Short-term cervical spinal cord stimulation for central post-stroke pain: a case report and literature review

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Introduction: Post-stroke central pain is disabling yet ineffectively treated with routine medical intervention. In this study, the authors presented an alternative neuromodulation therapy and conducted a brief narrative literature review to examine current evidence of spinal cord stimulation treatment for central post-stroke pain

Case presentation: Here, the authors reported a case of severe post-stroke syndrome, who achieved satisfactory improvement of pain symptom, as well as muscle rigidity with a novel neuromodulation therapy of short-term implantation of cervical spinal cord stimulation.

Clinical discussion: It remains a great challenge in the management of post-stroke pain, which in turn significantly reduces the quality of life and worsens the burden on the public health system. Spinal cord stimulation therapy is an emerging neuromodulation approach to restore pathological pain status and functional impairment to provide a prospective insight into neuromodulation and rehabilitation options in the management of post-stroke syndrome.

Conclusion: A potential role of spinal cord stimulation in the treatment of post-stroke pain is proposed in combined with traditional medication or other neuromodulation strategies, to achieve better control of pain in the future.

Keywords: case report, cervical spinal cord stimulation, neuromodulation, post-stroke pain

Introduction

Central post-stroke pain (CPSP) is a neuropathic pain complication associated with injury of somatosensory structures after cerebrovascular accidents[1], and is one of the most troublesome sequelae of stroke. In China, the incidence rate of CPSP has been estimated to range from 1 to 18%[2]. The total number of stroke population will keep rising up to 150 million per year by 2025 in Europe[3], of whom about 11–55% may unfortunately develop CPSP, especially for the aged[3–5].

In general, CPSP occurs three to six months following cerebrovascular attack[6], still, latent cases may present with pain symptoms even several years after initial stroke with a minor fraction[7,8]. Clinical manifestation of CPSP includes intractable

HIGHLIGHTS

- We provided our experience of a novel neuromodulation procedure for central post-stroke pain.
- Short-term but not permanent implantation of spinal cord stimulation successfully attenuated a severe case of post-stroke pain.
- We summarized current evidence for the application of spinal cord stimulation treatment for central post-stroke pain.

pain in the affected limb and/or trunk[9], which is characterized by burning, pinpricking, tearing, cutting, and occasionally squeezing or feeling cold[5,10]. As a result, ongoing requirement of pain intervention is essentially needed, and it significantly reduces the quality of life[11].

The current therapeutic method for the management of CPSP remains limited and unsatisfactory, mainly due to its complex and uncertain mechanism[8,12,13]. Despite traditional medication therapy, emerging invasive or non-invasive neuromodulation strategies may offer alternative options for control of CPSP, including motor cortex stimulation, deep brain stimulation, transcranial magnetic stimulation[14,15], and spinal cord stimulation (SCS) reported in this study. Of these, SCS may provide a lasting modulatory effect given its implantable design, as well as a relatively less invasive injury compared with deep brain stimulation.

The purpose of SCS treatment is to interrupt the abnormal nociceptive signal transmission conveyed in the ascending and descending neural pathway, which has proven to be effective in the treatment of failed back surgery syndrome, complex regional

pain syndrome, post-herpetic neuralgia, phantom limb pain, and diabetic peripheral neuropathy. However, it remains controversial about the SCS administration in CPSP, due to limited clinical data and inconsistent consensus about stimulation parameters[16–18]. Here, we report a severe case of CPSP that was effectively attenuated by short-term implantation of cervical SCS, to provide a novel neuromodulation strategy in the management of CPSP. In addition, we aim to evaluate the therapeutic efficacy of neuromodulation by reviewing previous publications of SCS in the field of CPSP[16,19–30].

Case report

History and examination

A 60-year-old female patient presented at our pain clinics in June 2023, complaining of intermittent burning pain related to the left head, face, and upper and lower limbs for three and a half years caused by thalamic haemorrhage of the right hemisphere. The magnetic resonance imaging of the brain confirmed the stroke lesion (Fig. 1).

This patient initially experienced mild and occasional pain, however, suffering a persistent deficiency of functional use of the left side of the body. Functional improvement was then achieved with a following rehabilitation program for several months that she was able to walk with crutches by herself. Unfortunately, pain severity has become worsen in the last 1 year, regarding episodic duration, frequency, as well as pain intensity (8/10, numerical rating scale), ongoing stabbing, burning pain that mainly affects the left upper extremity. Previous medication included non-steroidal anti-inflammatory drugs and gabapentin (0.5 g, Tid) with limited relief of pain. The only way to achieve temporal pain relief was to keep the left side upper extremity in an extension position back and forth. In addition to symptomatic pain, this case presented with decreased muscle strength (grade III) and enhanced muscle tone on the left side of the body.

SCS treatment

Due to unsatisfactory control of pain, the patient was recommended and consented to the neuromodulation therapy of short-term SCS implantation. The patient was placed in a prone position with necessary sedative administration. An eight-contact cylindrical lead (NO.3873, Medtronic Inc) was percutaneously

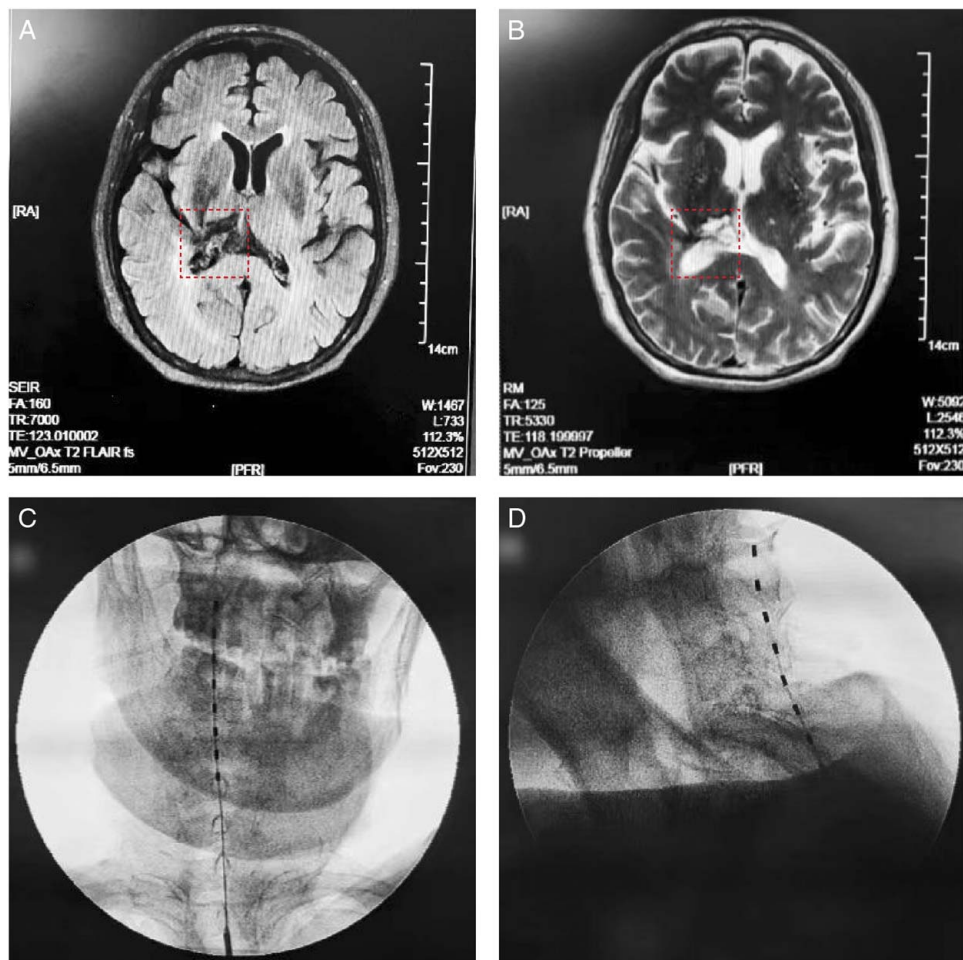**Figure 1.** Image data of the central post-stroke pain patient underwent short-term implantation of cervical SCS. Magnetic resonance imaging of T2 weighted (A) fluid-attenuated inversion recovery and (B) propeller techniques in identification of the lesion site. (C, D) Intraoperative fluoroscopy of anterior-posterior and lateral view for confirmation of the implantable site of SCS. SCS, spinal cord stimulation.

inserted into the epidural space at T5–6 level, and gradually advanced cephalically under fluoroscopic guidance. We aimed to place the top of the stimulation lead approaching the C1 level (Fig. 1) according to the preoperative assessment of painful regions, which should be optimally covered by SCS and confirmed with intraoperative sensory testing. This case reported a sensation of paraesthesia covering the left side of the upper and lower extremity at a frequency of 40 Hz (pulse width: 450 µs).

Clinical outcome

The stimulation programming was adjusted at least twice a day according to the patient-reported pain sensation that was performed by an experienced technician. Postoperative stimulation protocol was set at a 40 Hz frequency with a pulse width ranging between 450 and 500 µs. The initial stimulation voltage was set 2.4 volts and gradually lowered to 0.8 volts before the removal of lead. After SCS implantation, about 75% reduction of pain severity was reported in this case in relation to the upper and lower limbs compared with baseline. However, the patient still suffered moderate to severe craniofacial pain, which cannot be covered by the cervical spinal cord stimulation. As a result, the patient underwent once trigeminal pulsed radiofrequency for the control of craniofacial pain, which achieved significant relief from trigeminal suffering, and only mild and tolerable pain remained. We did not observe any obvious complications in this case. At the last follow-up, the patient still reported significant pain relief in the craniofacial and upper extremities 5 months after discharge. Unfortunately, recurrent and aggressive lower limb pain was reported in the last 2 weeks, and we recommended further rehabilitation and pain management therapy if necessary. Changes in pain severity were assessed with the numerical rating scale (numerical rating scale, shown in Fig. 2). In general, the patient reported satisfactory control of pain symptoms, as well as functional improvement.

Discussion

Here, we report one case who received short-term SCS treatment for CPSP, providing us with an alternative option for multimode management of intractable neuropathic pain syndromes after cerebrovascular attack. Previous reports of permanent SCS implantation are mainly applied in those with thalamic strokes, and about 80% (9 out of 11) of studies examined its validation in haemorrhagic lesions (Table 1). In general, permanent implantation should
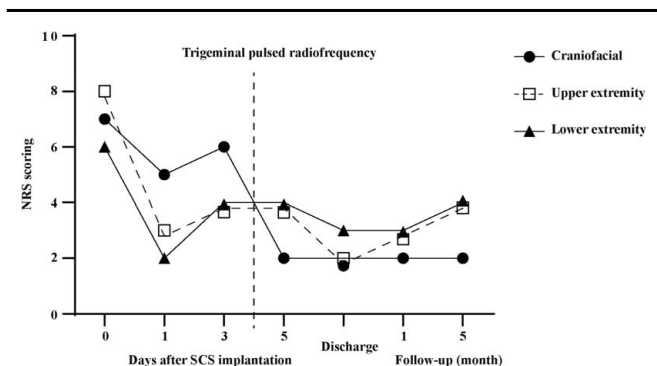
Figure 2. Therapeutic effect of short-term SCS treatment in pain severity. Preoperative and postoperative assessment was conducted according to the painful regions. NRS, numerical rating scale; SCS, spinal cord stimulation.

Table 1

General information and clinical data of enroled researches

Study	Sample size			Sex F/M	Age (years)	Pain duration (months)	Stroke		No. electrodes	Lead position		Follow-up (months)	Clinical outcome pain relief (%)
	All	Trial	IPG				Type	Location		Trial	IPG		
Hosomi et al. (2022)[19]	166	163	106	55/111	63.4 ± 7.9	44.5 (22.8–81.3)	Hemo (127) Inf (38) Co (1)	Thalamus (71) Others (95)	NR	C (67) T (98) L (14)	C (60) T (63) L (4)	24–63	≥30% (63) <30% (43)
Aly et al. (2010)[20]	30	30	10	9/21	65.2 ± 7.3	37.5 (6–156)	Hemo (22) Inf (8)	Thalamus (12) Others (18)	single	C (6) T (24)	NR	6–62	≥30% (7) <30% (3)
Yamamoto et al. (2016)[21]	22	22	19	7/15	61.4 ± 8.0	50.0 (6–168)	Hemo (18) Inf (4)	Thalamus (11) Others (11)	dual	C (13) T (12)	C (12) T (9)	24	≥30% (12) <30% (7)
Tanei et al. (2019)[22]	18	18	12	8/10	63.9 ± 8.5	42.0 (12–168)	Hemo (15) Inf (3)	Thalamus (8) Others (10)	single (2) dual (16)	C (6) T (15) L (1)	C (3) T (10) L (1)	12–100	≥30% (8) <30% (4)
Lopez et al. (2009)[23]	8	8	6	3/5	47.1 ± 14.8	NR	NR	Thalamus (8)	single	NR	NR	36–149	NR
Tanei et al. (2012)[24]	8	8	6	3/5	63.8 ± 6.2	NR	Hemo (7) Inf (1)	Thalamus (3) Others (5)	dual	C (1) T (6) L (1)	T (5) L (1)	NR	≥30%(5) <30% (1)
Yozu et al. (2016)[25]	1	1	NR	M	73	24	Hemo	Thalamus	single	C (1) T (1)	NR	NR	NR
Feierabend et al. (2016)[26]	1	1	1	NR	74	43	Hemo	Thalamus	dual	C	C	6	>80%
Noori et al. (2018)[27]	1	1	1	M	85	6	Inf	Other	single	T	T	6	>60%
Katayama et al. (2001)[16]	45	45	3	M	NR	NR	NR	Thalamus (45)	NR	NR	NR	NR	NR
Tanei et al. (2023)[28]	1	1	1	F	67	108	Hemo	Thalamus	dual	C (1) T (1)	C (1) T (1)	6	NR
Simpson et al. (1991)[29]	60	24	56	26/34	21–74	(3–600)	NR	NR	single (5) dual (11) others (44)	NR	C (25) T (35)	0.5–108	NR
Xu et al. (2020)[30]	1	1	1	M	71	2	Co	Thalamus	single	C	C	96	50%

C, cervical; Co, coexistence; F, female; Hemo, haemorrhage; Inf, infarction; IPG, implantable pulse generator; L, lumbar; M, male; NR, not reported; T, thoracic.

be considered for responders with pain relief of more than 50% treated with percutaneous trial electrodes in our centre, which is consistent with previous findings that pain reduction during the trial period is the strongest predictive factor for long-term successful control of pain. Satisfactory control of symptomatic pain in the upper extremity was achieved in this case; however, the patient and her family refused the secondary procedure of permanent implantation for the potential risk of long-term complication, nursing and cost issues. Overall, this patient still felt very satisfactory about pain control at discharge, the main reason she came to our department for help, and the analgesic effect was enduring up to almost half a year after the removal of the trial lead.

Despite duration, the implantation site is another key factor in SCS procedure, that placement of stimulation lead is designed to be closed to the spinal cord segments corresponding to the painful regions (Table 1), and dual leads may be used for optimal coverage of SCS in some cases with extensive pain suffering[21,22,24,27]. In general, cervical implantation is mostly applied; meanwhile, the therapeutic effect of cervical SCS is more reliable at trial, as well as long-term follow when compared with thoracic and lumbar segments[19].

Neural projection between the high cervical spinal cord and trigeminal nerve system may provide the anatomic fundamentals for the intrathecal drug delivery system in the management of orofacial pain[31–33]. However, severe craniofacial pain was barely attenuated by cervical SCS therapy in this case; thus, we recommended a distinct pattern of neuromodulation by introducing trigeminal ganglion pulsed radiofrequency. Surprisingly, trigeminal ganglion neuromodulation provided effective relief of craniofacial pain by decreasing numerical rating scale from 8 to 2, and the pain relief maintained for over 20 weeks. We speculate that a distinct form of aetiology and functional mechanism between SCS and intrathecal drug delivery system may result in an inconsistency of analgesic effect in patients with craniofacial pain. Recently, we have provided one novel intrathecal strategy to effectively attenuate the intrathecal cancer-related pain by placing the intrathecal into the prepontine cisternal space[34–36], which can subsequently act on the facial pain-related cranial nerves (i.e. trigeminal nerve), and the brain stem structures nearby corresponding to the supraspinal processing of pain signal. Given the circulation of cerebrospinal fluid, we assume that further validation of this intrathecal therapy via prepontine cisternal routine may be considered for the management of CPSP.

In clinical practice, we propose that a multimode analgesic strategy should be highlighted in the management of CPSP, not only aiming to combine distinct interventional methods (i.e. electrical nerve stimulation, radiofrequency, and intrathecal drug delivery pump) but also to cooperate with a multi-disciplinary team consisting of pain physician, rehabilitation therapists, neurologist, and psychologist etc.

Ethical approval

Not applicable.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

X.Z., X.Y., Y.H., and H.Z. contributed all aspects of the manuscript, including acquiring patient consent, literature review, drafting the original manuscript, editing and revision of the final version of manuscript. The final version of this manuscript has been written, read, and approved by all authors. The material has not been published, either whole or in part, and is not under consideration for publication elsewhere.

Conflicts of interest disclosure

Not applicable.

Research registration unique identifying number (UIN)

Name of the registry: not applicable. Unique identifying number or registration ID: not applicable. Hyperlink to your specific registration (must be publicly accessible and will be checked): not applicable.

Guarantor

Haocheng Zhou.

Availability of data and materials

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Provenance and peer review

Not applicable.

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