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Stimulation of the Dorsal Spinal Cord For Treatment of Intractable Pain: A Preliminary Report

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"Electrical stimulation of the nervous system has been advocated as a means of alleviating pain in situations in which more conventional methods have been ineffective. A chronically implanted electrode on the dorsal surface of the spinal cord may prove to be a valuable adjunct to the neurosurgeon's armamentarium for pain control in selected individuals. The physiologic basis for this action is unclear but has been related to Melzack and Wall's gate control theory. This preliminary report deals with a series of patients treated with implanted dorsal cord stimulators."

Methods

THIRTEEN patients considered suitable candidates for implantation of dorsal cord stimulators were studied from November 1969 to December 1973. The etiologies of their pain syndromes are summarized in Table 1. Patients usually underwent surgical implantation under local anesthesia in the right lateral decubitus position. Laminectomy with local anesthesia allows the patient to describe the distribution of paraesthesias produced by the electrode and assures proper placement. For phantom limb pain, electrode placement was aimed at producing paresthesias in the region of the phantom limb. The electrodes were placed endodurally between layers of dura, in the subarachnoid space or in the subdural space as shown in Table 2. All units were obtained from Medtronic, Inc.

Results

The dates of initial implantation and follow-ups are tabulated in Table 2. Criteria for grading results are as follows:

Excellent: Complete pain relief, with return to active life or gainful employment. Narcotics are not necessary for pain relief.

Partial benefit: Incomplete pain relief, with partial incapacity due to symptoms. Narcotics are occasionally necessary for pain relief.

No benefit: No pain relief with functioning stimulator or malfunctioning stimulator* or because stimulator was removed due to local complications.

Two patients have sustained excellent results with the dorsal cord stimulator. Two others have achieved partial benefit. The remainder are no longer using the device or the stimulator has been removed.

In cervical canal implants when the electrode is slightly eccentric, the evoked tingling occurs first in the ipsilateral arm, not confined to one segment, and then in the contralateral arm. When the voltage is high enough to produce tingling in the legs, the sensation in the arms is near intolerable levels. We conclude from this that the root entry zone or dorsal gray matter is activated at appreciably lower thresholds than the fibers of the posterior columns. We therefore use the term "dorsal cord stimulator" rather than "dorsal column stimulator."

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* These categories are differentiated on the basis of the statement that subjective sensations elicited are or are not the same as the sensations elicited shortly after implantation.

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TABLE 1
ETIOLOGY OF PAIN IN 13 PATIENTS RECEIVING DORSAL CORD STIMULATORS BETWEEN NOVEMBER 1969 AND MARCH 1973

Patient	Age	Etiology	Duration of Pain	Previous Operations
1	64	phantom pain	2 years	bilateral lower extremity amputation
2	35	phantom pain	8 years	traumatic amputation of left hand, two neuroma excisions
3	61	brachial plexus avulsion	5 years	
4	55	back and leg pain	4 years	two spinal fusions (paraplegic), bilateral D11 cordotomy
5	50	spinal and pelvic metastases, lung cancer	6 months	
6	65	radiation myelitis	2 years	
7	21	phantom pain	3 years	right upper extremity amputation, neuroma excision
8	50	back and leg pain	11 years	three lumbar laminectomies, right L5-S1 rhizotomy
9	48	back and leg pain	3 years	two lumbar laminectomies
10	39	phantom pain	4 years	traumatic amputation of left hand, six plastic revisions, neurolysis, ulnar nerve capping
11	68	phantom pain	45 years (2 severe)	lower extremity amputation
12	45	back pain	8 years	L4-5 fusion, three laminectomies
13	34	back pain	2 years	four lumbar laminectomies

TABLE 2
DATES OF INITIAL DORSAL CORD STIMULATOR IMPLANTATION AND FOLLOW-UP

Patient	Date of Implant	Date of Revision	Date of Removal	Result December 1973
1	9/30/69 (D10, SD)		11/10/69	DCS removed
2	4/25/69 (C5, SD)	3/23/73 (C5, SD)		no benefit
3	1/15/71 (C4-5, SD)			no benefit
4	2/8/71 (D10, SD) 7/6/72 (D8, SD)		12/14/71	no benefit
5	6/5/71 (D2, SD)			no benefit
6	7/25/71 (D1-2, ED)			no benefit
7	2/28/72 (C3-4, ED)			excellent
8	3/9/72 (D10, ED)	3/19/73 (D10, ED)		partial benefit
9	4/12/72 (D10, ED)	3/13/73 (D10, ED)		no benefit
10	4/27/72 (C3, ED)	5/30/72 (C3, ED)	6/15/72	DCS removed
11	6/30/72 (D7, SA)	10/16/72 (D7, SA)		partial benefit
12	3/13/73 (D10, SD)			excellent
13	3/19/73 (D10, SD)			no benefit

SD = subdural placement
SA = subarachnoid placement
ED = endodural placement

Complications

Five patients required revision of the stimulating electrodes after initial placement. Equipment malfunction was implicated in patients 2, 8, 9 and 10. Patient 11 underwent repositioning of the electrode in order to achieve stimulation in the extremity with phantom limb pain, whereas previously the major distribution of electrical discharge was in the contralateral leg. A pseudomeningocele developed in patient 4, requiring removal of the stimulator. He later underwent reimplantation, with subsequent malfunction of that stimulator. The device was removed from patient 1, a diabetic, because of chronic meningitis, which cleared after removal. In patient 10, the stimulator was removed after a sudden onset of right-sided numbness two weeks after revision. No hematoma was found. Narrowing of the spinal canal at the site of implantation was demonstrated myelographically in patient 3. He shows no signs of cord compression. Four patients expired from causes unrelated to the implantation. Table 3 lists the complications.

Discussion

Current concepts of pain physiology at the spinal level have been the subject of recent reviews.[2,6,7] The gate theory of pain perception describes pain as principally small, unmyelinated C fiber input into the dorsal root entry zone which is integrated within the dorsal horn prior to ascending to the thalamic and cortical levels. Afferent stimulation of large A fibers is capable of modifying C fiber input and can alter the ascending discharges, thereby influencing the conscious awareness of pain.[6] Electrophysiologic studies yielding evidence contradictory to Melzack and Wall's original experiments have been reported,[1,3,4,9,12] and at present a precise neurobiologic explanation of the integrated pain circuits at the spinal levels is lacking.

Pain is a subjective phenomenon of great complexity. Not the least of the problems in evaluating the patient with a chronic pain problem is the overriding importance of memory, anticipation, symbolic significance and conscious or unconscious desire for secondary gain. At another level there is reason to believe that some patterns of complaint (fullness, tightness, tingling) are due to deficient asynchronous sensory input, with a resulting imbalance in central sensory physiology. Apparently, for reasons that are not clear, such distortions do not disturb all patients equally. We have called such syndromes "sensory deprivation" states. Common examples occur in phantom limb pain and partial nerve injury.

If the complexity of those events surrounding the interactions of the first and second order neurons is extrapolated to include the known interconnections between the initial nociceptive stimulus and awareness of pain as a higher function, the task of presenting a precise

TABLE 3
COMPLICATIONS FROM IMPLANTATION OF DORSAL CORD STIMULATOR

Patient	Complication
1*	Chronic meningitis. Cleared after removal of DCS
2	C5–6 instability, anterior fusion. Complete relief for 3 years, then equipment malfunction. Revision: Postrevision malfunction
3	Spinal canal narrowed by electrode and scar (myelogram). Equpiment malfunction probably due to scar
4*	Stimulator removed due to pseudomeningocele. Pseudomeningocele repaired. Stimulator reimplanted with subsequent malfunction
5*	None
6*	None
7	None
8	Equipment malfunction. Revision: Transient good result. Recurrent malfunction. Incidental herpes zoster
9	Equipment malfunction. Revision: Postrevision malfunction
10	Equipment malfunction. Revision: Sudden onset of right side sensory deficit. Cleared after DCS removed
11	Improper electrode placement requiring revision
12	None
13	Equipment malfunction

* Expired from unrelated causes.

mechanistic description of pain physiology becomes formidable. Similar difficulties are encountered in attempting an explanation of electrical stimulation for the relief of pain. The way the afferent stimulation makes the patient stop feeling pain may be due to blockade, or modification of central patterns in a poorly understood manner or it may be similar to the relief of dysesthesia by increased afferent input as in rubbing a numb or tingling area. The increase in comfort may be at the "psychic" level (whatever that may mean) or simply a matter of distraction.

The clinical application of A fiber stimulation for alteration of nociceptive afferents has been carried out with chronically implanted electrodes.[5,9,10,11] It appears from this study, however, that beneficial effects are temporary and initial complaints eventually return in most patients treated with dorsal cord stimulators. Some of these failures are explainable, many are not. In attempting to identify the causes of late failures, psychologic factors are the most difficult to explain. Pain relief is dependent on the patient's mood, which fluctuates from day to day, and a change in the subjective effect of the stimulator is sometimes seen. A major difficulty is separating the bioengineering problems from the neurophysiologic problems associated with altered pain perception.

There are as yet no reliable methods for predicting the types of pain syndromes most amenable to implanted dorsal cord stimulators. Those patients with sensory deprivation states, of which phantom limb pain is the best example, appear to have the most dramatic immediate relief. However, these patients have eventually encountered difficulty with recurrence of symptoms in long-term follow-up. In addition, there is a significant complication rate and sometimes permanent morbidity.

At present we have no plans to implant dorsal cord stimulators in new patients. This attitude is in part due up now to a lack of new hardware systems superior to those that were used heretofore. Furthermore, we feel that transcutaneous electrical stimulation as a possible method of pain control deserves a trial, since it is safe and noninvasive.

In attempting to treat a highly complex, subjective disorder, a standardized protocol is mandatory to define indications for treatment and to search for objective methods of pain evaluation. A coordinated effort using the resources of the neurosurgery, physical medicine, and psychiatric departments seems highly desirable.

Summary

Electrical stimulation of the nervous system is a promising technique for pain relief. Dorsal cord stimulation deserves further study, but is still an investigational procedure. Criteria for patient selection and objective methods for testing results of treatment need to be established. An ideal stimulator for chronic implantation in close proximity to the spinal cord has not yet been developed.

We feel that until patient criteria and methods of evaluation have been established, dorsal cord stimulation for pain relief should be confined to centers using standardized protocols. Ideally, this should be a cooperative study involving clinics in which teams from the neurosurgery, physical medicine, and psychiatric departments are sufficiently interested to provide the intensive study required. Transcutaneous electrical stimulation, a noninvasive technique of pain relief, deserves serious investigation.

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