Spinal Cord Stimulation for Multiple Sclerosis and Spinal Cord Injury

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Introduction

Since 1973, spinal cord stimulation (SCS) has been reported to modulate abnormal motor functions such as spasticity, weakness, ataxia, athetosis, neurogenic bladder, dysarthria, dystonia and torticollis. As reported in 39 papers, improved neurological functions did occur in 45 to 64% of 1,008 patients with multiple sclerosis (MS), spinal cord injury (SCI), cerebral palsy and other dystonic and hyperkinetc disorders. In the last 30 years, trials of stimulation, equipment and techniques have improved, particularly in electrode design and numbers (#4-8-16 buttons) and the positioning in regards to the dorsal epidural spinal cord. It is recommended that moderately affected MS and incomplete SCI (ASIA: C&D) patients undergo SCS trial. If there is a *50+%* functional improvement, permanent implantation should be considered as a rehabilitation aid to improve their independence and quality of life.

Multiple Sclerosis

In 1973, Cook and Weinstein [1] reported dramatic improvements in strength and ambulation in MS patients undergoing SCS for pain relief. There have been 3 major reviews in the last 30 years concerning the improvements of MS patients from SCS. Siegfried et al. [2] reviewed the literature from 1973 to 1980 where 616 MS patients had been studied, from which they culled 355 as having had comprehensive evaluations with 200 *(56%)* improved. Bladder function improvements were seen in *50-75%* of cases stimulated. Of their own 36 MS patients, one showed very good improvement, with 20 having good improvement, 13 fair and 2 no improvement with SCS applied at low cervical to upper thoracic levels.

In 1985, Gybels and Van Roost [3] reviewed 39 papers on the effects of SCS on dystonic and hyperkinetic disorders in 1,008 patients. Whereas SCS cannot prevent deterioration in progressive neurological disorders, the literature showed useful overall relief from disabilities including MS in *10-45%* of the cases. No conclusions could be drawn as to differences in results using cervical versus thoracic SCS. SCS appears to decrease excessive spinal reflex activity.

In 1992, Davis and Emmons [4] did a blinded quantitative study of *5* MS patients with SCS at the C7-T1 level. The 5 patients (4 males, 1 female; 4 tetraparetics, 1 hemiparetic) were 36-45 years of age having had symptoms for 12-22 years. Five quantitative tests were given prior to and during SCS on 4-8 occasions; “OFF” periods were planned and also occurred when the electrode(s) broke (3 patients). With SCS, hand dynamometry showed a 2- to 4-fold increase in the 3 patients with weak hand function. Jebson Hand Time Testing showed a rapidity improvement to 1/2 to 1/7 of time in the same 3 patients. Minnesota Manipulation Testing with SCS was improved to 1/3 to 1/2 of time in 2 of these 3 patients tested. Manual muscle strength increased in all patients by 20-50% in ‘normal range’. Ambulation in the parallel bars increased with SCS in 2 of the 4 wheelchair patients, while the hemiparetic patient could walk without his cane. All patients showed varying quantifiable improvements with SCS, but over the duration or testing the patients slowly deteriorated.

In 2002, Davis [5] reviewed the literature for SCS results, when used to reduce spasticity, augment neurological weakness, imbalance, sensory loss and cranial nerve function following MS and SCI.

Spinal Cord Injury

In 2002, Herman et al. [6] treated a quadriplegic SCI Subject (ASIA: C), who is a wheelchair-dependent and has sub-functional motor strength in both lower limb muscles, and moderate spasticity. The study utilizes partial weight bearing therapy (PWBT) followed by SCS. The SC electrode was positioned epidural over the lumbar cord enlargement of L2, where the ‘pattern-generator’ for walking has been demonstrated to exist by Dimitrijevic et al. [7]. PWBT led to improved stereotypic stepping patterns associated with markedly reduced spasticity, but was insufficient for over-ground walking in terms of safety, energy cost, and fatigue. SCS with PWBT generated immediate improvement in the subject's gait rhythm when appropriate stimulation parameters were used. When compared to the non-stimulated condition, a reduction in time and energy cost of walking, sense of effort, and a feeling of ‘lightness’ in the legs featured over-ground walking with SCS across a 15 m distance. After a few months of training, performance in speed, endurance, and metabolic responses gradually converged with/without SCS at this short distance, suggesting a learned response to these conditions. However, at longer distances (e.g., 50-250 m), performance with SCS was considerably superior. The subject was able to perform multiple functional tasks within the home and community with SCS. They also conclude that SCS elicits greater activation of an oxidative motor unit pool, thereby reducing the subject's sense of effort and energetic cost of walking.

SPINAL CORD STIMULATION for SPINAL CORD INJURY							
AUTHOR (year)	Electrode **placement**	**Patient** **#**	**compl/** **incomp**	**Spasticity**	**Bladder**	**Movement**	**Gait**
Richardson	L1-4	6	comp=5	6 (100%)			
1979			incom=1				
Dimitrijevic-	below	7	comp=3	7 (100%)	6 impr.		
1981	injury		incom=4			4 impr.	
Dimitrijevic-	below	8		7 (88%)			
1987	injury						
Davis	C7-Th1	4	comp=0				
1981			incom=4	4 (100%)		4 impr.	4 impr.
Davis	C7-Th1	3	comp=0				
1995			incom=3	3 (100%)		3 impr.	1 impr.
Reynolds	Cerv.	2	comp=1	2 (100%)			
1982	1000-1400		incom=1				1 impr.
Frerebeau	45% above Inj.	20	comp=3	8/10 (80%)			
1985	55% below Inj.		incom=4			38% impr.	
Barolat	below	5		5 (100%)			
1985	injury						
Barolat	below	16	comp=8	14 (88%)	3 impr.		
1988	injury		incom=8			8 impr.	
Barolat	below	43	comp=23	29 (68%)			
1994	injury		incom=20				
Koulousakis	Th 9-11	3	comp=1	3 (100%)	1 impr.		
1987			incom=2				2 impr.
Waltz	at/below	169		139 (82%)	123 (73%)		
1987	level injury					65%	
TOTAL		286		227 (82%)			

Discussion

Mild to moderate spasms and spasticity in either MS or SCI, appears to be most likely reduced following SCS, either immediately or over the ensuing months. Bladder function improvements were seen in *50-75%* of cases stimulated, which has been suggested that benefits result from inhibition of excessive spinal reflex activity. The evidence for augmenting motor weakness, standing and ambulation, sensation, coordination and cranial nerve dysfunctions, is also presented and appears valid. In ambulatory patients who suffer from easy fatigability due to upper motor neuron disorder, SCS does increase endurance. Patients with spasticity due to exaggerated stretch reflex and released cutaneo-muscular 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 their upper and lower extremities and in their speech with the high cervical quadrapolar electrodes.

The question is whether the long time use of SCS in MS is as effective as when first used, or is the MS process slowly causing the deterioration? The answer is most probably the latter. When SCS is stopped, all abilities measurably decreased until restimulated. The stimulation parameter question, particularly the frequency, is an individual finding, all the above series, unless indicated, used below 200 Hz. However, the electrode location is best placed high enough and accurately to distribute the paresthesiae into the affected limb(s), and low enough to be just below the injured area in the SCI group. The equipment now available is more reliable than that used in the earlier series of the 1970s through to the mid 1980s, particularly with stronger and more electrodes to select the current distribution.

Dimitrijevic and Faganel [8] in discussing the neurophysiology of SCS, state that any model of the stimulation effects must consider the fact that it takes 2-3 days to fully develop and the stimulus must be continuous in order for the effect to be lasting. When stimulation is discontinued the effect will decline in a few hours and disappear after several days. Therefore, neuronal circuits alone cannot comprise an adequate model. Effects such as long-term potentiation must be incorporated. SCS is a physiological neuro-augmentative procedure having the ability to modify various motor disorders and especially caused by spinal cord and brainstem dysfunctions.

In the management of spasms in MS and SCI patients, the exact role of SCS has to be more clearly defined. Barolat et al. have indicated that patients who have extremely severe spasms of the lower extremities and who can guarantee a reliable follow-up are candidates for intrathecal baclofen infusion. If they are unreliable, an ablative procedure (myelotomy, rhizotomy, intrathecal phenol, etc.) could be offered. Incomplete SCI and MS patients who are ambulatory can be served by either SCS or intrathecal baclofen. Patients who have a spastic hemiparesis or quadriparesis and spasms affecting both the upper and lower extremities, are excellent candidates for SCS. SCS, unlike an ablative procedure or intrathecal baclofen infusion, appears to pose a low risk to the patient, and is a reversible procedure. The long-term medical, social and economic implications of the various treatment modalities certainly do influence the decisions.

In the last 30 years, trials of stimulation, equipment and techniques have improved, particularly in electrode design, positioning and numbers (#4-8-16 buttons). This reviewer recommends that moderately affected MS and incomplete SCI patients, especially the ASIA: C&D levels, undergo a trial of SCS. If there were a *50+%* functional improvement, permanent implantation should be considered as a rehabilitation aid to improve their independence and quality of life. .

References

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