PERIPHERAL NERVE SURGERY—POSTOPERATIVE REHABILITATION*

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(Received for publication February 26, 1944)

Rehabilitation of the wounded Soldier, Sailor and Marine is receiving more and more attention of the members of the Medical Departments of the Army and the Navy. Our responsibilities as Medical Officers do not end with the suture of the wound, the setting of a fracture, or the repair of a damaged nerve, but continue until the patient is fit to return to duty or discharge from the service in the best possible physical condition.

Owing to our lack of practical experience we have been interested in the methods used by our Allies and as an example of what can be accomplished I would like to refer to a case described in the British literature. Watson-Jones,† in discussing rehabilitation in the Royal Air Force, tells the following story:

An air gunner of the Royal Air Force, a man of proved courage and determination, was admitted to a civilian orthopaedic hospital for the treatment of a torn and displaced semilunar cartilage. Ten months later he was still in the hospital and still totally incapacitated. He asked about the delayed recovery. The diagnosis had been correct and a skilful operation performed without complications. Early treatment had been continued in the physiotherapy department but the muscles of the thigh remained atrophic and weak. The joint had twice been manipulated under anaesthesia without improvement. The man’s gait was slow and hesitant. He limped. He could not run. He had never tried to run. The medical officer blamed him because “he would not co-operate,” because he was disinterested, depressed and resentful. He was depressed, for after ten months the incapacity was more complete than on the day of admission. He was disinterested because, in his own words, “nobody takes any notice and it looks as if it is hopeless.” He was resentful because he could not believe the fault was his. Had he not been told that “the nerve to his knee had been cut”?

He was transferred to one of the orthopaedic rehabilitation centres of the R.A.F. Medical Service. He saw the sky, the sea, the open spaces. For many months he had seen only the stone walls of the hospital wards, the stone walls of massage rooms, the stone walls of many corridors. His new surroundings were different. There was a lounge and a writing room, tasteful decorations and flowers, a menu which was varied and excellent, an atmosphere of well-being and contentment. After a few days he smiled. There was sometimes a sparkle in his eye. Within a week he sensed the spirit of optimism. It grew upon him and he was reassured. His difficulties were explained and he was taught special exercises. He learned to walk and then to run. He became an enthusiast and worked hard. He worked in the gym, played on the fields, swam in the pool, cycled on the track. Time raced past, for he was busy. He attended lectures, played billiards and went to concerts. He became bronzed and fit. He laughed and was full of the joy of life. In seven weeks he returned to his unit and to full duty. He forgot about the “nerve in his knee.” Ten months total incapacity. Seven weeks full recovery. That is the story of rehabilitation in one air gunner.

† The opinions or assertions contained herein are the private ones of the writer, and are not to be construed as official or as reflecting the views of the Navy Department or the naval service at large.

Presented at the meeting of the American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 22 to 26, 1944.
The experience of the air gunner is not unusual. It is typical of victims of injuries to the extremities. In the hospitals of every country at war, there are many injured men whose surgical treatment has been completed for months but who are incapacitated because of minor disuse changes, because confidence is lacking, because morale has been destroyed. Their bodies have been treated, not their minds. The treatment of fractures has been concentrated upon securing bony union, and the treatment of peripheral nerves concentrated upon end-to-end anastomosis. No treatment has been directed to the tone and volume of muscles, the stability of joints, and the circulation of the limbs. There has been no measurement and graduation of physical activity. There has been no attempt to continue treatment until the patient regained confidence and recognized for himself that recovery was complete.

It is a well-recognized fact that a successful nerve repair may be followed by an incomplete or faulty functional recovery, if the muscles are not properly prepared. Davis, in his monograph, states: "It is unfortunate that many times nerve ends are sutured and no thought is given to what we consider to be of at least as great importance—carefully supervised and persistent physical therapeutic after-care." Many structural and metabolic changes may and do take place in the denervated group of muscles. This is especially true when there is associated destruction or trauma to the contiguous structures, such as the muscles, the long bones and the joints. Every traumatized extremity should be treated as a unit and the peripheral nerves should be carefully considered from the standpoint of a functional return. Disabilities resulting from injuries to the radial, median and ulnar nerves, as well as sciatic, tibial and peroneal nerves should be analyzed, and any treatment instituted should include every means to insure a good functional final result. The activation of denervated muscles by passive or active motion, as well as electrical stimulation, increases the metabolism and the circulation of the muscles, and keeps them in much better physical condition, and therefore much more receptive to re-inervation. Although it is difficult to measure accurately, it is an accepted fact that those patients who receive physical therapy show evidences of recovery of function much earlier, and the degree of recovery is much greater, than those who do not.

Physical therapy should be carefully supervised because atrophied, denervated muscles may be injured by rough methods and fatigue. In many cases better results are obtained by simple devices and games which effect an unconscious and effortless exercise of the contracted muscles.

Massage and passive motion have long been used to take the place of active exercise. If massage is to be of service in cases of nerve suture it must be used skillfully at the right time.

The preoperative treatment of peripheral nerve injury cases should be carried out very carefully and should comprise all of the various forms of massage. In the preoperative stage, massage and exercises should be used to keep joint and muscle senses intact, to maintain full mobility or to restore it if lost, to encourage the fullest activity in muscles capable of contraction, and to devise movements and exercises to maintain the vitality of the part as a whole. In the Peripheral Nerve Centers in England during the postoperative treatment of peripheral nerve injuries, skilled masseurs initiate
treatment about a wound with sutures still in place, and massage started at this time may prevent the formation of scars. This type of massage is very delicate, and any abuse tends to encourage rather than discourage the scar tissue in its formation. The best results are obtained when treatment is applied early in the critical ten-day period and the ideal time to start is as soon as it is known that sepsis as a result of operation is not likely to occur.

The first effect of massage is a reflex contraction which may cause fatigue followed by a paralytic effect which may defeat the very objective desired. A muscle deprived of its nerve must, sooner or later, make its first contraction during recovery which may be a feeble flicker to the observer, but to the muscle fibres themselves, a violent and severe effort. Thus it is that during the early stages of recovery any successful attempt at contraction may be followed by massage of the same type as that which should be applied during the stages of complete paralysis. In this way a muscle can be encouraged to make this effort a second and perhaps a third time, but the danger lies in encouraging it too much and causing too great a fatigue. Massage should, therefore, be used up to the point at which active movement can be employed since active muscular contraction provides the perfect form of massage. It has been found with regard to exercise that, until recovery is complete, anything and everything which can be devised to exercise the recovering muscles should be prescribed.

Electrotherapy is useful in postoperative treatments only when contractions of the denervated muscles are produced. Judiciously used, electrotherapy may conserve the volume and nutrition of the muscles, and keep the fibres functionally adequate for voluntary movement when regeneration has progressed sufficiently.

The interrupted galvanic and sinusoidal currents manually or mechanically interrupted, waved or surged currents of low voltage, are often very useful for the production of muscular contractions. They may frequently be employed interchangeably with the interrupted or surged faradic current. The sinusoidal currents are more comfortable than the surged faradic currents for production of such stimulation. They are often useful in initiating muscular contractions before the patient is capable of producing such contractions voluntarily, and they may be employed to teach a patient how to perform voluntary muscle exercises for individual muscles. A few simple modifications of the three basic currents, that is, the interrupted galvanic, the slow sinusoidal, and rapid sinusoidal currents, are all that is required for adequate therapy.

Just as the purpose of massage, exercises, and electrotherapy is to maintain the nutrition of the denervated muscles, the first aim of mechanical splints should be to prevent overstretches of the paralyzed muscles. The ideal splint should be light, simple, easily applied and removed, inexpensive and as inconspicuous as possible. The character of the splint required depends also upon the time which has elapsed between the original injury and the institution of treatment.
When a purely motor or mixed motor and sensory nerve has been divided and its conductivity lost, the muscles supplied by it lose their tone. This allows the joint on which they normally act to assume an abnormal position due to the action of the opponent muscles. The deformity is not due to the loss of tone of paralyzed muscles but rather to a combination of this with the force of gravity. In injuries to the radial nerve there is a very characteristic “wrist drop” or inability to extend the wrist. If the forearm and hand were held continuously in full supination with the elbow at right angles, gravity would act as a dorsiflexor, and its force would be sufficient to counteract the pull of the unbalanced flexor muscles of the forearm. In this position of dorsiflexion the paralyzed extensor muscles would be relaxed, which is the ideal condition for a resumption of function if and when the conductivity of the nerve has been restored. To overcome the position and relaxation of paralyzed muscles, adequate splinting should be used.

When a group of muscles is paralyzed by injury to its motor nerve, deformity may result in the joint on which it acts, and if such a deformity remains uncorrected, secondary contraction occurs in the opposing group of muscles, thereby preventing even passive restoration of the normal position. It is essential that the muscles supplied by the injured nerve be maintained in a position of relaxation until normal function has been resumed. Clinical evidence indicates that the optimum angle for recovery of the muscles is a neutral position at which return of voluntary power appears at the earliest possible moment.

Although splinting plays no part whatever in the regeneration of the peripheral nerve, it is important so far as muscle function and the prevention of deformity are concerned. An overstretched muscle will not regain its contractility even though its nerve supply may be restored completely. According to the reports from Great Britain, six types of splints are required: (1) the abduction splint for brachial plexus injuries; (2) the knuckle duster splint for ulnar paralysis which maintains flexion of the metacarpal phalangeal joints and encourages the patient to keep the interphalangeal joints extended; (3) the splint for median paralysis, and (4) the combined median and ulnar splint which is an elaboration of the knuckle duster; (5) radial paralysis splint to overcome wrist drop, and (6) the splint for sciatic paralysis to overcome foot drop.

Splinting can be overdone. The function of a splint is to prevent paralyzed muscles from being stretched, not to fix joints. Unless contra-indicated, the joints of a paralyzed limb should be put through a full range of movement once daily. If the movement is carried out with care the paralyzed muscles will not be stretched to a harmful extent. If some stiffness is present the range of movement should be increased by passive movement. Gentle manipulation under anesthesia is permissible if not too severe.

There is one phase in the rehabilitation of peripheral nerve injuries which most physicians have completely ignored. This consists of tendon transplantation for paralysis of muscles due to lesions of peripheral nerves.
One of the conditions where this is indicated is paralysis of the muscles supplied by the radial nerve. This procedure is employed when suture of the severed radial nerve is impossible or when function does not return after repair. In injuries of the radial nerve above the level of the origin of the posterior interosseous branch the tendon of the flexor carpi-radialis muscle is inserted into the three extensors of the thumb, and into an extensor of the index finger. The flexor carpi- ulnaris tendon is transplanted into the extensors of the remaining three fingers, and the pronator radii teres is transplanted into the tendons of the extensor carpi-radialis longus and brevis muscles. When the lesion is below the origin of the posterior interosseous nerve the radial extensors of the wrist are not disturbed, and the tranference of the pronator radii teres muscle is of course unnecessary.

At some of the Peripheral Nerve Centers the tendon transplantation is being used in conjunction with the repair of the divided or injured radial nerve. This obviates the necessity for a supportive splint, and when the nerve has regenerated and the function restored, the tendons can be returned to their normal function. It has been pointed out in the rehabilitation of radial nerve injuries that the patient who has a tendon transplant in conjunction with the peripheral nerve repair can return to duty much earlier and there is no time lost waiting for the nerve to regenerate.

While tendon transplant for paralysis of muscles supplied by the median nerve is usually contra-indicated, Bunnell has described such a technique. The extensor carpi-radialis longus is transplanted from the extensor surface of the wrist into the flexor pollicis longus tendon. The profundus tendons to the index and middle fingers are detached proximally and reinserted into the flexor profundus tendons of the ring and little fingers. The flexor carpi-ulnaris may be either inserted into the flexor sublimis tendons to increase the strength of the flexors of the fingers and produce a more central pull on flexion of the wrist, or used as the motor power to produce opposition of the thumb. Steindler replaces the lost opponent action of the thumb by utilizing the flexor pollicis longus muscle provided this structure is active and strong. Royle, on the other hand, transfers the flexor sublimis tendon of the fourth finger into the sheath, and inserts it into the short flexor and opponents tendon at the level of the metacarpo phalangeal joint of the thumb.

Occupational therapy at Peripheral Nerve Centers is a valuable addition to active exercise treatment. In cases of permanent paralysis, it helps develop and improve subsidiary and trick movements. In every case, clear directions should be given to the occupational therapist about the details of motor, sensory and trophic disturbances, and supervision of this therapy by the physician is of great importance. In every case the occupational therapist should record all observations, for these can be of great help to the doctor in evaluating the results of treatment.

The British Medical Association has reported extensively upon rehabilitation and advised that it include (a) functional treatment in hospital wards by regular active exercise, (b) treatment in rehabilitation centers by organ-
ized physical and recreational activities with the object of overcoming residual disuse changes, restoring the confidence of patients in the completeness of their recovery, and bridging the gap between the exercises of the hospital ward and the stresses of normal work; and (c) vocational retraining for the very small proportion of men whose disability is permanent, and who must learn a new trade. Experience has proved conclusively that the demands of rehabilitation are not satisfied by "pepping up the massage department," that it is difficult and usually impossible to fulfill the requirements within the grounds and buildings of a hospital, that a rehabilitation center without the right atmosphere is almost worse than no rehabilitation center at all. The object of functional treatment is not only to cure but also to prevent muscle wasting, joint stiffness and other disuse changes. The treatment must begin as early as possible after the injury and the patient should be kept busy from morning until night. A certain amount of discipline should be maintained and it has been found necessary to organize a rehabilitation team. To every group of fifty patients there have been allotted a team consisting of one medical officer, one physical training instructor, and one masseuse. These individuals have been selected for their personality and their ability to command respect and loyalty. The masseuse is engaged not only in electrotherapy and massage, but also in the teaching of exercises and the corrections of the limp. The physical instructors take charge of group exercises, games in the "gym," a limited period of marching and drill, medicine ball or similar activity. At each center there is an organizer of games. The medical officer is responsible for every activity that concerns his own group of patients.

It has been found important to have a large gymnasium with massage, examining rooms and canteen. If possible, it is desirable to have a playing field and a swimming pool. The arts and crafts type of occupational therapy finds its greatest application in the hospital wards where there are many idle hours to fill. Simple workshop activities, such as carpentry, sawing, model airplane construction, and basket or rug making are interesting additions to the rehabilitation center, particularly during the winter months when outdoor activities are limited. Workshops, occupational therapy benches, and massage cubicles are like medicine balls, climbing ropes or equipment which are sometimes useful but never indispensable.

The intention of these rehabilitation centers is that the patients who are capable of ordinary work, for limited periods should use the workshops and at the same time continue treatment. It was also intended that men might be tested from time to time under working conditions, in the same way that an air crew center is equipped with a fuselage by which to test the physical ability of pilots. It has been argued that treatment in rehabilitation centers is unnecessary and wasteful because all injuries fall into one of two groups, the first being those from which full recovery is possible without rehabilitation; and two, those which cause permanent disability despite rehabilitation.
However, it is a well-known fact that it is impossible to assess the degree of permanent disability with any accuracy until a patient has been treated and observed in a rehabilitation center.

Thus rehabilitation begins as soon as the medical officer examines the wounded patient and ends with the return to duty or other disposition of the case. It combines the physiological principles of wound healing, tissue metabolism, circulation, tissue regeneration, and functional recovery. It embraces physical therapy, electrotherapy, splinting and occupational therapy. The object should be the restoration of the injured Soldier, Sailor and Marine to as normal a functioning individual as is possible subsequent to the injuries to which he has been subjected.

REFERENCE