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Original Article

Retrospective analysis on temporary spinal cord stimulation in the treatment of postherpetic neuralgia

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Abstract: Objective: This study aims to investigate the efficacy, safety and parameter characteristics of temporary spinal cord stimulation (SCS) in treatment of postherpetic neuralgia (PHN). Methods: Twenty-five patients with PHN were enrolled in the trial. All patients were provided with SCS. Changes in pain degree and sleep quality were observed before treatment and at different time points after treatment (the 1st day, 10th day, 1st month, 2nd month and 3rd month). The scores of the short-form McGill pain questionnaire-2 (SF-MPQ-2), Hamilton anxiety (HAMA) and Pittsburgh sleep quality index (PSQI) were used to evaluate treatment efficacy. SCS parameters, such as duty cycle (frequency × pulse width), and frequencies of complications and adverse reactions were recorded. Results: The SF-MPQ-2 and visual analogue scale (VAS) scores of all the patients decreased in the first day after the treatment ($P<0.05$) compared with that at T0. The SF-MPQ-2 and VAS scores significantly decreased at T2, T3, T4 and T5 ($P<0.01$). The HAMA and PSQI scores decreased in the first day after the treatment ($P<0.05$) and significantly decreased at T2, T3, T4 and T5 compared with that at T0 ($P<0.01$). All of the patients required to regulate SCS parameters in the first 3 days. Moreover, 50% and 15% of the patients required regulation on days 4 to 8 and on the last 2 days, respectively. Conclusion: SCS can rapidly alleviate pain. The duty cycle between 0.5% and 13% was confirmed as safe for PHN treatment.

Keywords: Neuropathic pain, postherpetic neuralgia, spinal cord stimulation

Introduction

Postherpetic neuralgia (PHN) is one of the most common types of neuropathic pain (NP) [1]. The development of PHN is contributed by pathophysiological mechanisms, including peripheral and central sensitisation, dysfunction to the nervous system and abnormal effects of somatic nerve and sympathetic nervous system [2]. The clinical features of PHN include persistent severe burning and throbbing pain and lancinating intermittent pain; the latter is described as sharp, shooting or electric shock-like sensation and accompanied with paresthesia, hyperalgesia and dysesthesias [3, 4]. PHN can last for a long time after the rash heals and significantly affects individuals and their families; PHN may lead to social withdrawal, depression, physical disability and interference with daily activities [3].

Treatment of PHN remains challenging. Pregabalin, nerve block and pulsed radiofrequency are used as first-line treatment in clinical practice. Although these methods have been devoted with adequate and reasonable efforts, a proportion of people with PHN fail to obtain pain relief. For this condition, spinal cord stimulation (SCS) is considered a pain management therapy after conventional therapies, including pharmacological and nonpharmacological techniques, to alleviate pain; surgical treatments have also been attempted but failed to provide satisfactory outcomes [5]. SCS devices stimulate nerves by modulating abnormal neural activity caused by a disease or injury [6]. Temporary electrodes have a large market in China, but permanent placement is hindered by economic condition. Researchers explored the effectiveness of temporary SCS and its program control parameters, especially the duty

Table 1. Baseline characteristics of 25 patients with postherpetic neuralgia (PHN) pain

Number	Age (y)	Sex	Comorbidity	Coursed (m)	Involved level	Burning pain	Stabbng pain	Allodynia	Itch	Anesthe-sia	VAS (cm)
1	59	F	b	6	T4-6R	+		+			8
2	64	f	a	7	C4-7L	+		+			8
3	85	f	abc	14	C4-6L	+	+	+			9
4	65	m	abd	3.5	T9-12L	+	+	+	+		10
5	62	f	b	6	T4-7L		+	+			8
6	91	m	abc	3	T4-7R	+	+	+			9
7	67	f	ab	5	C4-6L		+	+		+	8
8	85	f	ac	3.5	C6-T1R	+		+			7
9	70	f	bcd	4.25	L2-S1R	+		+			9
10	78	f	bcd	3.25	T5-9L	+		+			8
11	87	f	abc	4.5	T9-12L	+	+	+			7
12	59	f	a	5.25	T2-5R	+	+	+			9
13	58	m	a	3	T1-4R	+	+	+			8
14*	63	m	b	3	C3-5L	+		+			7
15	78	m	bc	3.5	L5-S1L	+		+			8
16	69	f	c	3	T2-5R	+		+			10
17	72	f	a	3.5	T11-12R	+	+	+			10
18	69	f	ac	3.5	T9-12L		+	+			8
19	62	m	bd	3.5	C7-T1L	+	+	+			9
20	59	m	b	5.5	T2-5R	+	+	+			8
21	66	m	c	4	L5-S1L	+	+	+			7
22	72	m	c	6	T4-7R	+		+			8
23	67	f	d	4	T2-5R	+		+			7
24	70	m	c	3	T9-12L	+	+	+			9
25	65	f	a	4	L5-S1R		+	+			8

Note: m, male; f, female; a, cardiovascular; b, diabetes; c, osteoporosis; d, asthma; L, left; R, right. *Electrode came off.

cycle (frequency × pulse width) [7]. The mechanism of traditional SCS in inducing NP relief is the production of paresthesia-replaced pain, which can be successfully measured by the extent of paresthesia-pain overlap [8]. Despite the proven benefits of standard SCS, up to 30% of patients with PHN fail to experience relief [9]. Pre-clinical studies reported that 10 kHz SCS can provide substantial pain reduction in NP with difficulty to treat, but reporting on specific parameter settings for stimulation (dose strategies frequency and pulse width) is insufficiency [10, 11]. This retrospective analysis aims to determine the clinical efficacy of temporary SCS in treatment of PHN. We will also evaluate the 'therapeutic dose' of the duty cycle to provide a new and ideal tool for PHN treatment. In traditional SCS, the electrodes are placed on the anatomical midline of the dorsal column, but recent studies demonstrated that high-frequency stimulation near the dorsal root or dorsal root entry zone [11]. The objective of this study was to assess the effectiveness of the more comfortable medical treatment with optimum parameter adjustment and more suitable location of SCS. The proposed technique will enhance quality of life and increase the participation of patients in daily activities.

Materials and methods

General information

This study has been approved by the ethics committee of Qingdao Municipal Hospital. All patients voluntarily joined this study and provided informed consents. We retrospectively analysed 52 patients diagnosed with PHN in Qingdao Municipal Hospital between December of 2014 and March of 2016 (**Table 1**). Finally, 25 patients were selected for the stud by using

the following inclusion criteria: patients with visual analogue scale (VAS) score higher than seven points; patients with normal function of the heart, lung, liver and kidney; nonpregnant patients; and patients without cancer. The patients were prescribed with 150 mg of pregabalin bid orally for a week. The patients were normalised but still failed to experience relief.

Treatment

Temporary electrode (eight contacts) were selected according to the characteristic distribution of the somatic ganglia. Spinal cord stimulators (model 3861, Medtronic) were placed in the posterior epidural space closer to the dorsal root entry zone (DREZ) through an epidural needle placement. The third and fourth electrodes were placed in the most painful ganglion segment. External stimulator (Medtronic 3625) was attached to the temporary electrode. An electrical current from the electrodes induced paresthesia or a tingling sensation that masks the pain. The position of the electrode was determined when the patients showed concordant stimulation over usual pain distribution. The parameters for external stimulator included pulse width of 60-80 μs, frequency of 60-80 Hz and amplitude of 0.8-3.2 V. When the patient feels no obvious discomfort, the Tuohy needle was removed and the electrode wire was attached to the skin. We adjusted the parameters for 10 days according to the abnormal feeling of the patient. The test stimulation was completed within 10 days, and patients who obtained at least 50% pain relief during this period were considered to experience satisfactory treatment outcome. We removed the temporary electrode after 10 days.

Observation index

Before the trial of temporary electrode im-plantation, the patients were asked to report their pain and sleep quality by using short-form McGill pain questionnaire-2 (SF-MPQ-2), VAS, HAMA and Pittsburgh sleep quality index (PSQI). The scores of SF-MPQ-2, VAS, HAMA and PSQI were recorded on the 1st day of stimulation and after 10 days, 1 month, 2 months and 3 months of the treatment. The SF-MPQ-2 includes 22 items, each representing a different quality of pain or related symptoms as follows: 1) continuous pain descriptors (six items): throbbing pain, cramping pain, gnawing pain, aching pain, heavy pain and tender; 2) intermittent pain descriptors (six items): shooting pain, stabbing pain, sharp pain, splitting pain, electric-shock pain and piercing; 3) predominantly neuropathic pain descriptors (six items): hot-burning pain, cold-freezing pain, pain caused by light touch, itching, tingling or pin- and needle-like pain and numbness; and 4) affective descriptors (four items): tiring exhausting, sickening, fearful and cruel punishing. Each item was rated based on a 0-10 scale, with 0 equal to no pain and 10 equal to the worst pain during the past week. The total score was calculated as the mean of all 22 items. PSQI is a scale consisting of 19 questions and seven components to evaluate subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction. Each item was scored with zero to three points. The total of the seven components indicated the total PSQI score points. The overall score ranged from 0 to 21, and low scores denote healthy sleep quality.

Complications

Complications, such as cerebrospinal fluid leakage, pain, seroma, lead migration and hardware failure and infection, were observed after placing the spinal cord stimulators. Complications that occur must be dealt contemporaneously.

Statistical analysis

All the measurements, including SF-MPQ-2, VAS, HAMA and PSQI scores provided by the patients, were scored and statistically analysed by Statistical Package for Social Sciences 16 (SPSS16.0) statistical software.All variables were expressed as mean ± SEM. Comparisons of variables were performed using two-tailed paired t-test. A *P*-value less than 5% was considered to be statistically difference and less than 1% was considered to be statistically significant difference.

Results

Baseline characteristics of patients

The 25 patients aged 50-92, 15 women and 10 men, were treated between December of 2014 and March of 2016. The pain areas were unilat-

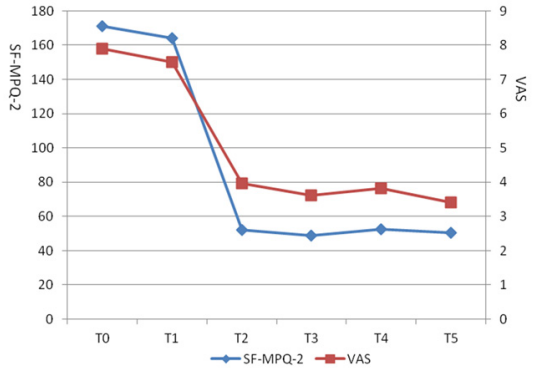

Figure 1. Changes in visual analogue score (VAS) and short-form McGill pain questionnaire-2 (SF-MPQ-2) scores compared with the baseline ($\bar{X}$ ± *SD*, *n*=25). The SF-MPQ-2 scores and VAS of all the patients decreased on the first day after the treatment (*P*<0.05) and significantly decreased at T2, T3, T4 and T5 (*P*<0.01) compared with that in preoperation (T0).

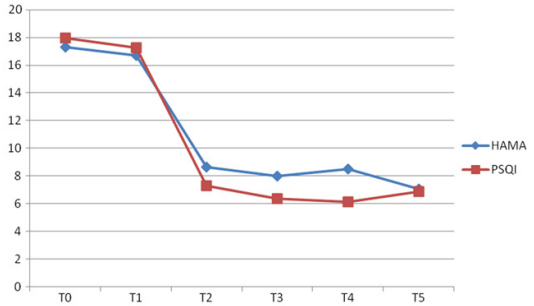

Figure 2. Changes in Hamilton anxiety (HAMA) and Pittsburgh sleep quality index (PSQI) score compared with the baseline ($\bar{X}$ ± *SD*, *n*=25). The HAMA scores and PSQI decreased after the operation (*P*<0.05). Furthermore, these scores decreased significantly at T2, T3, T4 and T5 compared with that in preoperation (T0) (*P*<0.01).

eral nerve involvement and distributed in the neck, upper limb, chest, lumbar spinal cord, and lower limbs. Duration of disease mostly during a 3-14 months: 23 cases were reported to lasted from 3 months to 6 months, one case was reported to lasted 7 months, one case was reported to lasted 14 months. The VAS scores preoperatively were all up to 7.0. The characteristics of the patients are presented in **Table 1**.

SF-MPQ-2 and VAS score

The SF-MPQ-2 scores of all the patients decreased on the first day after the treatment (*P*<0.05) and significantly decreased at T2, T3, T4 and T5 (*P*<0.01) compared with that in preoperation (T0). After 3 months, the score was only 50.4±13.14. The VAS of all the patients decreased from (7.9±0.72) to (7.5±0.32) on the first day after the treatment (*P*<0.05) and significantly decreased at T2, T3, T4 and T5 (*P*<0.01). After 3 months, the VAS score was only (3.4±0.76) (**Figure 1**).

HAMA and PSQI score

The HAMA scores were 17.32±0.93 before the treatment and 16.72±0.067 day after the operation (*P*<0.05). After 3 months, the score decreased to 7.08±2.53 (*P*<0.01). The PSQI also decreased from 17.96±1.46 to 6.88±1.39 (*P*<0.05) at the last observation (post-treatment 3-month). Furthermore, the score decreased significantly at T2, T3, T4 and T5 compared with that at preoperation (T0) (*P*<0.01) (**Figure 2**).

Regulation of SCS

The electrode came off in one patient only on the 6th day; the patient received pulsed radiofrequency treatment thereafter. The rate of electrode prolapse was 4%. The rate of the adjusting on the first 3 days was 100%. All patients required to regulate the SCS parameters (pulse width, frequency and voltage) on the first 3 days. The rate of the adjusting on the first day was found to be the highest (90%). From days 4 to 8, 50% of the patients required regulation. On the last 2 days, only 15% of the patients required regulation. SCS was adjusted all days on the first 3 days. After 3 days, this result was observed in the daytime. Four patients required five to six times of regulated treatment on the first 3 days in the daytime. The regulated times of these patients in the daytime are higher than those in the nighttime. The duty cycle ranged from 0.5% to 13%. The relatively high duty cycle was found to be 24%; of which, 67% was observed in patients whose PHN occurred in the neck or shoulder. The duty cycle between 12% and 13% was applied in two patients with leg ministry PHN. No limb weakness and numbness were detected in all the patients (**Table 2**).

Complications

No complications, such as cerebrospinal fluid leakage, pain, seroma, lead migration, hardware failure and infection, were detected in all patients.

Table 2. Spinal cord stimulation (SCS) treatment and pain characteristics of 25 postherpetic neuralgia (PHN) (*n*=25)

Number	VAS (cm) Visual analog scale			Treatment parameter	
	Baseline score	Test period	Last SCS follow-up	Amplitude (Voltage)	Pulse Width × Frequency (duty cycle)
1 (T4-6R)	8	2	1-3	2.5-5	0.78%-2.0%
2 (C4-7L)*	8	2	1	0.5-0.9	7.2%-7.5%
3 (C4-6L)	9	1	1-3	1-3	0.9%-2.2%
4 (T9-12L)	10	3	2-4	1.5-5	0.6%-2.5%
5 (T4-7L)	8	1	0-1	2.5-5.5	0.5%-2.0%
6 (T4-7R)	9	2	0-2	2-6	0.6%-2.5%
7 (C4-6R)*	8	2	0-1	0.5-1.0	7.2%-7.5%
8 (C6-T1R)	7	2	2-4	1-2	0.5%-2.0%
9 (L2-S1R)*	9	2	1-3	1.0-1.2	12%-13%
10 (T5-9L)	8	3	2-4	3-5	1.2%-2.0%
11 (T9-12L)	7	2	0-1	3-5	1.2%-2.0%
12 (T2-5R)	9	3	2-4	2-4	2.0%-2.5%
13 (T1-4R)	8	1	1-2	1.5-5	1.2%-2.5%
14 (C3-5L)*	7	1	0-1	0.5-1.2	7.2%-7.5%
15 (L5-S1L)*	8	2	2-3	0.6-1.0	12%-13%
16 (T2-5R)	10	1	0-1	1-5	1.2%-2%
17 (T11-12R)	10	2	0-1	2-6	2.0%-2.5%
18 (T9-12L)	8	1	1-3	1-5	1.5%-2.5%
19 (C7-T1L)*	9	3	1-2	0.7-1.2	7.2%-7.5%
20 (T2-5R)	8	3	2-4	2-5	2.0%-2.5%
21 (L5-S1L)	7	4	1-3	3-6	1.2%-2.5%
22 (T4-7R)	8	4	1-2	1-5	0.9%-2.0%
23 (T2-5R)	7	4	2-4	2-3	0.9%-2.0%
24 (T9-12L)	9	3	2-3	3-5	1.2%-2.5%
25 (L5-S1R)	8	4	0-1	3-6	2.0%-2.5%

Discussion

PHN is an important neurological complication of herpes zoster or shingles [1]. The etiology of PHN is complex. Varicella zoster virus establishes latent infection mainly in the dorsal root ganglia and dermatome supplied by the sensory nerve; the infection inhibits transmission in ascending spinal pathways and transfers excessive excitatory signal into the central nervous system. The peripheral receptors are then activated by sympathetic efferent fibers, thereby increasing the activated excitability of the primary afferents [3, 8, 9]. Fabian found that PHN is caused by neurogenic inflammatory damage and demyelination in nerve fibers of the spinal cord foot [12]. As such, PHN is often refractory to treatment and can last for years. In the present study, all patients received routine medication treatment, which did not relieve their pain. The proposed temporarily SCS treatment relieved the pain intensity, anxiety and depression and improved the sleep quality of the patients. The analgesic effect gradually stabilized after 1 week, and persisted 3 months after the surgery. This result is consistent with those reported in domestic and foreign studies.

SCS, which was developed in 1967 [13], can effectively reduce pain associated with PHN. The mechanism of SCS in PHN treatment may be multifactorial; analgesia may be due to reduced pain sensation, and the downregulation of sympathetic activity improved blood circulation and oxygen supply [6, 14]. Scholars reported that pain relief by SCS could be due to large diameter fibers (A-mechanoreceptors); these fibers activated signaling neurons in the central nervous system by electrical stimulation, leading to increased pain intensity caused by low-threshold of mechanoreceptors [15]. SCS can enhance the release of γ-aminobutyric acid, decrease the release of excitatory amino acids, such as glutamic and aspartic acid in the dorsal horn, inhibit the tactile-evoked allodynia and promote the release of endogenous analgesic substances [16, 17]. The therapeutic effect of SCS is influenced by the different placements of the electrode, the type of stimulation electrode and the adjustment of program stimulation parameters (pulse width, frequency and amplitude) [18]. In traditional SCS, the electrodes are placed on the anatomical midline of the dorsal column to relieve pain transmission [18]. This method can expand the scope of paresthesia to patients with PHN. Usually, PHN often violated the uni-

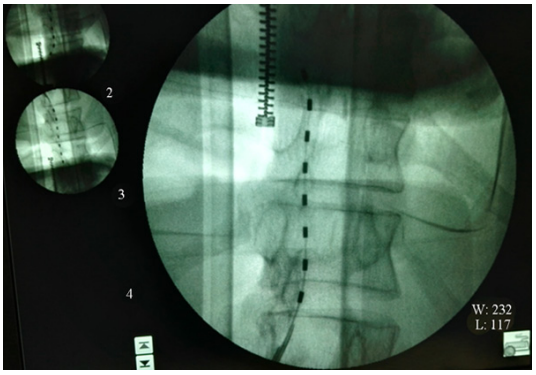

Figure 3. Position of the SCS in the posterior epidural space closer to the dorsal root entry zone (DREZ). The lead with the elec-trodes was visualized in the left of T11-12 X-ray images.

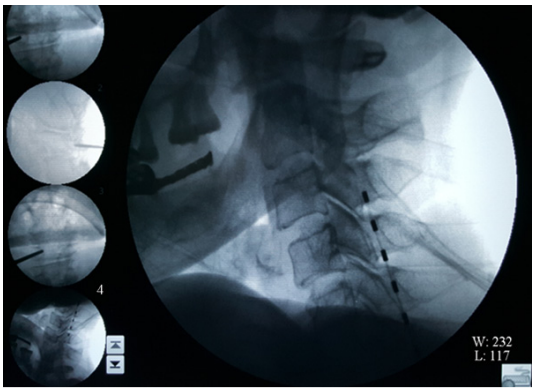

Figure 4. Position of the SCS in the posterior epidural space closer to the dorsal root entry zone (DREZ). The lead with the elec-trodes was visualized in the left of lateral X-ray images (C3-5).

lateral ganglion [9, 19]. In the present study, the electrodes were placed into the epidural lateral space in the affected side, and proximal contacts were located in the dorsal root entry zone (DREZ) (**Figures 3**-**5**). The results showed that temporary SCS can induce the numbness of the lesion area without affecting the contralateral sensation.

On the first 3 days after the treatment, all patients needed to repeatedly adjust the stimulation parameters including the position of the electrode, pulse width, frequency and amplitude. Up to 90% of the patients needed to adjust the parameters to achieved adequate analgesia on the first day. After 4 to 8 days of operation, only 50% of the patients required to adjust the parameter settings including pulse width, frequency and amplitude. After 9 to

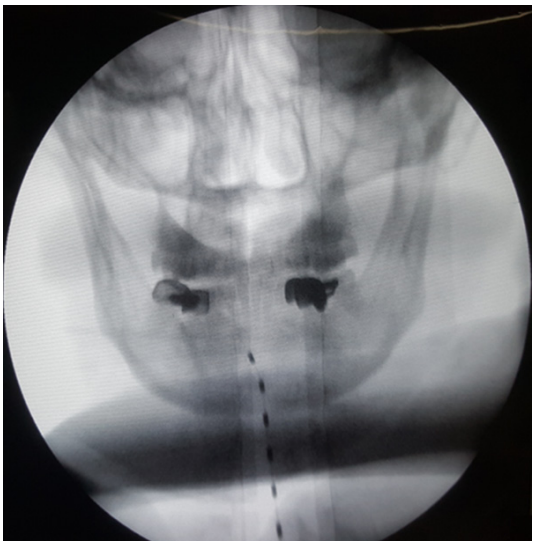

Figure 5. Position of the SCS in the posterior epidural space closer to the dorsal root entry zone (DREZ). The lead with the elec-trodes was visualized in the left of C3-5 X-ray images.

10 days of operation, only 15% of the patients required to adjust the parameters setting (pulse width, frequency and amplitude) (**Table 3**). This finding could be due to the position-adaptive period experienced by the patient; in this period, the position of the electrode in the epidural space can be easily changed in the early days. The cervical spinal segment is the most frequent part of parameter adjustment, whereas parameters are less frequently adjusted in the waist area. This finding may be related to the following two points: 1) stimulation would be perceived differently at various spinal levels due to segmental changes in the size of the spinal cord and cerebral spinal fluid layers; and 2) electrode in the neck is relatively close to the dorsal column. Changes in the subtle position will provide patients with great sensation change. The adjusted number of stimulation parameters decreased after 3 days, and the adjustment was frequent at day and less during the night. Hence, the requirements of analgesia of individual patients were satisfied with the electrode position on the DREZ.

With the development of neural regulation, duty cycle has been widely used in clinical practice. Duty cycle represents 'the charge second' and is a combination of frequency and pulse width [7]. Duty cycle can be increased by increasing the frequency, increasing the pulse

Table 3. Spinal cord stimulation (SCS) treatment and pain characteristics of 25 postherpetic neuralgia (PHN) (*n*=25) (continous)

Number	Regulated time (Times/Day)								
	1 (Day/Night)	2 (Day/Night)	3 (Day/Night)	4 (Day/Night)	5 (Day/Night)	6 (Day/Night)	7 (Day/Night)	8 (Day/Night)	9 (Day/Night)
1 (T4-6R)	4/3	3/1	3/0	2/0	1/0	1/1	1/0	1/0	0/0
2 (C4-7L)*	0/0	2/1	1/0	0/0	1/0	0/0	0/0	0/0	1/0
3 (C4-6L)	0/0	2/1	1/0	0/0	0/0	0/1	1/0	1/0	0/0
4 (T9-12L)	5/1	3/2	3/1	2/1	2/0	2/0	1/0	1/0	0/0
5 (T4-7L)	5/2	6/3	5/3	3/2	3/1	3/1	3/1	1/1	0/0
6 (T4-7R)	4/2	3/4	5/4	2/2	2/1	1/0	0/1	1/0	0/0
7 (C4-6R)*	0/1	0/1	1/0	0/0	0/0	0/0	0/0	0/1	0/0
8 (C6-T1R)	2/1	1/1	1/0	3/2	2/1	2/2	1/0	0/0	1/0
9 (L2-S1R)*	5/1	5/2	4/1	4/1	3/2	0/1	0/0	0/0	1/0
10 (T5-9L)	4/1	5/3	5/2	4/2	4/2	4/1	3/1	1/0	0/0
11 (T9-12L)	4/0	4/2	4/0	3/1	3/0	1/0	0/0	0/0	0/0
12 (T2-5R)	5/0	5/3	6/0	2/0	4/0	3/1	2/0	1/0	0/0
13 (T1-4R)	4/1	3/2	3/0	3/0	2/0	1/0	1/0	1/0	0/0
14 (C3-5L)*	0/1	0/1	1/1	1/1	2/1	0/1	Electrode pole come off		
15 (L5-S1L)*	5/0	5/1	3/2	3/1	4/2	3/0	2/0	0/0	2/0
16 (T2-5R)	6/0	6/0	5/0	5/2	2/0	2/0	1/1	3/2	0/0
17 (T11-12R)	4/0	4/1	3/1	2/0	0/0	0/0	1/0	0/0	0/0
18 (T9-12L)	4/1	3/1	3/0	3/0	2/0	2/0	0/0	0/0	0/0
19 (C7-T1L)*	0/0	0/1	0/0	2/0	2/0	1/0	2/0	0/0	0/0
20 (T2-5R)	4/1	5/2	5/1	3/1	3/2	3/3	2/0	1/0	0/0
21 (L5-S1L)	0/3	1/2	1/1	1/1	0/0	3/0	3/2	1/0	0/0
22 (T4-7R)	0/1	0/3	2/1	1/0	1/0	0/0	0/0	1/0	0/0
23 (T2-5R)	0/1	0/0	1/0	1/0	1/1	0/0	0/0	0/0	0/0
24 (T9-12L)	4/2	4/2	5/1	3/0	3/2	1/1	2/1	1/0	0/0
25 (L5-S1R)	3/2	3/2	3/2	2/1	2/1	2/1	1/1	1/0	0/0

Note: *Duty cycle >7.2%.

width or the combinations of both [7]. This strategy will allow large amounts of energy to be delivered to neural tissues with less paresthesia generated from high amplitude and pulse width [17, 20]. In the present study, we used low amplitude but employed high 'duty cycle' (almost high frequency) to increase the charge delivery and avoid uncomfortable sensation caused by the increasing amplitude. Moreover, different frequencies enable different rates of release of endogenous substances. For example, low-frequency stimulation can increase the levels of enkephalin and endorphins in cerebrospinal fluid; high-frequency stimulation can increase the level of spinal dynorphin, which elicits the endogenous analgesic effect [21]. In the present study, low and high duty cycle exerted effective analgesic effect; that is, the low 'duty cycle' provided absolute further pain reduction at 0.5%-2.5%, and the high duty cycle provided satisfactory pain relief at 7.2%-7.5%. The maximum duty cycle reached 12%-13%. The VAS and SF-MPQ-2 scores significantly decreased after the electrode implantation ($P<0.05$) and at 10 days, 1 month, 2 months and 3 months ($P<0.01$) after the operation. The patients experienced a significant reduction in VAS value and satisfactory treatment effect compared with the baseline. In four patients with high duty cycle (relatively high frequency but not the high pulse width), the optimal analgesic effect was observed. This result may be related to the following: placement of the electrode near the midline epidural space of the spinal cord, leading to excessive stimulation with wide width pulse; or the high frequency might provide a comfortable feeling.

In summary, SCS therapy can significantly improve the quality of life and sleep of patients. SCS (duty cycle from 0.7% to 13%) is considered effective and safe for PHN therapy. This strategy quantifies the energy value of SCS in treatment of Chinese patients with PHN. This retrospective study exhibits major limitations.

Long-term follow-up was not included in the analysis, and bias may occur because of small sample size. Multidisciplinary input and prolonged follow-up are needed for treating the patients. Further studies must employ a large sample size to identify the pathophysiological mechanisms of SCS.

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Disclosure of conflict of interest

None

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