PERIPHERAL NERVE INJURIES

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ALTHOUGH in 1811 Charles Bell had dissociated the functions of anterior and posterior spinal nerve roots, and in 1822 Magendie had shown the anterior root to be motor and the posterior root sensory, up to the time of the American Civil War interest in peripheral nerves was centred mainly in their histology. During that war, Weir Mitchell (1864) organised the first hospital devoted solely to the care of central and peripheral nerve disorders and injuries; an acute clinician, he studied in considerable detail the effects of peripheral nerve injuries, and his many contributions include what persists as the classical description of causalgia. War provided his material; it has done so twice in this country. During the first world war, Sir Robert Jones was mainly responsible for the establishment of special centres for the treatment of injured peripheral nerves, among them one at Bangour Hospital, where Sir Harold Stiles played so notable a part. These years, and the succeeding ones, were described as "the heyday of peripheral nerve surgery" (Platt, 1937). During this period, the main achievement was the perfection of operative technique, what Seddon (1947) has described as the standard method of repair to-day, namely, "the mobilisation of nerve stumps, resection to healthy bundles centrally and peripherally, and end-to-end suture with the limb in a position that permits easy approximation." According to the late Rowley Bristow (1947), who was one of few with experience of nerve injuries in both world wars, the main lessons learned in 1914-1918 were first, the importance of maintaining joint mobility, especially of the small joints; secondly, that "frozen hands" could not be improved by manipulation under anæsthesia; thirdly, that physiotherapy and rehabilitation were essential parts of the whole treatment; and fourthly, that while certain orthopædic operations were successful, such as the muscle transplant for irreparable musculospiral nerve injury, others such as the tenodesis for drop-foot, were uniformly unsuccessful. Some of these lessons had to be relearned during the recent war.

In 1940, however, through the foresight of the Medical Research Council, there were established in Britain five centres for the care of patients with nerve injuries; again one was in Edinburgh, under the charge of Professor J. R. Learmonth, with whom I was privileged to work for a time and to whom I am indebted for the use of certain material for this lecture. A uniform system of recording clinical findings was adopted throughout the centres, so that in due course

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it would be possible to collect and correlate data from a large number of patients, which was an advance on the 1914-1918 arrangement, in which each centre used its own system, so that it was impossible later to correlate the results of nerve suture, neurolysis and so on. The co-operation of the Ministry of Pensions was obtained, and with their financial help it was possible to review patients for as long as five years after operation.

The machinery was thus built for further advances, and in view of the possibility of a third widespread conflict, it is pertinent to ask if new lessons were learned, further advances made, during this second heyday of peripheral nerve surgery, and to take stock of the surgical resources, diagnostic, technical and otherwise at our command. A review of this material forms the basis of my lecture, which is not a statistical survey, since in the near future the Medical Research Council report will be published, embodying the results from all five centres; rather I shall endeavour to present my own views on the subject, and I propose to deal with only two aspects: diagnosis and treatment.

Diagnosis

One would have thought that the diagnosis of nerve injury would be easy; yet injury is not infrequently overlooked, the nerve most often missed in war wounds being the median. It may happen in civil practice. Three years ago a patient was referred as a case of unilateral Raynaud's disease (which does not occur), although some six weeks previously she had sustained a through-and-through wound of her wrist; more recently a colleague referred a patient who, following treatment of a cut wrist at a hospital, had been allowed to continue work as an apprentice joiner for eight months with his left median nerve divided; and two weeks ago I sutured the ulnar nerve of a boy whose cut wrist had also been treated in a hospital eleven months ago. It must be borne in mind that anomalous innervation of muscles is not infrequent, as Highet (1942, 1943) so ably demonstrated, and may be quite misleading; Bristow (1947) mentions a case in which all the intrinsic muscles of the hand were innervated by the ulnar nerve. Anomalies are less frequent in the lower extremity, but I have found on two occasions that the extensor digitorum brevis was innervated not by the lateral division of the anterior tibial nerve, but by some branch of the musculo-cutaneous; confirmation was obtained at operation on one patient, who had the clinical picture shown in Fig. 1; the other did not have an operation. In diagnosis of median nerve injury particularly, too little attention is paid to subjective and objective sensory findings; for while the cutaneous distribution can vary considerably, the terminal phalanges of the index are invariably anæsthetic and analgesic. With possible anomalies in mind, the diagnosis of nerve injury should not present any problem. I do not intend to discuss the sympathetic paralysis which occurs, but must mention the investigations

of vasomotor function by Richards (1946) and of sudomotor function by Guttman (1940), which increased the diagnostic resources and added to the knowledge of the phenomena of regeneration and of functional recovery.

As a general rule, the diagnosis of the type of nerve lesion is easy in civil practice; cutting injuries cause anatomical division of nerves; traction injuries lead to anything from mild transient palsies to severe nerve disruption over many centimetres of nerve, as in dislocations of the knee and in some brachial plexus injuries; while closed fractures tend to cause, at most, lesions-in-continuity which regenerate spontaneously, although one of the longest lesions which I have seen in the musculospiral nerve followed a simple transverse fracture of the humerus; such a complication is rare, however, and in fact only about 5 per cent. of humeral fractures have neurological complications.

MUSCLE CHART

T.A.	0
E.D.L.	0
E.H.L.	0
P.T.	0
E.D.B.	4
P.L.	5
P.B.	5

FIG. 1.—Innervation of extensor digitorum brevis by musculo-cutaneous nerve; confirmation was obtained at operation.

Following penetrating war wounds, on the other hand, it is frequently impossible to differentiate between anatomical division and lesion-in-continuity, for in the early stages they behave clinically and electrically in exactly the same way. For that reason, the agreed policy has come to be that such nerves are explored early, as soon after three weeks as conditions permit. If a number of months has elapsed since the injury, when the patient is first seen, however, and the paralysis is still complete, it may be that help can be obtained by electrical examination, and two methods have been developed during the recent war.

First, there is examination of the strength-duration curve (Ritchie, 1944). Electrical stimuli of variable strength (5 to 80 volts) and variable duration (one-tenth of a second to ten micro-seconds) are applied to the muscle in question through two electrodes, an indifferent one placed somewhere against the limb and an exciting one which must be placed against that part of the limb which, by trial and error, is found to give a maximum response. The results are plotted in graph form, with duration of current as abscissa and strength of current as ordinate. A normal muscle gives the type of record shown in Fig. 2, "N." Because muscles vary in response, the muscle corresponding to that under investigation must be examined in the contralateral limb and its graph used as "normal"; in this case the muscle in question was extensor digitorum communis. Following a

musculospiral nerve paralysis secondary to a fracture of the humerus rather higher than the usual site, the most proximal muscles had become active at the expected time, but voluntary recovery in extensor digitorum communis was much delayed, and it seemed possible that compression by callus might be impeding recovery. The change in shape of the curve at the sixteenth week made it possible to decide that reinnervation was occurring and that voluntary power would return, as indeed it

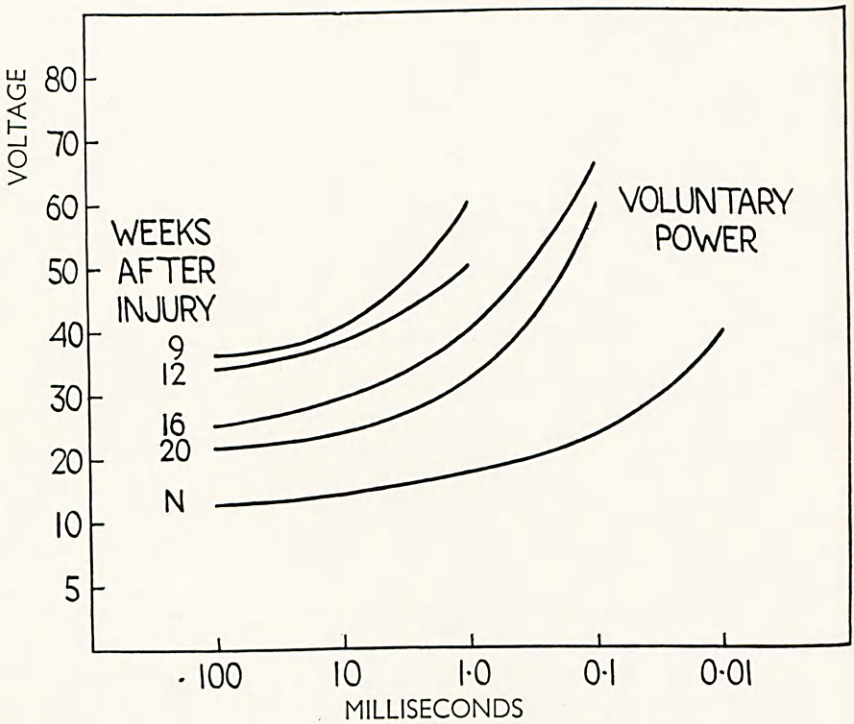

FIG. 2.—Strength-duration curves of extensor digitorum communis, following fracture of humerus; significant lowering of the curve precedes the return of voluntary power by at least four weeks.

had by the twentieth week, although the curve was by then still abnormal. Determination of strength-duration excitability of a muscle must be repeated to be of value, but if there is a significant lowering of the curve towards normality, then it is justifiable to regard the lesion as one in continuity rather than anatomical division. A change is discernible some weeks before voluntary power returns.

The second electrical method is electromyography (Weddell *et al.*, 1943), of which I have no personal experience. The differences in electrical potential of normal muscle, denervated muscle and reinnervated muscle can be used to determine whether or not any particular muscle is becoming reinnervated; again it is necessary to perform at least two examinations with about seven days' interval,

in order to demonstrate any change in action potentials suggestive of increasing reinnervation.

There is no doubt that in estimation of strength-duration excitability and in electromyography the present-day clinician has valuable aids to diagnosis which were not available to his predecessors in the first world war.

Treatment

(*a*) *Non-operative*

(1) *Splinting.*—In the early days of the war there was a tendency to over-splint and to splint incorrectly, and the main disability of some patients to-day can be attributed to this tendency, in particular with regard to the metacarpo-phalangeal joints. I believe that splints are necessary for only four types of nerve injury: first, paralysis of deltoid, when some form of abduction splint is necessary; secondly, paralysis of biceps brachii, when a simple sling will achieve its purpose, although some function can be given to the elbow by an elastic appliance; thirdly, in paralysis of the musculospiral nerve a good splint will not only prevent overstretching of the paralysed muscles but will permit useful function in the hand; and fourthly, an appliance of some sort is necessary to prevent foot-drop in paralysis of the lateral popliteal nerve. I do not believe that there has yet been devised a satisfactory splint for injuries of either median or ulnar nerve, and I personally believe that an intelligent patient can prevent deformity by faithful passive exercise of the affected digit, which he must be taught by his surgeon.

(2) *Passive Movement.*—A limb the site of nerve injury must undergo a full range of movement at least three times a day; this should be active when possible, passive when necessary, and should be supervised by a physiotherapist at least once each day. This is by far the most important part of physiotherapy in nerve injuries, and the most important part of non-operative treatment. During the war, I had to send home by troopship some 500 patients without facilities for treatment en route, and I attempted to instruct them in the various passive exercises they should employ; when I saw many of them later, it was obvious that the mobility of their hands was directly proportional to the assiduity with which the movements had been performed. Passive movements should be begun as soon after wounding as the patient can co-operate; stiffness and contractures almost disappeared in patients from the Burma front once this became understood by the forward medical officers.

(3) *Massage.*—Once a limb has been warmed, massage can be comforting, but I doubt if it has any true therapeutic value in peripheral nerve injuries.

(4) *Electrical Stimulation.*—In any centre where large numbers are under treatment, the routine use of galvanic stimulation is impossible since there is not sufficient time. None the less, it has been shown

(Jackson, 1945) that the application of 90 stimuli each day for six days each week is successful in preventing wasting of intrinsic hand muscles, except in the early weeks following injury, when it lessens the amount of wasting, that in itself being of significance. This involves only five minutes' electrical treatment daily for any one patient and is therefore practicable if reserved for injuries of the median and ulnar nerves.

(5) *Re-education.*—Once neurological recovery has occurred, an attempt must be made to enable the patient to resume accurate voluntary control. For instance, neurological recovery after suture of the lateral popliteal nerve may include reinnervation and strong power in all muscles, but attempts strongly to dorsiflex the ankle may lead to a mass action in which the peronei participate, with poor function; similarly, individual action of the intrinsic muscles of the hand is rarely obtained after suture of the ulnar nerve for war injury, although easier to acquire after civil injury. Some attempt must be made to re-educate the individual muscle to respond, but it has to be confessed that the results are in the main disappointing. This disordered function is, of course, due to axonal criss-crossing at the suture line, and it appears to be impossible for the cerebral cortex, even with time, to compensate for the cross-innervation of muscles. Bowden (1951) mentions an interesting case of cervical and brachial plexus injury in which some fibres normally destined for the diaphragm or accessory respiratory muscles made their way to biceps brachii, which contracted weakly with each inspiration, and continues to do so four years later, in spite of the return of voluntary power as well.

(*b*) *Operative*

(1) *The Treatment of an Injured Nerve at the Primary Operation.*—I believe that a severed digital nerve should be sutured; that all other nerves should be left alone. It is commonly recommended that in order to prevent retraction, the ends of the nerve should have one non-absorbable suture passed through them; this practice appears to me to lead eventually to the resection of more nerve tissue at secondary suture than if retraction occurs, since one will have to resect not only neuroma and glioma, but also such nerve as becomes even mildly fibrosed in the normal reaction of wound repair (Fig. 3). A nerve the ends of which can be easily brought together by one suture will not retract far, and in any case such retraction as occurs will be easily made up in the normal mobilisation at secondary suture. I do not consider that primary suture has a place, except in the case of digital nerves, although it might be defensible in a child who also has injury to tendons. It is known that there is a higher percentage of poor results after primary suture than after secondary suture (Zachary and Holmes, 1946). During the last three years I have re-explored four nerves repaired by primary suture following clean wounds by glass, and in

three was forced to re-suture the nerve; the delay in proper repair cost the patients a number of months of disability and, when the interval was considerable, reduced the eventual degree of recovery.

(2) *The Optimum Time for Operation.*—When the state of the nerve is known, the decision is easy, because suture should be undertaken as soon as possible after the elapse of three weeks from the time of injury, for by then neuroma and glioma are well defined, Schwann cells are showing maximum activity, and the sheath is slightly thickened and holds suture well. Frequently in war injuries, however, and occasionally in civil practice, it happens that it is impossible to decide at an early stage whether a complete clinical lesion is an anatomical division which requires suture, or a lesion-in-continuity which will

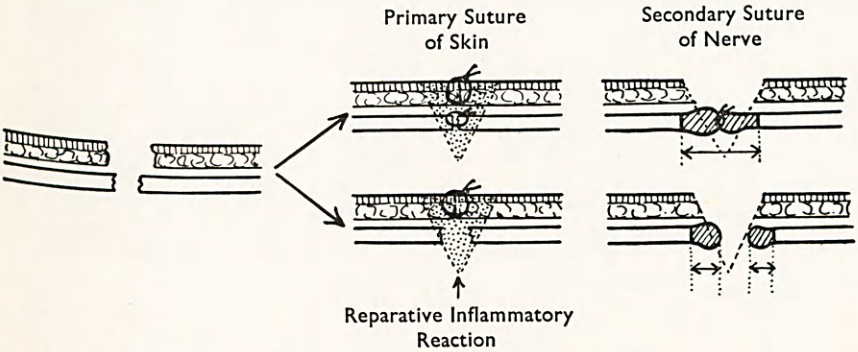

FIG. 3.—Diagram illustrating how apposition of nerve-ends at primary operation may lead to resection of more nerve-tissue than if nerve-ends are allowed to retract.

regenerate spontaneously; this is especially true if a neuroma is palpable. It is correct, I believe, to explore such an injury as soon as conditions allow after the interval of three weeks. Longer delay will cost the patient time if suture is necessary, while if suture is unnecessary the price is a three-inch scar; this implies that exploration is merely part of the diagnostic armamentarium and early intervention has come to be the agreed policy in this country, the view of Cairns and Young (1940) and of Sunderland (1947) that the delay should be six months being generally unacceptable.

Bristow (1947) recommended that when a fracture is complicated by a nerve injury, which is known to be anatomical division, suture of the nerve should take precedence over the fracture, in order that bone-shortening may be undertaken if it is necessary for end-to-end suture of the nerve. In closed fractures, of course, spontaneous recovery occurs in the majority of cases, as it does in 80 per cent. of all closed nerve injuries.

When there is concomitant vascular injury, with aneurysm formation, early exploration is indicated, as soon as it is reasonable to believe that sufficient collateral circulation has developed, because a pulsating aneurysmal sac has the power to compress a nerve severely and may cause considerable pain, as in one of my cases. This man had received

a through-and-through wound of the right arm in November 1944; when I examined him six weeks later I found a complete median nerve lesion, with a small brachial aneurysm 1½ centimetres in diameter. The findings at operation are illustrated in Fig. 4. It was necessary to perform a double ligation of the artery, with resection of the affected segment of vessel; since this was performed well below the profundi brachii, there was no risk of ischæmia in the limb distally, but the possibility of ischæmic change in biceps was a hazard, since in the majority of cases this muscle receives only one large branch

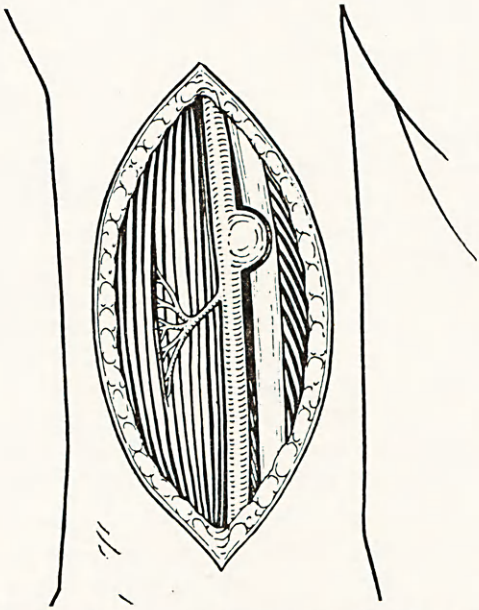

FIG. 4.—Drawing of operative findings in case of brachial aneurysm and painful median nerve paralysis.

of supply, about the middle of the arm. Following resection, there was a reasonable flow from the distal end, however, and there was not at any subsequent time any suggestion of biceps contracture; eight months later I heard that the median nerve was showing early functional recovery. The effect of pressure by an arteriovenous aneurysm on the ulnar nerve is demonstrated in Fig. 5.

(3) *The Indications for Late Operation.*—When the patient first presents some time after injury, or even after suture, and there is some degree of neurological recovery, the question of operation is most difficult. This is particularly true if suture has already been performed, for as Sunderland (1949) has shown, a second resection not only causes a greater degree of funicular dissimilarity at the suture line, increases the retrograde degeneration and causes further stretching of the nerve in order to close the gap, but it also may fail to ensure a better outcome. There are, however, certain indications for

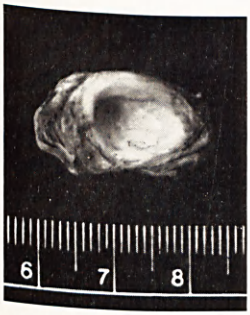

FIG. 5.—Segment of ulnar nerve compressed by arteriovenous aneurysm.

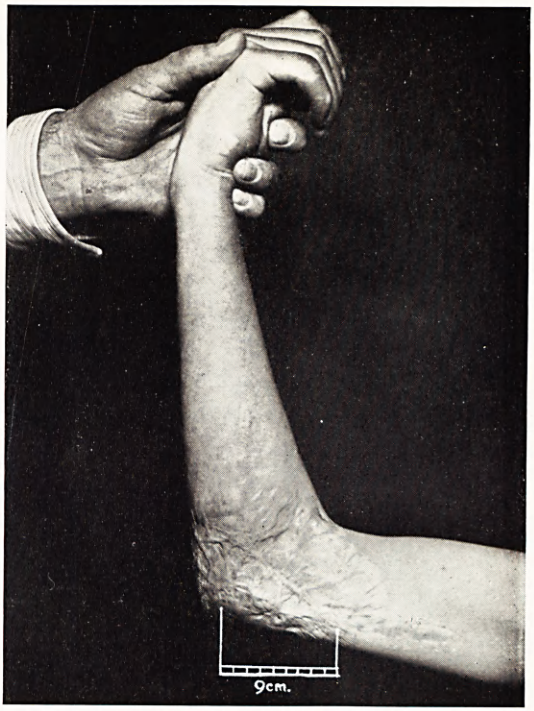

FIG. 6.—Case T. E. Extensive high tension burn involving elbow joint, treated by split-skin graft, through which a gap of 11 cm. in the ulnar nerve was closed by suture.

FIG. 7.—Case T. E. Good function in ulnar nerve two years later, as illustrated by the power in flexor minimi digiti.

re-exploration. There is failure of the nerve to have regenerated either spontaneously or after suture to a stage which can now be assessed for the average nerve, taking into account the conditions at the first operation, the state of the nerve then disclosed, the level of injury, the interval since injury or suture, and the operator. Learmonth (1944) has suggested certain indications for late nerve exploration, even when some recovery has occurred, in order to determine the exact state of the nerve and, equally important, of its surroundings. They are: (1) previous long-continued sepsis, which may have caused scar contraction around the nerve; (2) when a nerve lies at the bottom of a healed "trough" wound; (3) when there has been severe bleeding, with the possibility of muscle necrosis and later strangulation of the nerve, of the median, for instance, between the heads of pronator teres; (4) in closed crushing injuries, when a cicatrising collar may strangle the nerve; (5) when a main artery has been divided at the same level; (6) when two or more nerves are divided at the same level; and (7) when persistent pain or persistent hyperhidrosis is present, although if the pain is true causalgia it would be advisable to attempt relief by temporary sympathetic block in the first instance. As has been indicated, both strength-duration estimation and electromyography may help in reaching a decision.

(4) *Procedure at Operation.*—I do not intend to describe technique in detail or to mention the different types of suture material, and I need not stress the necessity of having a faradic coil at hand if there is any doubt about the nature of the lesion. It is for the doubtful lesion that I shall attempt to produce some guiding principles; although in other fields of surgery a wrong decision may be more serious, there is to my mind nothing more difficult than deciding, in some cases, whether or not to resect a nerve lesion. If the operation is being undertaken early and after inspection and palpation there is still uncertainty, then I believe that it is correct to leave the nerve as it is found, except that it should be laid in a healthy bed; it must be accepted that with high lesions this decision is irrevocable, for late suture of high lesions is almost invariably unsuccessful; in fact, the view of Stopford (1918) that suture of high lesions gave better function than suture of low lesions is no longer tenable, although it is true that the rate of regeneration is faster in the early stages after repair.

If the operation is being undertaken late, and after inspection, palpation and faradic stimulation there is still uncertainty, one is left with three possibilities: trial section, resection and no action. Trial section can be of great value, for if it shows that half the nerve is scarred, then one can proceed to resection and suture in most instances, since microscopic scarring of apparently intact nerve is always greater than expected; exceptions occur in high lesions of ulnar and external popliteal nerves, which give disappointing results

after suture, especially late suture, and which are best left undisturbed if there is doubt.

Once the decision to resect has been made, further difficulty may arise in war wounds, namely, whether or not the gap can be closed by end-to-end apposition and suture. Surgical ingenuity can close enormous gaps as is shown in Table I. It has become apparent, however, that there is a limit to the extent which may be resected with end-to-end suture; as Seddon (1947) describes it, " There is a

TABLE I

Nerve.	Forrester-Brown (1921).	Babcock (1927).
Median in arm	11·5 cm.	15·0 cm.
Median in forearm	16·5 cm.	23·0 cm.
Ulnar in arm	12·5 cm.	16·0 cm.
Ulnar in forearm	16·5 cm.	12·5 cm.
Radial in arm	9·0-10·0 cm.	15·0 cm.
Sciatic	10·0 cm.	14·0 cm.
Posterior tibial below mid-leg	15·0 cm.	13·0-15·0 cm.

biological limit, which is stricter than the anatomical, to the extent of the gap that can safely be closed by mobilisation and end-to-end suture." He calls this length of nerve the " critical resection length " and it appears to vary to some extent from nerve to nerve, as shown in Table II. At present, " critical resection lengths " are under review and these figures must be regarded as provisional, but it is unlikely that they are very far wrong. None the less, it is to be hoped that not too rigid standards will be accepted. I have sutured across a gap

TABLE II

Nerve.	Forrester-Brown (1921).	Zachary, quoted by Seddon (1947).
Median in arm	11·5 cm.	7·0 cm. *
Median in forearm	16·5 cm.	7·5 cm.*
Ulnar in arm	12·5 cm.	about 6·0 cm.*
Ulnar in forearm	16·5 cm.	
Radial in arm	9·0-10·0 cm.	7·5 cm. with A.T.*
Sciatic	10·0 cm.	Not yet determined

* Provisional figures.

of 11 centimetres the ulnar nerve of a 13 year old boy; the nerve had been destroyed at the elbow by a high-tension electrical burn, and a split-skin graft had been applied by Mr A. B. Wallace (Fig. 6). At operation I left undisturbed behind the elbow a segment of charred nerve which measured 11 centimetres, closing the gap by anterior transposition and suture. Two years later this youth has excellent motor function (Fig. 7) and although his sensory localisation is quite inaccurate, no part of his hand is analgesic or anæsthetic; it is true that youth is on his side, yet I do not believe that a graft could have

given a better result. Few civilian injuries cause large lesions, but I believe that one must be careful in deciding to graft, particularly since it involves the sacrifice of a sensory nerve. This youth also illustrates the necessity for co-operation between plastic surgeon and nerve surgeon, particularly where there is little subcutaneous tissue, a matter which has been described elsewhere (Learmonth and Wallace, 1943).

None the less, it has clearly been shown that nerve grafting is practicable, a view which was not held during or immediately after the first world war. The graft must be autogenous, and as a general rule a cutaneous nerve is used either as a single strand for small nerve repair, or as a cable for larger nerves; occasionally, where two main nerves are grossly damaged, a free graft from the less important is used to repair the more important; for instance, the injured external popliteal was used by Seddon (1947) for repair of the more important internal popliteal nerve; he found in addition that a moderate degree of degeneration in the larger graft rather favoured its survival. It is in free nerve-grafting that the use of plasma-clot for maintaining apposition has come to be almost standard technique.

At the Edinburgh centre, grafts were infrequently used and my personal experience is small. Of interest, however, are two cases of double injury to the ulnar nerve; double suture was performed, with anterior transposition of the intermediate portion which served as a free graft. The outcome in both was excellent, one being illustrated in Table III.

TABLE III

Injury.	Operation.	Distance from Medial Epicondyle.		Result 26.1.48.	
		Proximal.	Distal.		
November 1944	January 1945	10 cm. above	9 cm. below	F.C.U. F.D.P. A.D.M. Lumb. Add. Pol. Dors. Int. I	3 1 4 + 3 2

(c) *The Role of Sympathectomy*

(1) *Causalgia.*—This distressing condition occurs in one or two per cent. of all war injuries to nerves, and is rarer in civil life. During the 1914-1918 war, no satisfactory treatment was found, but in the interval between the wars the development of the surgery of the sympathetic system led to the hope that interruption of the sympathetic pathways might cure the condition. This was found to be the case, as many have described (Goodman *et al.*, 1946; Mayfield and Devine, 1945; Slessor, 1948). It is not yet clear whether sympathectomy achieves its effect by interrupting afferent pain-bearing fibres which run in the sympathetic chain, or by interrupting efferent impulses and

preventing cross-stimulation of the pain-bearing C fibres at the level of injury. While the presence of pain-bearing fibres is well-recognised in the splanchnic nerves, their existence has yet to be proved in the peripheral sympathetic system. For that reason I favour the latter view, especially since it is known that if the distal segment of a divided sympathetic chain is stimulated by faradism at operation under local anæsthesia, the patient with causalgia experiences pain whereas the

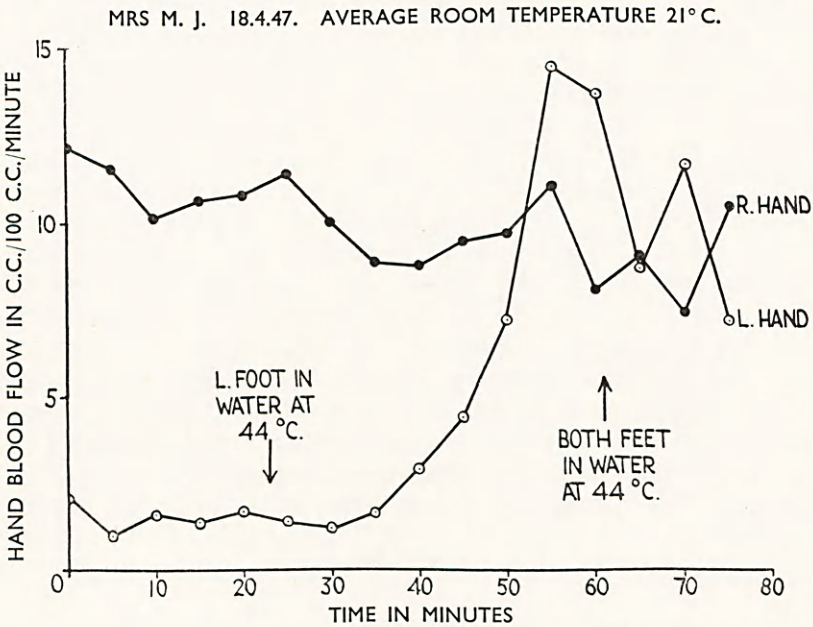

FIG. 8.—Case M. J. Blood flow of hand one month after preganglionic sympathectomy; absence of reflex vasomotor response to heating of lower extremities.

patient with some other condition is unaffected (White, personal communication).

Causalgia is very rare in civil practice, but occasionally follows trauma to a digital nerve, especially the terminal branches of the median nerve, either at the time of injury or at subsequent amputation of the finger. It is important to distinguish the painful neuroma, which is sensitive but does not cause spontaneous pain, from true causalgia, with its characteristic burning pain, continuous but with exacerbations, particularly as the result of emotional stimuli and environmental change. My experience of causalgia following injury to digits is limited to 4 cases. All were relieved by sympathectomy; the third suffered a recurrence of burning pain about nine months after operation, although there is no doubt that the sympathectomy was initially complete as estimation of blood flow one month after operation shows (Fig. 8). This interval of nine months corresponded closely to the time at which some sympathetic control returns to limbs following operation for Raynaud's disease (Barcroft and Hamilton,

1948) and the patient was, on further investigation, found to have considerable vasomotor function as is shown in the blood flow, fourteen months after operation (Fig. 9). Stellate ganglionectomy relieved the recurrent causalgia, and she remains free from pain three years later. The fourth patient, whom I saw through the kindness of Mr Quarry Wood, and on whom sympathectomy was done three months after a crushing injury to the right middle digit, is working as a miner, pain-free fifteen months after operation.

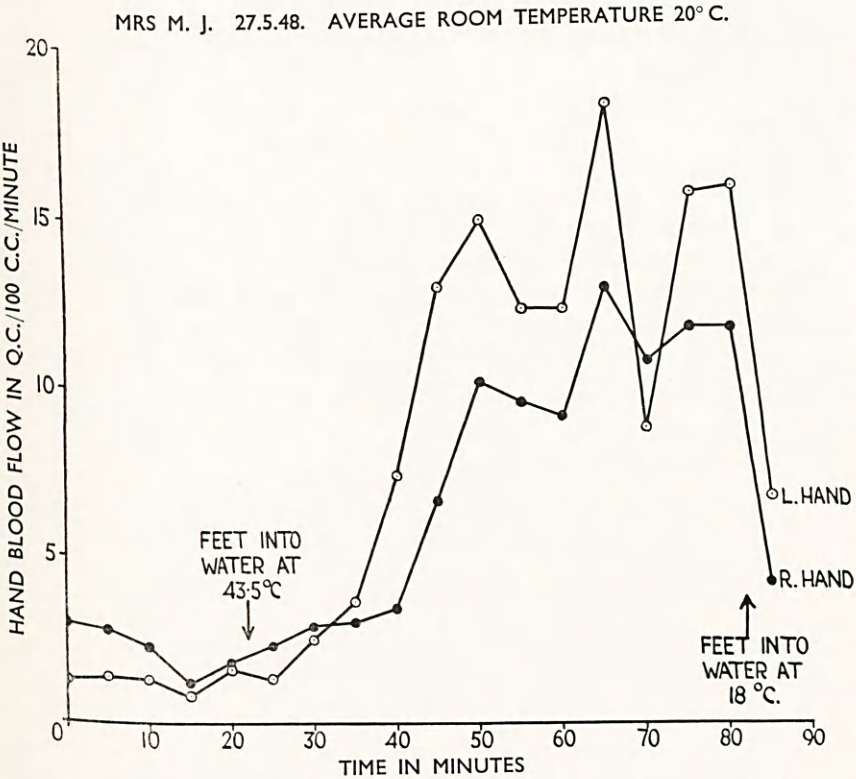

FIG. 9.—Case M. J. Blood flow of hand fourteen months after preganglionic sympathectomy return of vasomotor activity as shown by reflex response to heating of lower extremities.

It has been said that to be successful sympathectomy must be performed relatively soon after injury. None the less, in certain cases even very late operation may be beneficial; I have operated on three late cases for whom, as prisoners of war, early operation was not available. The operations were done seven, six and three years respectively after the original wound, with success in each case.

(2) *Combined Arterial and Nerve Injury.*—Following recovery from nerve injury, patients tend to have persistent cold-sensitivity in the limb; this is worse if the main vessel has been divided, and in order to prevent the return of vasoconstrictor tone in the most peripheral vessels, Learmonth (1944) advocated that preganglionic sympathectomy

be performed at some stage of recovery before the peripheral vessels had become reinnervated. The success of such a procedure would seem to depend on the degree of sensory recovery which eventually occurs, since it was shown by Lewis (1936) that digits do not regain their normal resting temperature until sensory regeneration has occurred. This is well demonstrated by a case whom I recently saw at the request of a colleague from a plastic surgery unit. Thirty

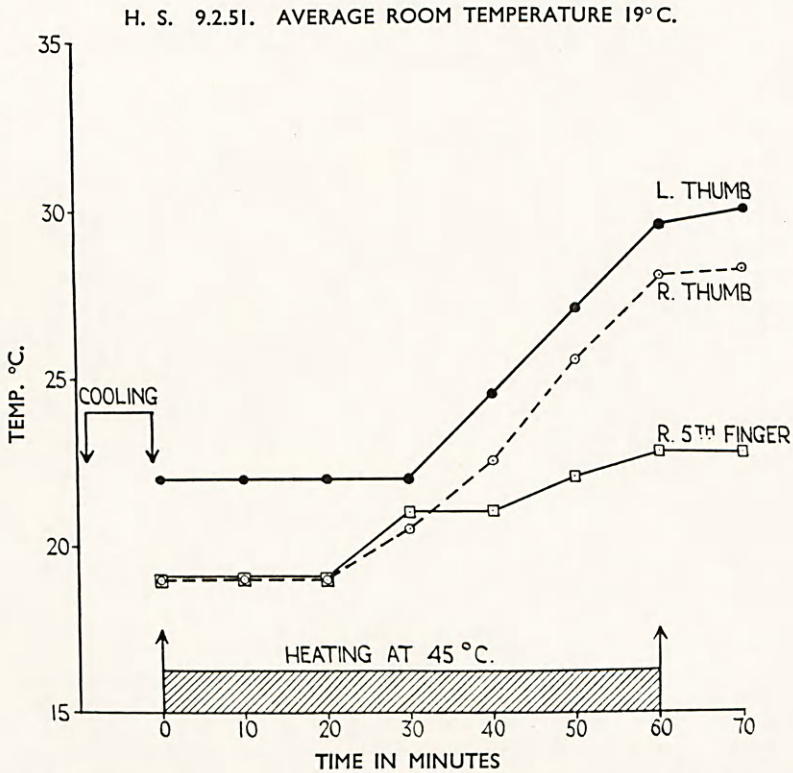

FIG. 10.—Case H. S. Reflex vasodilatation chart. Note that response of well-reinnervated thumb approaches normal, while that of poorly reinnervated fifth digit is poor.

months ago this patient had suffered a severe friction burn of the right wrist and hand, injuring both radial and ulnar arteries; considerable tissue loss was repaired by skin grafting, and a median nerve injury, originally complete, recovered spontaneously; an ulnar nerve lesion, however, showed only minimal recovery, deep pain being appreciated in a patchy distribution. The question arose of improving the blood supply to the hand, in order that further grafting could be safely performed, and as the tests indicate (Fig. 10), reflex vasodilatation occurred in the sensitive median area but not in the poorly innervated ulnar territory.

(3) *To Reduce Axonal Competition following Suture.*—In order to reduce the inevitable physiological competition between motor, sensory

and sympathetic fibres after suture, the ingenious suggestion has been made (Learmonth, 1944) that motor and sensory fibres would enjoy a greater likelihood of successfully finding an appropriate Schwann tube if sympathetic competition was abolished by post-ganglionic section prior to suture of the nerve. So far as I am aware, the suggestion has not been put into practice, but it should not be allowed to become forgotten, only to be resurrected at some later date.

Conclusion and Summary

I believe that it may with justice be claimed that advances were made during the second heyday of peripheral nerve surgery, and that as a result the surgeon is better equipped to-day than he was between the wars. He is better equipped for the diagnosis of nerve injury, and particularly of the type of nerve injury ; he is better equipped for treatment in that he knows how different nerves are likely to behave after suture, how different suture levels influence the result and to what extent he may safely bridge gaps by end-to-end suture after resection. He also knows that careful nerve grafting can be successful, and he has the broad help of the plastic surgeon for certain difficult problems. In sympathectomy he has a treatment for causalgia, and, in carefully selected cases, a treatment for the cold-sensitive hand.

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