Spinal Cord Stimulation in Post-Amputation Pain

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One of the pre-operative screening tests for dorsal column stimulation involves direct acute percutaneous stimulation of the dorsal column. The test simulates the postoperative therapeutic situation, shows the patient's reactions to electrically induced paresthesias and enables physician and patient to evaluate beforehand the degree of pain relief to be obtained with the implant.

DORSAL column stimulation is a non-destructive[3] operative procedure for the control of chronic intractable pain, theoretically based on the pain gate-control concept as described by Melzack & Wall[4] in 1965. It was Shealy who first described a DCS implantation in a patient in 1967, and since then this method has been clinically evaluated in various neurosurgical centers with varying success. As long lasting pain tends to change the personality of the patient, a high percentage of pain patients show certain psychopathological manifestations. A small number of patients show little tolerance to the electrical paresthesias induced by the pulse generators. For these and other reasons, it has become obvious that careful patient selection is of high importance for the success of this new mode of treatment.

Patient Selection

We have selected a group in which the cases have a similar etiology and normal life expectancy. We have limited our efforts to patients with amputation stump and phantom pain. Three different pain complaints were described by these patients: phantom pain, localized stump pain and painful jerking of the stump as a spontaneous motor phenomena.

Most of the patients in our group were war veterans whose pain had existed for many years. Personality problems were very common and were thought to be principally due to the long lasting experience of pain. Nevertheless, the description of the amputation pain has been rather uniform, indicating that there is a somatic mechanism at work.

Most of these patients were workmen's compensation cases. Therefore, operations were only performed after a clarification with the veterans administration assuring that if there were pain relief, their income would not be reduced.

As a first step in the screening of all our patients, transcutaneous stimulation (TNS) is applied for two weeks. If good, continuous, pain relief is obtained, the patient is discharged from our service with a NEUROMOD® transcutaneous stimulation device.

Phantom pain is only occasionally influenced by TNS.[9] Localized stump pain is, in general, a better indication, but very often, the cutaneous electrode cannot be used because it cannot readily be fitted into the prothesis. Further, if the patient had a local sensory loss, there may be the danger of cutaneous burning.[7,9]

Among the various pre-operative screening procedures, only percutaneous stimulation of the spinal cord[1] by special electrodes permits

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Supported by Sonderforschungsbereich Hirnforschung (SFB 70) der DFG and Bundesministerium für Arbeit und Sozialordnung, Bonn/W. Germany.

Editor's Note: This paper, although substantially different from the original presentation, was rewritten largely based on data presented at the seminar, plus subsequent data, and resubmitted December 1, 1974.

KEY WORDS: dorsal column stimulation · direct percutaneous dorsal column stimulation · transcutaneous nerve stimulation · phantom pain · stump pain · phantom limb · chronic pain

one to simulate the post-operative situation. For about three years, we have performed this testing procedure with a rigid, small wire electrode inserted into the subarachnoidal space. We usually performed dorsal column stimulation for about thirty minutes (83 patients). During the last four months, we have begun to use a floating electrode (a very flexible spring coil electrode covered with silicon) which permits us to do screening stimulations for up to three days. This gives more opportunity to stimulate during pain attacks, very important in those cases of intermittent pain.

As DCS does not suppress acute test pain[4] (pin pricks, painful electrical stimulation, etc.), we do not know of any reliable parameter that will give a clear prognosis of the DCS results during pain free intervals. Therefore, we always try to test during pain attacks.

Good pre-operative pain relief during the percutaneous test stimulation correlates with the post-operative results in most cases where the electrical paresthesias over the painful areas. (Tables 1 and 2). Testing procedures should be done above the spinal segmental level of the pain (although we observed in a few cases, using the floating electrodes, a decrease in pain when stimulation was done even below the pain segment).

Table 3 lists 14 patients with spinal floating electrodes observed during a three day period. There is a significant correlation between good test results and operative successes. The significance of the correlation with the new floating electrode is much higher than with the old technique of direct puncture with the smaller rigid electrodes, most likely due to the longer observation period. However, it seems to us too early to give a final interpretation of the predictive value. We did exclude more patients from the operation with this new procedure than we did before with the rigid electrode.

In some of the above mentioned patients, the test was done repetitively as the area with electrical paresthesias did not overlay the area of pain. With the exception of patients 3 and 13 in Table 3, where we introduced the electrode at cervical level, the puncture was always done in the lumbar area and threaded upwards to the desired level.

In the following tables:

0 = No pain relief
1 = 0-25%
2 = 25-50%
3 = 50-75%
4 = 75-100%

TABLE 1
TEST STIMULATION VS. OPERATIVE RESULTS

Pain Relief During Test Stimulation	Pain Relief					
	N	0	1	2	3	4
excellent pain relief	46	10	6	7	11	12
marked reduction of pain	12	5	2	4	0	1
pain free interval	8	1	4	1	1	1
no statement of value	7	3	1	1	1	1
	73	19	13	13	13	15

TABLE 2
MASKING OF PAIN AREA AND POST-OP DCS RESULTS

Masking on Pain Areas and Electrical Paresthesias	Pain Relief					
	N	0	1	2	3	4
masking	40	2	4	10	11	13
not masking	33	17	9	3	2	2
	73	19	13	13	13	15

Patient Selection Criteria

We excluded those patients: 1) who disliked the test paresthesias (less than 10%); 2) who had incorrect response during the test with a high suggestibility (about 5%); 3) with chronic permanent pain not diminished by test stimulation although the electrode was felt to be in a correct position. Drug addicted and patients with abnormal personality structures should be seen and in some cases treated by a psychiatrist before testing.

Operative Procedures

The first 5 electrodes were implanted subdurally according to the method of Shealy and Nashold, et al.[5,8] The main complications were CSF cysts and CSF leaks. Consequently, all subsequent electrodes were implanted between the two layers of the dura mater (endodurally). With the endodural implantation, complications of the CSF space and the intraoperative CSF loss were eliminated. Unipolar endodural stimulation is as effective as the subdural position if high output transmitters are used with longer pulse width, up to 1 msec.[2] As the CSF space is not opened, the whole operation can be performed in older and higher risk patients.

Spontaneous radicular pain ...ed by direct contact of the ...ctrode with the roots was never observed. Radicular effects caused by post-operative stimulation can generally be diminished by increasing the pulse width.

Results

Out of 60 limb amputation cases with intractable pain, 52 were evaluated and the results are shown in Table 4. As for the groups 2 and 3, especially those with malignancies, no final judgment can be made since the number of cases is still too small.

Table 5 relates post-operative drug intake to the level of pain relief achieved.

Unipolar and Bipolar Electrodes with Endodural Implantation

In a group of nine patients with chronic pain of the lower extremities, bipolar electrodes were implanted. The endodural implantation of these electrodes is somewhat more difficult as they are larger and not quite as flexible as the unipolar ones. The short time results up to now show a marked difference comparing bipolar with unipolar stimulation. The phenomenon of the variable projection of electrical paresthesias relative to the pulse width, as seen very often with unipolar electrodes, was never observed in any of the bipolar cases. There was no shifting of the electrical sensation above the segment of implantation as observed with the unipolar electrode, where the paresthesias are at times felt as high as six segments over the implant.

For these reasons, we feel at this time that unipolar electrodes should be used for pain in the upper limbs and bipolar electrodes for the lower limbs. Using unipolar electrodes together with adjustments in pulse frequency and pulse width, one can get the electrical paresthesias to pass only into the arm of value in painful amputations; whereas with bipolar stimulation, we always saw a distribution of the paresthesias down into the lower part of the body. Further, with bipolar stimulation, we never saw any painful radicular side effects.

TABLE 3
DCS—Precutaneous Spinal Floating Electrodes

Pat. Nos.	Pain Description	Masking effect of Paresthesia	Pain Decrease	DCS Implant	Post-op. results at discharge
1	upper thigh amp. post-traumatic phantom	yes	4	yes	4
2	upper thigh amp. post-traumatic stump	yes	4	yes	4
3	upper arm post-traumatic stump	yes	4	—	—
4	brachial plexus post-traumatic varying intensity	partly	2	yes	0
5	upper thigh amp. post-traumatic stump	yes	0	no	—
6	upper thigh amp. post-traumatic phantom	partly	3	yes	op. compl. DCS explanted
7	upper thigh amp. post-traumatic stump	yes	3	yes	3
8	radicular lumbar post-operative varying intensity	yes	3	yes	3
9	spinal thoracic lumbar-traumatic constant pain	no	0	no	—
10	radicular lumbar traumatic attacks	partly	1	no	—
11	upper thigh vascular phantom	partly	0	no	—
12	radicular lumbar traumatic causalgia	yes	3	—	3
13	upper arm amp. traumatic phantom and stump	yes	3	yes	3
14	peripheral nerve traumatic	yes	4	yes	4

TABLE 4
Post-Operative Results vs. Pain Relief

		Pain Relief				
Diagnosis	N	0	1	2	3	4
post amp. pain	52	10	10	10	11	11
peripheral, rad., spinal lesions	16	7	3	2	1	3
other pain syndromes	5	2	0	1	1	1
	73	19 44%	13	13	13 56%	15

Failures and Complications

In one case of a high cervical implantation at C3, an acute paraplegia with respiratory complications at full consciousness developed. The position of the electrode was corrected immediately with complete restitution after some hours. This was probably due to pressure or traction buckling of the electrode or electrode lead by muscular contraction, pushing it against the spinal cord. After that

incidence, we fixed the electrode lead on the higher vertebral arch.

In one case, a negative effect was probably caused by heavy anatomical alterations. This patient with phantom leg pain had a marked kyphoscoliosis. In this case, the paresthesias were felt only on the opposite side of the trunk and no reduction of pain in the phantom occurred.

In all other unresponsive cases, there was no pain relief in spite of the correct position of the electrode and the paresthesias. The reasons are still unknown. In these cases, the patients continued to take strong analgesics.

TABLE 5
POST-OPERATIVE DRUG INTAKE VS. PAIN RELIEF

	Pain Relief						
Drug Intake	N	0	1	2	3	4	
no drugs afterwards	25	4	1	4	6	10	73%
less than before	28	2	8	6	7	5	
same as before	15	8	4	3	0	0	27%
more than before	5	5	0	0	0	0	
	73	19	13	13	13	15	

Discussion

Within our group with amputation pain, we reached a success rate of 63%; for stump pain, it was 65%. We did consider it a failure if less than 25% of pain relief is obtained. Our results seem to be slightly better compared with the results of other authors due to a tight clinical patient selection procedure, a pre-selection with floating spinal cord test electrodes, as well as varying post-operative stimulation parameters. A success rate of 63% so far for a non-destructive procedure like DCS, seems to be very promising especially compared with the results of other destructive procedures like cordotomies[6,11] even though our longest observation period is only three years.

The major difference between unipolar and bipolar devices with endodural placement is clinically seen in the phenomena that one can shift or enlarge the area of paresthesia, by varying the pulse width, from a segmental distribution to a broader distribution which is more caudal. Therefore, it is our opinion that the unipolar electrode should be recommended for pain in the upper extremities or indications where a more limited segmental distribution of the paresthesias is desired. In those cases, a distribution of the paresthesias into the lower part of the body can be avoided. Further, there is a reduction in the side effect of ataxia during walking, which we saw in about 50% of our cases, where the paresthesias spread into the lower limbs. With bipolar stimulation, however, we never saw unpleasant radicular stimulation which is frequently seen with unipolar stimulation so that we would recommend bipolar electrodes for all indications of pain in the lower part of the body.

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