CLINICAL EVALUATION OF THE EFFECTS OF SPINAL STIMULATION ON MOTOR PERFORMANCE IN PATIENTS WITH UPPER MOTOR NEURONE LESIONS

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ABSTRACT

Chronic, continuous electrical stimulation of the spinal cord of patients with upper motor neurone disorders has been successfully used to modify the motor performance of a group of 16 patients with multiple sclerosis, spinal cord injury and degenerative disorders. Principal motor effects observed over the period of observation (approximately one year for the longest duration stimulation) were the increased endurance of the patients, improved coordination, and decreased spasticity. The method appears to be effective if the patients have partial preservation of voluntary and reflex motor control.

INTRODUCTION

The usefulness of spinal cord stimulation (SCS) for the treatment of impaired motor control in patients with demyelinating and degenerative disorders has been previously reported (1,2). Recently we had the opportunity to observe the improvement in motor control not only in these disorders but also in patients with spinal cord injury (3). The method of SCS for modification of motor control by the subdural placement of electrodes is not a new technique in clinical practice. It has been used very widely for suppression of intractable pain, but it was found to be of very limited value. Therefore it is understandable that reports of successful usage of SCS for improvement of motor control met with considerable skepticism. Thus, all of us who have the opportunity to study SCS continue to face questions regarding the utility of this method in patients with upper motor neurone disorders, of how much it is useful and finally how we can select the appropriate patients. In an attempt to answer this question, we have evaluated the effects of epidural Spinal Cord Stimulation (SCS) on three different groups of patients, those exhibiting motor disorders with predominant signs of:

1) ataxia
2) spasticity

and 3) poor coordination and fatigue.

The devices and techniques for spinal cord stimulation that have been used to treat the patients in this paper are reviewed elsewhere (1). The system consists of electrodes in the epidural space of the thoracic spinal canal attached to a subcutaneous implanted receiver energized via an external apparatus consisting of a transmitter and an antenna. Chronic spinal cord stimulation using this system has been applied in 18 patients.

PATIENTS

Multiple sclerosis: This group consists of 5 female and 3 male patients whose disease had its onset from 1956 to as recently as 1971. These patients all had considerable impairment of motor

function ranging from wheelchair-bound to walking with support aided by a cane or another individual (Table 1). Their ages varied

Table 1. Multiple Sclerosis

INIT.	SEX	AGE	ONSET	MOBILITY	ELECTRODE PLACEMENT	SYSTEM IMPLANT	ELECTRODE LOCATION
T.G.M.	M	55	1971	walk. w/supp.	6/7/77	6/10/77	T-2, T-4
F.W.	F	40	1967	walk. w/supp.	6/7/77	6/10/77	T-3, T-4
R.B.	M	51	1956	walk w. cane	7/11/77	7/14/77	T-4, T-7
M.P.	F	26	1971	wheelch./stand.	7/27/77	8/1/77	T-3, T-6
T.M.	F	28	1967	walk w/supp.	8/ 2/77	8/5/77	T-2, T-3
H.B.	F	64	1960	walk w/walker	4/11/78	4/14/78	T-1, T-2
G.D.	M	55	1958	walk w/walker	5/9/78	5/12/78	T-1, T-2
M.A.	F	42	1963	walk w/ cane	5/19/78	5/26/78	T-1, T-2

from 28 to 55 years. The leading electrode placements (2 in each patient) varied from T-2 to T-4 and the trailing electrodes from T-3 to T-7 with the interelectrode distance ranging from 1 segment up to 3 segments.

Spinal cord injury: There are 8 male patients in this group but only 5 in whom the system was implanted. Their ages at the time of implant ranged from 25 to 55 years. The onset of their injuries ranged from 1969 to 1975 and the levels of injury from C2-3 to T7-8. The motor impairment was considerable, varying from wheelchair bound with trace movement to walking with crutches or a walker (Table 2). Placement of the leading electrode in this group ranged from T-2 to T-7 with trailing electrodes from T-4 to T-7 with the electrode distances varying from 1 up to 4 segments (most were 1 - 2 segments).

One patient (H.F.) was not implanted because of some loss of function during the period of trial stimulation. A second (R.C.) was not implanted because the stimulus did not significantly improve his motor performance, and indeed interfered with some spasticity which had some useful functioning in transfers. The third (C.B.) decided not to proceed with the implant in spite of moderate improvement in his condition.

Degenerative disorders of the nervous system: There are 2 patients in this group. One is a 20 year old college student with Friedreich's ataxia clinically evident since 1965 at the age of 8. He had his electrodes placed at T-1 and T-2. The other patient is a 65 year old female with familial spastic paraplegia clinically evident since the age of 40. Her electrodes were placed at T-2 and T-3 (Table 3).

METHODS

All patients were evaluated clinically for verification of their diagnosis by a neurologist (R.J.C.) as a prerequisite for enrolling in the SCS program. The neurological evaluation

Table 2. Spinal Cord Injury

INIT.	SEX	AGE	ONSET	MOBILITY	ELECTRODE PLACEMENT	SYSTEM IMPLANT	ELECTRODE LOCATION
R.T.	M	29	1969	incompl., use walker, part. sensory	7/27/77	8/ 1/77	T-2, T-7
B.B.	M	20	1975	inc.,wheelchair bound, partial sensation	8/19/77	8/23/77	T-2, T-4
H.F.	M	55	1971	inc, walk crutches, part. sensation	8/22/77	----	T-2, T-4
E.H.	M	47	1975	incompl.,pain, spast., w/c bound, partial sensation	1/24/78	1/27/78	T-4, T-5
R.C.	M	45	1974	incompl., pain, walk w/walker, sens. preserved	1/24/78	1/27/78	T-4, T-5
K.C.	M	25	1968	spastic, sens. pres. walk w/ walker, clonus	2/10/78	2/16/78	T-4, T-5
T.C.	M	25	1970	poor walk w/ supp., spastic	3/ 7/78	----	T-4, T-5
C.B.	M	22	1976	walk w/cane, spastic, poor endur.	5/26/78	----	T-2, T-4

Table 3. Degenerative Disorders of the Nervous System

INIT.	SEX	AGE	ONSET	MOBILITY	ELECTRODE PLACEMENT	SYSTEM IMPLANT	ELECTRODE LOCATION
S.L.	M	20	1965	unsteady walk with walker	8/17/77	8/22/77	T-1, T-2
C.C.	F	65	1954	spast. gait, walk w/cane, poor endurance	3/14/78	3/20/78	T-1, T-3

consisted of a descripton of the neurological findings as well as a description of the motor control of the patient based on observations of patient performance of tests for motor coordination, reflex and volitional control (See Tables 4,5,and 6). A kinesiological evaluation, together with evaluation of standing, walking, writing and speech has been carried out directly (M.M.D.) or indirectly through services of the Institute (P.T., O.T. departments). Bladder functions and the status of peripheral circulation were judged through patient reports and nursing staff observations (See Tables 4,5, and 6).

After the patients were accepted as candidates for SCS, they

were evaluated neurophysiologically (4), and placement of the system for SCS was completed in two phases (P.C.S.). The first phase consisted of the placement of the electrodes in the spinal canal, and connection to an external stimulator. In the second phase, the passive receiver was implanted and connected to the electrodes via a subcutaneous tunnel. This second stage is entered only if the first phase testing is successful.

RESULTS

The scores shown in Tables 4, 5 and 6 represent a summary evaluation of the patients' condition over the entire time period from the initial electrode placement through May, 1978. In almost all cases, the effects of SCS were moderate in degree, and relate to improvements in the three neurological deficits; ataxia, spasticity, and poor coordination and fatigue.

Table 4. Effects of SCS in Multiple Sclerosis Patients

INITIALS	COORDINATION	STANDING	BLADDER	SPEECH	WRITING	ENDUR.
T.G.M.	+	++	+	X	+	++
F.W.	++	++	+	+	+	+
R.B.	+	0	+	X	+	+
M.P.	+	+	+	X	+	+
T.M.	+	++	+	X	+	+
H.B.	+	+	+	X	+	+
G.D.	X	+	+	X	+	+
M.A.	+	+	+	+	+	+

Table 5. Effects of SCS in Spinal Cord Injury Patients

INIT.	SPASTIC.	CLONUS	MOTOR COORDIN.& VOLITION.	CONTR.	PERIPHERAL CIRCUL.	BLADDER FUNCT.	PAIN MOD.
R.T.	+	+	+		+	+	X
B.B.	++	+	++		+	++	X
H.F.	0	X	0		+	-	0
E.H.	+	+	+		++	+	0
R.C.	++	+	+		+	+	+
K.C.	++	+	+		+	+	+
T.C.	0	0	0		0	0	0*
C.B.	+	X	+		X	X	X

KEY
WORSE: -; NO CHANGE: 0; IMPROVED: +;
REMARKABLE IMPR: ++; NOT INVOLVED: X.

NOTES
* - unable to evaluate patient, who was emotionally unstable

The decrease of ataxia was evidenced in the upper extremities by an increased facility for self-feeding, and in the lower

Table 6. Effects of SCS in Patients With Degenerative Disorders

	INIT.	COORD.	STAND.	BLADDER	SPEECH	WRITE	WALK.	ATAXIA	SPAST.	VOL. CONT.
S.L.	++	++	X	++	+	+	++	0	X
C.C.	+	++	0	0	0	+	X	+	+

KEY
WORSE: -; NO CHANGE: 0; IMPROVED: +;
REMARKABLE IMPR: ++; NOT INVOLVED: X.

extremities by improved gait. In the patient with Friedreich's ataxia, SCS had an effect on nystagmus. This effect was demonstrated by the disappearance of nystagmus during stimulation, and its immediate reappearance upon cessation. There was also a noticeable improvement in this patient's speech.

With respect to spasticity, we found a reduction in massive reflex movements in paralyzed spinal cord injury patients after SCS. One patient in particular (B.B.), was able to reduce the level of drugs taken, and to function more effectively in a normal environment. His spasticity was not completely eliminated; interestingly it now seems to appear only when he is under stress. In two other SCI patients, (R.T. and E.H.), SCS suppressed their exaggerated muscle tone. One SCI patient with sustained bilateral clonus of the wrist and ankle experienced a reduction in the amplitude and duration of the clonus during SCS.

The suppression effects of SCS were also noted in an increased capacity of otherwise spastic bladders. Following SCS, these patients uniformly reported that their frequency and urgency of urination had decreased. In one SCI patient (R.T.), the proper choice of stimulation parameters allowed him to discontinue an external catheterization program.

In the third group of patients, who were ambulatory, there was an improvement in the coordination of muscle activity during gait and while standing, and a consequent improvement in their stability and endurance in performing motor activities.

CONCLUSIONS

SCS does have an effect on the motor performance of patients with upper motor neurone disorders. This effect is developed relatively quickly with the beginning of stimulation, and lasts for the duration of the stimulation. The effects of SCS on functional restoration depend on the degree of preservation of motor control. In ambulatory patients who suffer from easy fatiguability, SCS can improve endurance. Patients with spasticity due to the exaggerated stretch reflex and released cutaneomuscular reflexes and spastic bladder can benefit from SCS, which decreases the extent of release of segmental reflexes. Patients with ataxia and other related signs have shown some improvement in upper and lower extremities, and even in speech and reduction of nystagmus, but this effect is of lesser degree compared to the improved endurance and suppression of spasticity.

In conclusion, spinal cord stimulation is a method of choice for a selected group of patients with upper motor neurone disorders of the spinal cord and brain stem. This group is comprised of those patients whose condition is stabilized with non-progressive symptoms, and with any of the following motor deficits: 1) moderate weakness and poor endurance, 2) spasticity, and 3) moderate ataxia. Finally, the patient must be in a position to utilize the improvements in motor control which may result from SCS. In this group of potential candidates, SCS can have a generalized effect on the central nervous system which improves the patient's motor control.

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