PREVENTION OF NERVE REGENERATION AND NEUROMA FORMATION BY CAPS OF SYNTHETIC RESIN*

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(Received for publication June 20, 1945)

THE ACUTE PAIN that is associated clinically with the formation of neuromas following the section of peripheral nerves in amputations has led to the introduction of various procedures designed to suppress the regeneration of nerve fibers from the cut (for literature, see Guttmann and Medawar, and Boldrey). Surgical interventions have been aimed mainly at blocking or diverting fibers rather than suppressing their growth and have been only partially effective in preventing neuroma formation, while chemical and physical treatments, which eliminate living fibers from the nerve end, have yielded varying success depending on the agent used. From the experiments of Guttmann and Medawar it has become apparent that to inhibit the formation of a neuroma, the old axons in the terminal segment of the nerve stump must be killed and this segment rendered imperious to regenerating fibers; mere blocking is insufficient.

In addition, experimental studies on the effects of prolonged denervation are frequently thwarted by the reconnection of nerve fibers that have escaped from inadequately blocked proximal stumps or have spanned extensive resection gaps. This is true particularly in the case of small nerves, which are technically difficult to handle, or in small animals, where regeneration distances are short. But even for larger experimental nerves, previously suggested methods are inconvenient when it comes to treating a number of animals.

In several series of experiments on rat nerves, a rapid, simple method has been developed which is effective both in impeding fiber regeneration and preventing neuroma formation. Approximately 75 nerves of white rats (100 to 300 gm.), including femoral, sciatic, facial and lumbar branches (0.2 to 1.5 mm. in diameter), were treated as follows:

The nerve was exposed for 5–10 mm. and transected. The distal end of its proximal stump was then coated for a distance of 3–4 mm. with a thin (10 per cent) solution of methylmethacrylate polymer in acetone. The plastic hardened rapidly, and defects in the cap produced by shrinkage were repaired with a second or third coating. When the surface of the final coat had hardened, the nerve was returned to its bed and the wound sutured.

Occasionally, the epineurium was pulled down over the cut surface and ligated before applying the plastic but the results were equally satisfactory without this procedure. The caps were left in place for a few days to one year.

* This work was done under the direction of Dr. Paul Weiss under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the University of Chicago. It was also aided by the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.
When the nerves were reexposed, the caps were found to be firmly adherent to the nerve ends. Electrical stimulation tests proved that in all but one case no fibers had escaped either through or around the cap. Adhesions between the plastic and the surrounding tissues were minimal, and even after one year, no large swellings were present in the proximal portions of the nerves. In a few instances where the cap had contracted excessively, constricting the nerve end, the diameter of the nerve proximally was slightly larger than normal, but the typical bulbous enlargements associated with neuromas were not observed.

The histological features of the capped segment are illustrated in Fig. 1, showing the buccal branch of a facial nerve removed one year after operation. Proximally, the diameter of the nerve remains unchanged down to the level of the cap. Within the latter, the nerve tapers to a point; there is a space, apparently filled with serous fluid, between the nerve and the plastic which has prevented any adhesion between them and eliminated any possibility of pressure on the axons. A thin fibrous capsule, which is continuous with the epineurium proximally, invests the capped segment of the nerve. Nerve fibers are numerous central to the cap but within it, they decline in number rapidly so that the tapered end is composed mainly of strands of Schwann cells, macrophages and occasional patches of fibrous tissue. Some fibers have become tangled or turned back but most appear to have remained straight to their blind ends under the cap.

The effectiveness of the method resulted both from the fixing action of the acetone solvent and from the blocking action of the fluid-filled space con-