Retrospective analysis of 22 patients with chronic pain treated by peripheral nerve stimulation

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Twenty-two patients with chronic pain, chiefly from posttraumatic neuropathy, were treated by implanted peripheral nerve stimulators located proximal to the pain. Thirteen of these (62%) have experienced pain control for an average of 25 months. The experience of the surgeon is thought to be a major factor contributing to the successful results. There are theoretical and practical advantages to electrical stimulation at proximal portions of the peripheral nervous system. The surgical technique for implantation is described, and the necessity for reoperation in some patients is explained.

KEY WORDS • peripheral nerve • causalgia • pain • brachial plexus • electric stimulation

This report is a retrospective analysis of a treatment program designed to relieve chronic, intractable pain by electrical stimulation of large-diameter, afferent fibers of the peripheral nervous system. We are reporting on all patients in whom a stimulating electrode was implanted on a nerve situated between the central nervous system (CNS) and the site of the painful pathology. Stimulation in all reported cases evoked paresthesias overlapping the painful area. We are excluding those patients who were treated by stimulation of CNS structures, the skin, or the peripheral nerves, at or distal to the painful pathology.

Summary of Cases

Series Characteristics

Patients were selected for this surgery according to the following characteristics. All had severe, chronic pain, refractory to all low-risk methods of treatment. No patient had suffered pain for less than 1 year, and the average preoperative duration of pain was 4.7 years. There were 22 patients in the series, 15 of whom were male. They were operated on between August, 1971, and July, 1978.

In all but two cases, the pain was caused by traumatic neuropathy, which had clear evidence of injury to one or more peripheral nerves, as shown by appropriate, neuritic distribution. In the two exceptions, there may also have been nerve damage, but the onset and character of the pain made a definite diagnosis impossible. One of these two patients had a “vice-like” pain of the index finger; the other had an aching pain of the foot that precluded weight bearing.

All patients failed to respond to physical therapy, psychotherapy, transcutaneous stimulation, and drug treatment with minor narcotic analgesics, major and minor tranquilizers, diphenylhydantoin, and carbamazepine. In most patients, surgical treatments such as sympathectomy (or diagnostic sympathetic block), neurolysis, and neurectomy were performed in preference to peripheral nerve stimulation. These procedures did not succeed in these patients, so peripheral nerve stimulation was recommended. No patient had undergone a rhizotomy, or any more central pain procedure.

An important screening procedure consisted chiefly of consultation with our multidisciplinary pain clinic, patterned on the recommendations of Greenhoot and Sternbach. Repeated patient interviews by ourselves and these colleagues resulted in the exclusion of many patients who appeared to have pain as a symptom of psychological distress. We recognize that more objective and effective tests are desirable, such as those recently described by Viernstein, et al., to assist in making this crucial clinical distinction.

Patients were not excluded for the reason that they were using strong narcotics or had active compensation cases pending.

Surgical Technique

We familiarized the patients with the stimulating device and counselled them that the success rate was
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FIG. 1. Schematic representation of the components of a peripheral nerve stimulating system. For intraoperative testing, the transmitter (A) supplies radiofrequency current via an antenna (B) to the implanted receiver (C). Current is then supplied to the four stimulating buttons (G) around the nerve, via the temporary electrode switch (F), which merely facilitates testing of the effects of stimulation of each of the 21 combinations. D = six connectors; E = six-wire cable.

unknown, although we now estimate it to be 60%. They were told that more than one operation might be necessary to achieve success, and that in the exceptional event that infection occurred, it would be necessary to remove the device. If general anesthesia were required, we explained its potential risks and complications related to the operation. The patients were encouraged to consider this information over a prolonged period before consenting to surgery.

We wish to make a few additions to the excellent technical details previously described by Picaza, et al., Nashold and Goldner, and Campbell and Long. A length of the appropriate peripheral nerve was encircled by a multiple-button cuff electrode, which was secured so as not to constrict the nerve (Fig. 1). If the pain is within the distribution of any peripheral nerve of the upper extremity except the intercostobrachial nerve, we now advise that the cuff be placed upon the appropriate trunk of the brachial plexus that innervates the painful region. The radiofrequency receiver (Fig. 1C) may be placed through the same incision in a subcutaneous pocket over the pectoralis muscle. The wound was closed except for a 3-cm length, which was then infiltrated with local anesthetic. Through this gap coursed the two wires from the receiver, each of which supplied two of the four female connectors (Fig. 1D), and the four male connectors to the stimulating buttons (Fig. 1G). Depending upon the method of anesthesia, the inhalational agent or barbiturate was discontinued, or the narcotic was reversed. The transmitter (Fig. 1A) was connected to a sterilized antenna (Fig. 1B) placed upon the skin over the implanted receiver. A switching box (Fig. 1F) was interposed between receiver and stimulating buttons through a sterile six-wire cable (Fig. 1E). Each of the 21 possible combinations of the four stimulating buttons was individually tested, a process that took approximately 45 minutes. The patient’s verbal responses to two general lines of questions determined the optimal combination of stimulating electrodes. The patient was asked to report on the distribution of paresthesias following each test, so that we could identify the combination that best overlapped the painful region. At the same time the patients were asked when they first detected paresthesias and muscle contraction, so that an electrode combination could be selected that caused paresthesias to appear at intensities well below that required to produce muscle contraction. The cable to the switching box was then removed and the receiver was connected to the electrodes according to the chosen combination. Any unused male or female con-

*Multiple-button cuff electrode manufactured by Avery Laboratories Inc., Farmingdale, New York.
nectors were sealed or plugged, and all connectors were wrapped in a small Teflon bag and returned to the subcutaneous pocket before wound closure. Postoperatively, the patient was encouraged by the surgeon, hospital personnel, and family to achieve maximal benefits of pain relief. An index to the degree of benefit was the decreasing need of narcotic analgesics. We wish to emphasize the importance of telling the patient beforehand that more than one operation may be necessary to achieve optimal pain relief. One-half of the patients required further surgery. It was necessary to reoperate on seven patients to improve on the choice of stimulating button combinations. This simple procedure was performed under local anesthesia to broaden the topographic distribution of paresthesias or to eliminate troublesome muscle contraction that appeared at stimulus intensities approaching those near the threshold for perception. In a few of the patients who required reoperation, a change in the effectiveness of the initial stimulating pattern may have occurred in the first postoperative days or weeks, most probably due to rotation of the loosely applied electrode cuff. In other cases, the initial electrode selection may have been incorrect because the patient’s drowsiness during implantation interfered with his ability to report accurately the threshold of perception of stimulation. Testing of the other stimulating patterns was routinely employed before reoperation.

We reoperated on eight patients to reposition the electrode cuff on the same nerve, or on a different nerve, or to place an additional stimulating system on another nerve. We reoperated on two patients to correct difficulties in joint mobility due to the inadequate length of electrode wire. With the technique described above, this was no longer necessary in the series because wires so installed did not cross joints. One patient required repositioning of an unused male electrode connector. Two patients required replacement of implanted components because of equipment failure, one after the 4th month and the other during the 4th year. We thought the former malfunction was due to a small break in the insulation that may have occurred at the time of original installation. Six patients were reoperated on to remove the implanted stimulating system. Of these, four patients received no relief from their pain; one patient, who received relief, wanted the system removed because she objected to the cosmetic effect of the receiver located in the subcutaneous tissue of the arm; and one patient developed a chronic, draining infection. This last patient was eventually relieved by a percutaneous epidural stimulator.

Results

One of the 22 patients in the series could not be located for interview; he had received pain relief for 2 years before he lost contact with us. There were 13 successful cases. These patients continue to use only their stimulators for pain relief. The most recent of these is 9 months postimplantation, the longest is 88 months, and the average duration is 25 months. Six patients (29%) were unsuccessful in obtaining any useful pain relief.

The remaining two patients were more difficult to classify. They were not clinical successes because their systems were removed for infection and for cosmetic reasons, respectively, and their pain returned. However, during the limited span (13 and 16 months) of their stimulation, both patients obtained good pain relief.

Analysis of the data showed no statistically significant difference in success rate in respect to age, sex, preoperative duration of pain or usage of narcotic analgesics, presence of a known compensation issue, or presence of hyperpathia or hyperesthesia. There was no mortality nor permanent morbidity.

Discussion

This experience has convinced us that peripheral nerve stimulation is a practical and safe means of controlling localized chronic pain, if electrode locations are properly chosen. The challenge lies in reducing the rates of complication and reoperation, and increasing the percentage of success.

In our opinion, important factors in determining success are the surgeon’s experience with this method, and the selection process of those patients who should or should not be considered for surgery. If surgery is the best choice for the patient, it is critical that the location of the stimulating electrodes be determined with care. For example, pains that are not localized may be controlled by implanted epidural stimulation. The surgical technique for installation of peripheral nerve stimulators is not difficult, but our experience with various complications has taught us to be aware of the aforementioned technical details, which are unique to this prosthetic surgery. Larger experience also facilitates the efficient and accurate selection of the proper combination of stimulating electrodes, improves judgment regarding options for patients whose initial surgery did not totally succeed, and permits accurate diagnosis of component malfunction.

The technique we have described, which has gradually evolved over these years, may be expected to improve results for stimulation of the brachial plexus, for these reasons: 1) the paresthesias generated by stimulation of the brachial plexus are broad in their topography; 2) a single incision is used, which decreases operating time, theoretical risk of infection, and incisional neuralgia, and obviates the necessity for wires to cross joints; 3) the deep location of the electrodes renders them less vulnerable to trauma; 4) we can treat pain due to more proximal nerve damage, which is proportionally more common than pain due to distal nerve damage; and 5) this proximal stimulation has succeeded where more distal stimulation has failed.
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The importance of proximally situated electrodes was shown in the case of a patient who had had multiple, spontaneous, subcutaneous hemorrhages. Biopsy proved that she had Ehlers-Danlos syndrome. One hemorrhage had resulted in neuralgia of the ulnar and medial antebrachial cutaneous nerves, but pain was not relieved by neurolysis. In 1972, both the nerves were placed in a stimulating cuff, located several centimeters proximal to the neuropathy. She obtained only a fair degree of relief, but continued using Talwin (pentazocine hydrochloride). She returned a year later with increased pain at the same location. On reoperation, her receiver was connected to a new electrode cuff placed on the middle trunk of the brachial plexus. The induced paresthesias were felt over the ventral and dorsal surfaces of the medial elbow and distally to both surfaces of all fingers, except the thumb. She has used this stimulator for complete relief of the arm pain for 4 years.

To have located stimulating electrodes proximal to the injured sites on her nerves was not sufficient. It was necessary to broaden the zone of paresthesias to areas principally supplied by the median and radial nerves. It may be fundamentally incorrect to have identified the ulnar and medial antebrachial cutaneous nerves as the sole sources of the impulses that were perceived as pain.

In 1905, Head, et al., reported important observations on the topography of different types of insensitivity resulting from division of proximal versus distal portions of the peripheral nervous system. "Evidently, the peripheral nerves, looked at broadly, form the units of epicritic supply. On the contrary, from the protopathic point of view, no one nerve forms anything more than a tributary supply of an area innervated by a plexus of nerves, and whenever a single peripheral nerve is destroyed in the upper limb, the loss to light touch always exceeds to a considerable extent the loss to prick. But as soon as we have to deal with destruction of the cords of the brachial plexus, the extent of analgesia almost equals that of the loss of light touch." For the same reason that it is often insufficient to divide a single nerve or root to relieve pain within its distribution, it may not suffice to stimulate it.

Sweet may have witnessed a similar phenomenon. He reported a case in which pain of the dorsal, lateral hand was not well controlled by stimulation of the radial nerve, but relief was improved after electrodes were moved to the median nerve. Similarly, one of our patients has a sciatic nerve stimulator that generates paresthesias only to the painful tibial nerve distribution, but also relieves hyperesthesia of the peroneal nerve.

Not knowing the mechanism underlying the pain relief by peripheral nerve stimulation, we can only hypothesize that painful impulses arising within the epicritic zone of nerve X are, in part, transmitted over fibers contained in adjacent nerve Y. Successful relief seems to be obtained occasionally by stimulating the large fibers of X, but success may be improved by stimulating a nerve giving rise to both X and Y. Such proximal stimulation would theoretically enter a larger number of dorsal roots, possibly improving the beneficial effects of the hypothetical, inhibitory interaction in the central nervous system. This will require electrodes on the trunks or cords of the brachial plexus, or in the case of foot pain, the proximal sciatic nerve.

References

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