trunks of the limbs. The most useful tendon transplantation operations are (a) the classical transplantation of the pronator radii teres and flexors of the wrist in musculo-spiral palsy; and (b) the transplantation of a flexor sublimis digitorum tendon to the proximal phalanx of the thumb for the thenar palsy of median injuries.

IV. Operations for causalgia. The milder degrees of irritation respond to conservative treatment, but in severe causalgia, exploration of the nerve and the complete abolition of conduction is imperative. Two procedures, equally effective, have been used for this purpose: (a) the intraneural injection of 60 per cent. alcohol; and (b) resection of the lesion and end-to-end suture.

Operation Results.

(1) **Nerve suture.** In gunshot lesions varying degrees of imperfect recovery are to be expected. The main causes of failure are (a) the remote results of wound infection—ascending neuritis, scar compression at the level of the suture; (b) long delay in effecting repair; and (c) inaccuracy of regeneration, i.e., the failure of axons to reach appropriate end-organs.

The results vary considerably in the different nerve trunks. The *musculo-spiral nerve* has provided the largest number of successes. In 50 per cent. of sutures of this nerve almost perfect restoration of function has been obtained. The

median and *ulnar* nerve sutures are much less satisfactory, with, at the best, partial sensory recovery, full recovery in the proximal muscles, but incomplete recovery in the intrinsic muscles of the hand. The *sciatic nerve* is even more disappointing, for in the severe lesions a considerable proportion of limbs are later amputated, owing to intractable ulceration of the foot. The *external popliteal* nerve sutures have provided a fair percentage of complete recoveries.

(2) **Neurolysis.** The influence of neurolysis *per se* is not always easy to estimate. In long standing compression lesions where there are permanent changes in the interior of the nerve trunk, complete restoration of function cannot be expected.

REFERENCES.

A comprise list of References will be found in the following Articles :—

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