

Spinal cord stimulation

A. COSTANTINI ^{1, 2}

Spinal cord stimulation (SCS) is a neuromodulation technique using electricity, proposed for the first time by Shealy in 1967, as an alternative to neuroablation. Technological improvements in the last 20 years (percutaneous electrodes, single and dual leads, octopolar electrodes, high energy internal pulse generators) have allowed to obtain good results with SCS in various clinical situations of chronic pain. The main clinical indications to SCS are: vascular pain - refractory angina and peripheral vascular diseases (PVD); rachidian pain - failed back surgery syndrome (FBSS), degenerative low back leg pain (LBLEP), nerve root lesions, incomplete spine lesions, spinal stenosis; neuropathic pain; chronic regional pain syndrome (CRPS) type 1 and type 2; perineal pain and urological diseases (urge-incontinence, interstitial cystitis). There are important differences between Europe and USA in the SCS use in various indications, especially about PVD. Really, in Europe this technique has been widely used and, finally, there are prospective studies establishing the utility of SCS in: limb survival; pain control; regression to Fontaine stage II; improvement of free interval of claudication. All of this is going to change the attitude towards SCS in USA, where the amputation incidence for critical ischaemia is considerably higher than in Europe. An indication to SCS not very mentioned in literature and that seems to have good results is LBLEP due to acquired or mixed (constitutional-acquired) spinal stenosis. In

¹Unit of Physiopathology and Therapy of Pain
SS. Annunziata Hospital, Chieti, Italy
²Department of Anesthesia and Resuscitation
G. D'Annunzio University, Chieti, Italy

this situation SCS seems to improve notably pain control and quality of life index of patients.

Key words: Spinal cord stimulation - Peripheral vascular disease - Failed back surgery syndrome - Chronic regional pain syndrome - Low back pain - Spinal stenosis - Neuropathic pain - Urge-incontinence - Urological distress.

Spinal cord stimulation (SCS) was proposed by Shealy in 1967 ¹ as an alternative to the procedures of neurolesion and it consisted, in the beginning, in translaminar implantation of an intrathecal monopolar electrode. Only in the last 20 years SCS has spread among the invasive techniques of relief of chronic non-cancer pain. This is due to the technological improvements of devices regarding electrocatheters (from mono- to quadripolar and octopolar; from single to double electrocatheters; from surgical implantation to the percutaneous one) and pulse-generators (from partially to totally implantable; from low to wide range of programme; from low to high energetic capacity).

Address reprint requests to: Dr. A. Costantini, U.O. Centro di Fisiopatologia e Terapia del Dolore, Ospedale Clinicizzato SS. Annunziata, Via dei Vestini 17, 66100 Chieti, Italy.
E-mail: amedeocostantini@tiscalinet.it

Spinal cord stimulation

The main clinical indications are:²

— Vascular pain: refractory angina and peripheral vascular diseases (PVD).

— Rachidian pain: failed back surgery syndrome (FBSS), degenerative low back-leg pain (LBLEP), spinal stenosis, nerve-root avulsion, incomplete spine lesion.

— Chronic regional pain syndromes (CRPS) type I and II.

— Neuropathic perineal pain:³

— Urological diseases: interstitial cystitis, urge-incontinence.⁴

Some of these indications are examined comparing, when it is possible, literature data with direct clinical experience.

Vascular pain

PVD, particularly Fontaine stage III obliterant arteriopathy or chronic critical ischemia, have been considered for years one of the best indications of SCS,² both for pain relief and for limb survival. This was questioned⁵ at the end of the '90s when, after the evidence based medicine (EBM) affirmation, the absence of perspective studies undermines its credibility. In the last years, on the contrary, some important and perspective studies⁶⁻⁸ and a wide Cochrane Review⁹ definitively settle the importance of critical ischemia treatment.

On the basis of these studies we can deduce:

1) In non reconstructable critical ischemia SCS improves significantly the outcome, as to limb survival, compared to usual treatment.^{6,9}

2) Pain control in SCS-patients is better than in no SCS-patients absolutely and in relation with drugs use.^{6,7,9}

3) The number of patients regressing from Fontaine stage III to II is significantly higher among SCS patients treated than in SCS non-treated subjects.^{7,9}

4) Free walking interval in SCS patients improves notably in the follow-up.⁹

5) Using preliminarily TcpO₂ monitoring it is possible to select patients more responsive to the therapy.⁶

Rachidian pain

FBSS and chronic, degenerative LBLEP are 2 important indications for SCS, particularly from the end of the 90s, when the availability of dual-lead devices allowed to treat successfully not only radicular pain but also axial pain.¹⁰ Prevalence of FBSS is estimable in 5-15% of patients after laminectomy.^{11, 12} Persistent or recurrent pain after spine surgery due to scars, not to surgery complications, characterizes this syndrome. In usual opinion each reoperation in these patients will get worse their clinical and functional assessment.¹¹ About 60% of these patients, with SCS, has a significantly pain relief and a sensible improvement of quality of life index.^{13, 14}

The economic aspect has to be valued attentively in the patients using often dual-lead devices, the cost of which is relatively high. In 2002 a study on this topic was published.¹⁵ A cost-effectiveness analysis on 2 groups of FBSS patients randomised to conventional therapy or to SCS and including all the costs (hospitalisation, rehabilitation, imaging, nursing, devices, examinations, etc.), shows that costs in SCS group, in a 5-years follow-up, are significantly lower than in conventional therapy group (used as control group). SCS group has a better outcome.

A particular group of patients among those with rachidian pain is the group with spinal stenosis. Spinal stenosis, characterized by low diameters of lumbar spinal canal and due to mechanical compression of nervous structures and to their ischemia, may be constitutional (stenosis with short peduncles), not too much frequent, or acquired (bones and joints degenerative diseases).^{16, 17} Spinal stenosis is increasing probably for the progressive aging of population and in the elderly it is often impossible to carry out the surgical treatment (posterior laminectomy and/or vertebral fixing or fusion).

Clinically, there is a chronic neuropathic LBLEP with functional reduction, *claudicatio spinalis* and urinary distress at a late period. The serious patients have, at the end, important motor dysfunction up to paraplegia. This pain is typically SCS-responder, but in literature there are few data.¹⁸ More often refrac-

tory pain by spinal stenosis is treated with opioids intrathecal delivery. In this case, since 2000, the Pain Unit of the University Hospital in Chieti is treating with SCS every patient with spinal stenosis, nonsurgical and non-responder to conventional therapy (drugs, kinesiotherapy, rehabilitation). The results, that have to be published, are encouraging. Up to June 2004, 34 patients, aged between 59 and 85 years, have been treated; 23 of them have at least 12 months follow-up. All the patients showed a significant improvement of visual analogue scale (VAS), reduction of drugs consumption and significant improvement of quality of life index (Oswestry Disability Index).

CRPS

CRPS type I (sympathetic dystrophy) and type II (causalgia) are often very serious and, often, very difficult to be treated.¹⁹ Therapy has to be, when possible, multimodal (psychological, physical, rehabilitation therapy and pain control).²⁰ Pain control should be reached quickly and it is the *conditio sine qua non* to obtain *restitutio ad integrum*. SCS gives a substantial improvement or normalization of the autonomic function^{21, 22} and improvement of the quality of life index,²³ but it is very important to perform it early, when other techniques (drugs and blocks) do not give good pain control.²⁰

Perineal pain and urological distress

Dual-lead stimulators and a new technique "up to down" allow to treat patients with complex chronic neuropathic perineal pain, interstitial cystitis and urological distress, *i.e.* urge-incontinence.^{3, 4, 24} In these cases using the "up to down" technique we can stimulate the bilateral sacral root of S₂-S₃ and solve these "difficult" diseases.

Conclusions

SCS is an excellent therapy which can widen the range of patients with chronic pain

and obtain successful answers about pain control and quality of life. It is a method of functional neurosurgery with a low aggressiveness and a low biological impact, with few complications if carried out by experts. However, it should be performed after a correct diagnosis about pain assessment and a careful evaluation of the psychological condition of the patients.²⁵

Riassunto

Stimolazione del midollo spinale

La stimolazione del midollo spinale è una tecnica di neuromodulazione che utilizza l'elettricità, proposta per la prima volta da Shealy nel 1967, quale alternativa alla neuroablazione.

I miglioramenti tecnologici degli ultimi 20 anni (elettrodi percutanei, singolo o doppio elettrodo, elettrodi ottopolari, generatori di impulsi interni ad alta energia) hanno consentito di ottenere buoni risultati nella stimolazione midollare in diverse situazioni cliniche con dolore cronico.

Le indicazioni principali per la stimolazione del midollo spinale sono: dolore vascolare, angina refrattaria e vasculopatia periferica; dolore rachideo, sindrome post-laminectomia, dolore degenerativo lombare, lesioni di radici nervose, lesioni midollari incomplete, stenosi midollare; dolore neuropatico; sindrome dolorosa regionale complessa di tipo 1 e 2; dolore perineale e patologie urologiche (incontinenza da urgenza, cistite interstiziale).

Tra l'Europa e gli USA vi sono importanti differenze per quanto riguarda l'utilizzo della stimolazione del midollo spinale in diverse indicazioni, in special modo per quanto riguarda la vasculopatia periferica. In realtà, questa tecnica è stata ampiamente usata in Europa e vi sono studi prospettici che hanno evidenziato l'utilità della stimolazione del midollo spinale per: salvataggio d'arto; controllo del dolore; regressione allo stadio II di Fontane; miglioramento dell'intervallo di tempo libero da claudicazione.

Tutti questi dati stanno portando ad un cambiamento nei confronti della stimolazione del midollo spinale negli USA, dove l'incidenza di amputazioni a seguito di ischemia critica è considerevolmente più elevato rispetto all'Europa.

Una indicazione per la stimolazione del midollo spinale che non è molto citata in letteratura e che sembra dare buoni risultati è rappresentata dal dolore lombare dovuto ad una stenosi midollare acquisita o mista (costituzionale-acquisita). In questa situazione la stimolazione del midollo spinale sembra migliorare notevolmente il controllo del dolore e la qualità di vita dei pazienti.

Parole chiave: Stimolazione spinale - Malattia vascolare periferica - Dolore cronico - Stenosi spinale - Dolore neuropatico - Incontinenza.

References

1. Shealy CN, Mortimer JT, Reswick KB. Electrical inhibition of pain by stimulation of dorsal column: preliminary clinical reports. *Anesthesia Analgesia* 1967;4:489-91.
2. Simpson BA. Spinal Cord Stimulation. *Pain Review* 1994;1:199-205.
3. Alo KM, McKay E. SNRS for the treatment of intractable pelvic pain and motor dysfunction: a case report. *Neuromodulation* 2001;4:19-23.
4. Chancellor MB, Chartier-Kastler EJ. Principles of sacral nerve stimulation for the treatment of bladder and urethral sphincter dysfunction. *Neuromodulation* 2000;3:15-26.
5. Klomp HM, Spincemaille GHJJ, Sleyberg EW, Habbema JDF, Van Hurk H. SCS in critical limb ischaemia: a randomised trial. *Lancet* 1999; 353:1040-4.
6. Amann W, Berg P, Gersbach P, Gamain J, Raphael JH, Ubbink DT. SCS in the treatment of non-reconstructable stable critical leg ischaemia: results of the European Peripheral Vascular Disease Outcome Study (SCS-EPOS). *Eur J Vasc Endovasc Surg* 2003;26:280-6.
7. Tedesco A, D'Addato M. SCS for patients with critical limb ischaemia : immediate and long-term clinical outcome from the prospective Italian Register. *Neuromodulation* 2004;7:97-102.
8. Tiede JM, Huntoon MA. Review of SCS in PVD. *Neuromodulation* 2004; 7:168-75.
9. Ubbink TD, Vermeulen H. SCS for non-reconstructable chronic leg ischaemia (Cochrane Review). *The Cochrane Library* 2003;3:1-21.
10. Alo KM. SCS for complex pain: initial experience with a dual electrode programmable, internal pulse generator. *Pain Practice* 2003;3:31-8.
11. Burton CV. Lumbosacral arachnoiditis. *Spine* 1978;3:147-52.
12. Wilkinson HA. *The failed back syndrome : aetiology and therapy*. 2nd ed. Philadelphia: Harper-Row;1991.
13. Ohnmeiss DD, Rashbaum RF. Patients satisfaction with SCS for predominant complaints of chronic, intractable low back pain. *Spine J* 2001;1:358-63.
14. Van Buyten JP, Van Zundert J, Vueghs P, Vanduffel L. Efficacy of SCS: 10 years of experience in a Pain Centre in Belgium. *Eur J Pain* 2001;5:1-10.
15. Kumar K, Malik S, Demeria D. Treatment of chronic pain with SCS versus alternative therapies: cost-effectiveness analysis. *Neurosurgery* 2002;51:106-16.
16. Hahnel S, Forsting M, Dorfner A. Radiology of lumbar spine canal stenosis. *Aktuelle Radiol* 1996;6:165-9.
17. Szpalski M, Mighel F, Hayetz JP. Determination of trunk motion patterns associated with permanent or transient stenosis of the lumbar spine. *Eur Spine J* 1996;5:332-8.
18. Schofferman J, Szabo C, Derby R, Keaney D, White A. SCS for patients with structural lumbar spine pathology. Abstracts Book of the 9th Annual Meeting of North American Spine Society. October 19-22, 1994. Minneapolis, MN, USA.
19. Baron P, Binder A, Schattschneider J, Wasner G. Pathophysiology and treatment of CRPS. Proceedings of 10th World Congress on Pain. Progress in pain research and management. Vol 24. IASP 2002:683-704.
20. Stanton-Hicks M. SCS for the management of CRPS. *Neuromodulation* 1999;2:193-201.
21. Kemler MA, Reulen JPH, Barendse GAM, Van Kliff M, De Vet HCW, Van Den Wildenberg FAJM. Impact of SCS on sensory characteristics in CRPS type 1. A randomised trial. *Anesthesiology* 2001;95:72-80.
22. Segal R, Stacey B, Rudy T, Baser S, Markahm J. SCS revisited. *Neurol Res* 1998;20:391-6.
23. Oakley JC, Weiner RL. SCS for CRPS. A prospective study of 19 patients. *Neuromodulation* 1999;2:19-23.
24. Alo KM, Gohel R, Corey CL. Sacral nerve root stimulation for the treatment of urge incontinence and detrusor dysfunction utilizing a cephalocaudal intraspinal method of lead insertion: a case report. *Neuromodulation* 2001;4:53-8.
25. Gybels J, Erdine S, Maeyaert J, Meyerson B, Winkelmüller W, Augustinsson L. Neuromodulation of pain. *Eur J Pain* 1998;2:203-9.