EXPERIMENTS ON THE BRIDGING OF GAPS IN SEVERED PERIPHERAL NERVES OF MONKEYS*

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Bridge gaps that cannot be reduced by methods other than grafting continues to be one of the most significant as well as one of the most difficult problems in the technical management of peripheral nerve injuries in human patients. These gaps result from actual loss of substance at the time of injury, from subsequent retraction of the severed nerve ends, or from the necessary wide resection of proximal neuromas and densely scarred distal nerve ends (Schwannomas) at the time of delayed exploration. Many types of surgical manipulations have been employed in the attempt to accomplish primary anastomosis across such large gaps. These include: (1) Complete mobilization of the proximal and distal segments for long distances; (2) transposition of nerves; (3) extreme positioning of joints to shorten the course of the nerve, followed by slow progressive stretching of the nerve in single or multiple stage procedures as the joint is extended; and (4) shortening of extremities by sacrifice of a segment of long bone.

In view of the often asserted and experimentally demonstrated hazards of any but the most moderate degrees of tension,4 it has seemed important to pursue the search for new methods of bridging gaps that are irreducible by means other than extreme nerve stretching.

The use of nerve grafts has proved disappointing in human patients, in spite of numerous improvements in technique in the use of both fresh and preserved homografts.6,7,8,9,13,16 Autogenous grafts have been successful only in very small nerves, such as the facial3 or digital nerves,1 and in isolated reports of fresh cable grafts.10 According to Weiss,14 the critical distance which can be spanned in any significant number of cases by simple spontaneous regeneration of nerve fibers is no more than one to two times the diameter of the nerve for small nerves. As this distance is increased, the regenerating nerve fibers pursue such tortuous courses, and are obstructed by such an extensive degree of fibrous tissue invasion, that chances of successful regeneration across the gap decline materially.

If a gap between severed nerve ends can be bridged by a means that does not depend for its function upon the viability of an autogenous or homograft,6,7,8,9,13,16 this work has been aided by the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago, and partly by contract with the Research and Development Board Office of the Surgeon General, U.S. Army.

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enous nerve graft, some form of tubulation of the gap becomes possible, since under these circumstances, the regenerating nerve fibers and sheaths carry their own blood supply with them. Tubulation of simple blood bridges by various substances, such as arterial, collagen, or annealed tantalum tubes, has indeed been used experimentally with some success. However, technical difficulties resulted in numerous failures with this type of anastomosis. Tissue culture investigations showed that Schwann cells tend to adhere to the surface of glass or synthetic resin fibers in clotted blood. This suggested the use of such fibers as guides to effect preliminary longitudinal orientation of regenerating axis cylinders across a blood bridge. Weiss and Taylor reported a technique for such a procedure, which they carried out in a series of cats and rats, using fine artificial fibers embedded lengthwise in a blood bridge between the cut surfaces of the proximal and distal segments of the divided sciatic nerve. In their original description of this method they stated that it had the advantages of bringing the regenerating tissue into intimate contact with the guide fibers, and also of linking the stumps and fiber-blood bridge into a continuous chain, but had the disadvantage of disrupting the architecture of the nerve stumps at the actual suture point. They felt that the advantages overbalanced the disadvantages sufficiently to warrant further experimentation with the method. For further details on the rationale of the method, the original article may be consulted.

Because of the well-known limitations of clinical interpretation of nerve regeneration on the basis of experiments in lower mammals, it was felt desirable to attempt the bridging of irreducible gaps in peripheral nerves in higher forms by this technique. Therefore, a series of experiments was carried out in monkeys, bridging gaps in the posterior tibial division of the sciatic nerve in the mid-thigh. The diameter of the nerve at this point was approximately 2.0 to 2.5 mm. Gaps measuring from 6 to 14 mm. between proximal and distal segments were bridged, that is, gaps which were three to seven times the diameter of the nerve, a distance not usually bridged satisfactorily by spontaneous regeneration.

These experiments are subject to the same criticism which is justly levelled at all laboratory investigations dealing with peripheral nerve surgery, namely, that it is impossible to reproduce in the laboratory the type of complicated lacerated wounds with obliteration of tissue planes and formation of dense adherent scar tissue that is seen in a large proportion of human extremity wounds, especially those incurred in warfare. It is not justifiable to transpose unreservedly information obtained from clean operative wounds followed by immediate repair in laboratory animals to the complex, delayed wounds of human patients. However, the feasibility of operative techniques can be estimated and the functional results evaluated with sufficient accuracy at least to point the way to methods that deserve trial in human patients.

EXPERIMENTAL MATERIAL

The method reported by Weiss and Taylor was modified in certain minor respects in the present investigations. Instead of an arterial sleeve or one made of collagen, the suggestion of