



Sustainable Effects of 8-Year Intermittent Spinal Cord Stimulation in a Patient with Thalamic Post-Stroke Pain

Wenying Xu^{1,2}, Chencheng Zhang^{1,2}, Bomin Sun^{1,2}, Dianyou Li^{1,2}

Key words

- Central post-stroke pain
- Intermittent stimulation
- Spinal cord stimulation
- Thalamic pain

Abbreviations and Acronyms

- BPI:** Brief Pain Inventory
CPSP: Central post-stroke pain
DBS: Deep brain stimulation
IPG: Implantable pulse generator
MCS: Motor cortex stimulation
rTMS: Repetitive transcranial magnetic stimulation
SCS: Spinal cord stimulation
VAS: Visual analog scale

From the ¹Department of Neurosurgery and ²Center for Functional Neurosurgery, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China

To whom correspondence should be addressed:
Dianyou Li, M.D., Ph.D.

[E-mail: ldy11483@rjh.com.cn]

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INTRODUCTION

Central post-stroke pain (CPSP) is a chronic central neuropathic pain that mainly occurs after stroke during the subacute and chronic phases.¹ The associated pain is typically characterized by severe burning, shooting, or throbbing. The presence of allodynia and pricking hypoesthesia distinguishes CPSP from other pain types.² CPSP often involves intractable severe pain with serious effects on the quality of life, cognitive impairment, psychiatric disorder development, and declined social functioning.³⁻⁵ The mechanism of CPSP remains unclear, which impedes the provision of effective treatment to these patients. Previous studies have suggested that somatosensory pathway lesions are involved in CPSP pathophysiology, especially those in the

spino-thalamo-cortical sensory pathway, which includes the medulla, pons, lenticulocapsular region, thalamus, and cerebral cortex.^{6,7}

Pharmacological treatment of CPSP often involves the use of antidepressants, anticonvulsants, and opioids.⁸ However, this treatment usually has a weak response, and the dosage is limited by side effects. Inconsistent findings have been reported regarding the efficacy of neurostimulation therapy for CPSP, including motor cortex stimulation (MCS), deep brain stimulation (DBS), repetitive transcranial magnetic stimulation (rTMS), and spinal cord stimulation (SCS).⁹ SCS is a minimally invasive technique with a proven efficacy against neuropathic pain.^{10,11} However,

the efficacy of SCS for CPSP is yet to be adequately explored, and long-term stimulation results in a decrease, or so-called tolerance, of its effectiveness over time.¹² Some researchers applied an intermittent SCS pattern to avoid tolerance to stimulation and achieve the pain-relieving effect.¹³⁻¹⁵ We present the first report of an 8-year intermittent SCS in a patient with post-stroke thalamic pain.

CASE REPORT

History and Examination

A 71-year-old man initially presented with left thalamic stroke, which had no obvious precipitating factor, that resulted in right-sided numbness, weakness, and speech

■ **BACKGROUND:** Central post-stroke pain (CPSP) is a central neuropathic pain syndrome secondary to a cerebrovascular accident. CPSP treatment usually begins with medication; however, this is associated with inadequate pain relief and adverse effects. Neurostimulation therapies, including spinal cord stimulation (SCS), have been developed for improved pain relief. We report a patient with thalamic pain who underwent 8-year cervical SCS in an intermittent mode.

■ **CASE DESCRIPTION:** A 71-year-old man presented with left thalamic stroke that caused persistent allodynia and “pricking” sensations at right-side extremities. The pain did not respond well to several pain therapies, including medication, acupuncture, and nerve-blocking anesthesia. Subsequently, the severe and refractory pain caused dystonia in his right hand and seriously hindered recovery and rehabilitation of stroke sequelae. Further, the pain induced depression and severe anxiety mood status and had an effect on his functional activities of life. After SCS device implantation, the patient received intermittent stimulation with 90 minutes on/30 minutes off. A significant decrease in the patient's pain was observed with no serious side effects. After subtle programming of the implantable pulse generator, a significant improvement of his dystonia and affective mood was observed. Intermittent SCS allowed for persistent stimulation for 8 years. Taken together, this intervention allowed for an acceptable improvement of his functional quality of life.

■ **CONCLUSIONS:** Our findings indicate that SCS is safe and efficacious for CPSP, including thalamic stroke pain. Long-term intermittent stimulation can preserve implantable pulse generator battery life and achieve sustained improvement of a patient's pain, movement, and affective mood status.

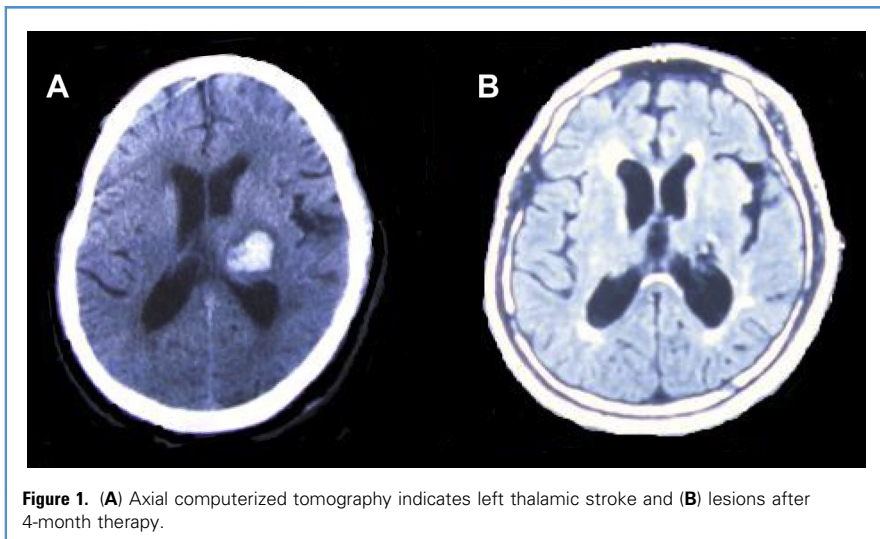


Figure 1. (A) Axial computerized tomography indicates left thalamic stroke and (B) lesions after 4-month therapy.

difficulties. Computed tomography findings revealed thalamic stroke in his left cerebral hemisphere (**Figure 1A**). He had a long history of hypertension and diabetes, which was generally controlled with

medication. While undergoing 4 months of neurotrophic and supportive therapy, the patient gradually regained sensation and motor movement of his right limbs. Computed tomography re-examination

revealed absorption of the hematoma and infarction (**Figure 1B**). Within the subsequent 2 months, he developed allodynia and a persistent pricking sensation at his right-sided extremities, especially the upper one. The patient received several pain therapies, including medication (gabapentin 1.8 g/day), acupuncture, and nerve-blocking anesthesia. However, the pain in his right upper limb was progressive and refractory to several therapies. The severe pain induced dystonia in his right hand, which resulted in difficulty holding and stretching his palm, and seriously impeded his recovery and rehabilitation of stroke sequelae, which affected his daily activities of life. The patient also experienced insomnia, loss of interest or pleasure, social dysfunction light-to-moderate depression, and severe anxiety mood status, which had a detrimental effect on his quality of life. The patient was admitted to our department and recommended MCS; however, the patient refused because of its possible adverse events. Finally, the patient opted for and underwent invasive percutaneous SCS trail stimulation.

Implantation Surgery and Programming

The patient was laid in the prone position, and a 4-contact cylindrical percutaneous lead (Model 3487A; Medtronic, Minneapolis, Minnesota, USA) was implanted under local anesthesia in the right midline of the epidural space; the distal tip reached the C3 vertebral level, which was confirmed by an operative X-ray photography (**Figure 2**). The position of the electrode was intended to produce paresthesia that would fully cover the upper-right extremity.

A 3-day trial stimulation improved the patient's neuropathic pain and right-hand dystonia. The implantable pulse generator (IPG) (Model 7425, Itriel 3; Medtronic) was connected to the electrode. The IPG programming started at 2 days postoperatively with the parameters of 210 μ s, 16 Hz, and 0.45 V for pulse width, frequency, and amplitude, respectively. The patient used the stimulator intermittently with 90 minutes on/30 minutes off. The parameters of the postoperative programming are listed in **Table 1**.

Clinical Measure

We measured the therapeutic effectiveness of the stimulation using the Brief Pain



Figure 2. Anteroposterior X-ray showing the spinal cord stimulation electrode location in the patient.

Table 1. Postoperative Programming of the Patient

Time	Contact	Pulse Width (μ S)	Frequency (Hz)	Amplitude (V)
2 days	2+3–	210	16	0.45
1.5 months	2+3–	210	16	0.45
3 months	2+3–	210	31	0.65
1 year	C+1–	120	45	0.3
	C+1–	90	31	0.75
8 years	C+1–	90	25	0.75

Inventory (BPI) and short form of the McGill pain questionnaire to determine the improvement of the patient's subjective feeling. The short-form of the McGill pain questionnaire subscales include the pain rating index, visual analog scale (VAS), and present pain intensity. We classified the degree of pain relief into 3 categories: good ($\geq 50\%$), fair (30%–49%), and poor ($< 30\%$); the classification was based on the following formula: $\%VAS \text{ reduction} = (VAS_{\text{prestimulation}} - VAS_{\text{poststimulation}} / VAS_{\text{prestimulation}}) \times 100\%$.¹⁶ We used the Hamilton Depression Rating Scale and Hamilton Anxiety Rating Scale to record mood changes. We obtained the baseline scores before neurostimulation and last follow-up values after the 8-year follow-up.

CLINICAL OUTCOMES

We observed symptom improvement after surgery in the patient, before simulator activation. **Table 2** presents the

8-year clinical outcomes. The mean BPI intensity score significantly improved by 44.4% from 9 at baseline to 5 at the 8-year follow-up. The mean BPI interference score slightly improved by 23.3% from 9.86 at baseline to 7.57 at the 8-year follow-up. We observed a 50% VAS reduction during the SCS stimulation period, which indicated good pain relief in the patient. The dystonia in his right hand responded well to stimulation, and there was improvement in his ability to take food with a spoon. Moreover, his depression and anxiety severity, as assessed by the Hamilton Depression Rating Scale and Hamilton Anxiety Rating Scale, respectively, were reduced by 58.6% and 59.1%, respectively. The only device-related adverse effect was the rapid exacerbation of pain after the patient accidentally switched off the IPG. However, the patient's condition stabilized after restarting the stimulator and programming.

Table 2. Summary of the Clinical Outcomes Over Time

Items	Baseline	8-Year Follow-Up
BPI		
Intensity	9	5
Interference	9.86	7.57
SF-MPQ		
PRI	6	4
VAS	10	5
PPI	5	3
HAM-A	29	12
HAM-D	22	9

BPI, Brief Pain Inventory; SF-MPQ, short-form of McGill pain questionnaire; PRI, pain rating index; VAS, visual analog scale; PPI, present pain intensity; HMA-D, Hamilton Depression Rating Scale; HAM-A, Hamilton Anxiety Rating Scale.

DISCUSSION

Several neurostimulation therapies for neuropathic pain relief have been developed to address the refractory nature of CPSP treatment. MCS has been reported to provide pain relief in 50% of patients with CPSP¹⁷; however, peripheral neuropathic pain has been reported to respond better to MCS than CPSP.¹⁸ Moreover, MCS requires a craniotomy, and its use is limited by its invasive nature and requirement of specialized neurosurgical technology.¹⁹ rTMS is a noninvasive technique that targets the cortex (mainly M1). Randomized sham-controlled trials have reported that rTMS has an analgesic effect on neuropathic pain with no serious side effects.^{20,21} The noninvasive nature of rTMS confers an advantage in CPSP treatment; however, its effects are transient, mild, and vary across individuals. DBS, which is also used to treat intractable pain, has efficacy against several pain disorders; however, only a few cases have been reported that used DBS to treat CPSP. A meta-analysis suggested that DBS is more effective for peripheral neuropathic pain than for central pain (51% vs. 31%).¹⁸

SCS, which involves electrical stimulation of the dorsal columns of the spinal cord, is regarded as a minimally invasive technique that is proven effective in relieving neuropathic pain.^{10,11} Simpson et al²² assessed the effectiveness of cervical SCS in 41 patients with either neuropathic or ischemic pain and reported that 68% of the patients experienced 51% pain relief. Aly et al.¹⁰ assessed 9 patients with medically refractory CPSP who underwent SCS targeting the C4–C7 and T9–T12 spinal level for upper and lower limb pain, respectively. After a mean follow-up duration of 28 months, they observed a mean VAS reduction of 42% in all patients.¹⁰ However, the prevalence of CPSP is related to the location of the stroke. The thalamic stroke is commonly associated with higher pain intensities in CPSP compared with other region, and the older age was also associated with low success rate of SCS.²³ In spite of this, our aged patient with thalamic pain had sustained relief after SCS treatment, which further proves its effectiveness. However, few studies on the use of SCS

to treat CPSP have been reported, and they have had small sample sizes. Therefore, the long-term efficacy of SCS on pain relief in patients with CPSP needs further investigation.^{10,24}

SCS has been shown to be favorable in a variety of patients with CPSP¹¹; however, the main drawback of neurostimulation is a decrease in its effectiveness over time. The most common reasons for lack or loss of efficacy over the long-term period are operation or mechanical issues related to the devices; patient-specific changes, such as psychological changes or new injury; and, most importantly, physiologic tolerance or habituation to the treatment.²⁵⁻²⁸ SCS can modulate neural circuits and various neurotransmitters by supraspinal pathways to improve pain, emotions, reward, and other functions in the brain.²⁹ The tolerance to treatment is due to reorganization of the central nervous system plasticity that takes place in neuropathic pain states.¹² Intermittent patterns of stimulation may weaken the effect of stimulus tolerance on clinical outcomes; therefore, we used intermittent stimulation in our patient from the beginning. Our patient had a stable VAS improvement of 50% after 8 years of 16–45 Hz intermittent stimulation with 90 minutes on/30 minutes off. SCS in the intermittent stimulation mode achieved pain relief, conserved the IPG battery, and reduced tolerance to the stimulation in our patient. Wolter and Winkelmüller¹³ showed an equal effectiveness of SCS in the intermittent and continuous stimulation modes. The authors collected 61 patients with refractory pain who underwent SCS and found that the average duration of the full SCS effect was 1 hour, and the average duration of partial effects was 90 minutes. However, further studies are needed to investigate the duration of pain relief after the cessation of stimulation and the effect of different intermittent SCS patterns.

CONCLUSIONS

We demonstrate the efficacy of SCS in a patient with CPSP secondary to thalamic stroke. Long-term pain relief was achieved through stimulation in an intermittent

mode. Neurostimulation significantly improved the patient's affective mood status and movements, which were affected by the severe and refractory pain from his post-thalamic stroke. Moreover, SCS significantly improved the patient's functional quality of life.

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