Available online at www.sciencedirect.com
ScienceDirect
European Journal of Pain 12 (2008) 53–59
www.EuropeanJournalPain.com

Spinal cord stimulation in adolescents with complex regional pain syndrome type I (CRPS-I)

Gunnar L. Olsson [a,*], Björn A. Meyerson [b], Bengt Linderoth [b]

[a] *Pain Treatment Unit, Astrid Lindgren Children's Hospital, 17176, Stockholm, Sweden*
[b] *Department of Neurosurgery, Karolinska University Hospital, Stockholm, Sweden*

Received 12 August 2006; received in revised form 26 February 2007; accepted 26 February 2007
Available online 21 September 2007

Abstract

Complex regional pain syndrome type I (CRPS-I) is not uncommon in children, particularly in adolescent girls. Most often, the condition involves a foot and is characterized by spontaneous pain, tactile allodynia and dysautonomic signs. There is usually a history of a minor, local trauma but sometimes no reasonable cause can be identified, and there are no signs of persistent tissue injury giving rise to ongoing nociception.

Common analgesics are generally of no benefit, and the standard treatment includes sociopsychological support, physiotherapy, tricyclic antidepressants and antiepileptic drugs, sympathetic blocks (SB), and cognitive-behavioural therapy. For a minority of patients who prove to be resistant to such therapies, spinal cord stimulation (SCS) may be tried.

The present study comprises seven girls, 11–14 years of age, presenting with severe, incapacitating and therapy-resistant CRPS-I, who were subjected to SCS. In two of them, percutaneous electrode implantation had to be performed in general anaesthesia. Trial stimulation was performed in all, but one. In two cases, it was not possible to produce paraesthesias that entirely covered the pain area. A pain relieving effect of SCS was usually not reported until after 1–2 weeks of trial stimulation. After another 2–6 weeks, pain alleviation was complete in five of the seven patients, one to eight years after the intervention. In one case, a local infection necessitated the removal of the electrode; nevertheless a few days of trial stimulation produced substantial pain relief that still persists. In four patients, the SCS use was gradually diminished and eventually the device could be removed.

The favourable outcome in all seven cases with no or minor remaining symptoms and without severe recurrences illustrates that SCS may also be an efficient treatment in paediatric cases with exceptionally therapy resistant forms of CRPS I.

Keywords: Complex regional pain syndrome; Spinal cord stimulation; Pain in children and adolescents; Sympathetic block; Neuropathic pain

1. Introduction

Complex regional pain syndrome type I (CRPS-I) is not uncommon in children and adolescents, especially in girls in the age range of 11–14 years (cf. Barbier et al., 1999). Commonly the pain is confined to the foot and lower limb (Olsson et al., 1990; Wilder et al., 1992; Sherry et al., 1999). The pain often originates from a minor trauma but sometimes no precipitating cause can be identified. Treatment includes active movements and physical therapy (Sherry et al., 1999), drugs such as amitriptyline (Wilder et al., 1992) and gabapentin, psychological therapy including cognitive behaviour therapy (Lee et al., 2002) and sympathetic blocks (Olsson et al., 1990; Wilder et al., 1992; Irazuzta et al., 1992). Randomized controlled trials of therapies for CRPS-I

* Corresponding author. Tel.: +46 8 5177 7270.
E-mail address: gunnar.olsson@karolinska.se (G.L. Olsson).

1090-3801/$32
doi:10.1016/j.ejpain.2007.02.007

(previously referred to as reflex sympathetic dystrophy) have only been performed in adults (review, see Forouzanfar et al., 2002). In cases resistant to all conventional treatments, spinal cord stimulation (SCS) has become an established therapy (e.g., Kemler et al., 2004; Grabow et al., 2003; Turner et al., 2004; Bennett and Brookoff, 2006). In seven adolescent girls presenting with severely incapacitating signs of typical, otherwise therapy-resistant CRPS-I, we have applied SCS therapy. This has to our knowledge, not previously been reported and the aim of this report is to provide evidence that CRPS-I both in children and adolescents may be amenable to treatment with SCS.

2. Methods

This is a retrospective case study reporting on seven girls 11–14 years of age with CRPS-I treated with SCS. They were referred to the Pain Treatment Unit at Astrid Lindgren Children's Hospital, Stockholm. Annually, about 10–15 children presenting with a CRPS-I diagnosis are referred to this unit. The cases reported here were consecutively selected in the period 1994–2004 for SCS, because they had all failed to respond to preceding intensive treatment trials. They had been extensively investigated at their local hospitals before referral. Investigations included blood screening for inflammatory disease, X-ray and MRI, but less often scintigraphy. A few cases had also been subjected to neurography. All tests had been negative and there was no need for further investigations in our unit. Treatments before SCS including physiotherapy and analgesics, often also amitriptyline, had been tried without success. All had received sympathetic blocks (SB) in the form of intravenous regional guanethidine (see Table 1). The clinical diagnosis CRPS-I was confirmed and all cases were seen by the paediatric psychiatrist in our team. Also, after beginning of SCS physiotherapy was continued. Before SCS, the patients together with their parents had been seen frequently at the unit by one of us (GO). After SCS surgery and during follow-up, GO and the neurosurgeon (BM or BL) examined and interviewed all patients.

Outcome measures included: spontaneous pain, evoked pain (allodynia), ability to bear weight, pain at bearing weight, dysautonomic signs, sensitivity to cold, analgesic consumption, and school attendance. A final follow-up interview by telephone was performed by GO in all cases in the spring of 2006 (see Table 2).

Table 1
Seven cases of spinal cord stimulation in girls with CRPS-I

Case	1	2	3	4	5	6	7
Age, years	13	12	14	14	14	11	13
Localisation	Foot	Hand	Knee	Knees	Foot	Foot	Foot
Trauma	Minor	Minor	No	No	No	Yes	Minor
Motor dysfunction	Minor	None	Major	Major	Major	Major	Minor
Sympathetic blocks	5	10	2	2	5	2	4
Effects of blocks	No	+/−	No	No	+/−	No	No
Interval to SCS	9 m	16 m	14 m	26 m	14 m	12 m	14 m
Duration of SCS	45 m	21 d	36 m	48 m+	7 m	3 m	4 m
Effect of SCS	c	c	p	c	p	c	c

c = complete, p = partial

Table 2
Follow-up March and May 2006 by telephone interview

Case	1	2	3	4	5	6	7
Time since SCS implantation/removal, years	12/8	10/10	6/2	6+	5/3	4/3 y	1+
Ongoing pain, VAS	0	0	0	0	0	0	0
Evoked pain, pain on bearing weight	No	No	No	Yes	No	No	No
Allodynia	No	No	No	No	No	Yes*	No
Dysautonomy	No	Yes*	No	No	Yes*	No	No
Other sensory disturbance	No	Yes*	0	No	No	Yes*	No
School/work absence	No	No	No	No	No	No	Yes*
Can you participate in sports	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Taking drugs	No	No	No	No	No	No	No
Periods of recurrences	No	No	(Yes)*	Yes*	Yes*	No	No
If recurrence of same pain:							
Would you have SCS again	Yes	Yes	No*	Yes	No*	Cannot tell	?
Would you recommend it for a close friend	Yes	Yes	Yes	Yes	Yes	Cannot tell	

* See text.

3. Surgical technique

A prerequisite for a positive effect of SCS is that paraesthesias can be elicited in the affected area. Therefore, it is preferred that the patient is awake during the procedure of positioning the electrode in the epidural space in order to enable test stimulation. This was accomplished in six of our patients. The 11-year-old girl (case 7) was exceptionally pain sensitive and it was not even possible to insert an i.v. line for anaesthesia with pre-treatment with xylocaine ointment (EMLA, ASTRA-Zeneca, Sweden). Thus, all interventions in this girl had to be performed under inhalation anaesthesia.

In all cases, quadripolar lead electrodes (Medronic Pisces® Quad Standard) were initially used. Because of difficulty producing adequate paraesthesia distribution in two of the patients, a laminotomy, plate electrode (Medtronic Resume®) was implanted instead. In all the cases except one, trial stimulation with a temporary percutaneous extension was performed during about two weeks before the permanent implantation of the pulse generator. Stimulation frequency was 50–60 Hz, whereas amplitude and pulse duration (250–450 μsec) were set to produce optimal paraesthesia coverage of the painful area.

4. Cases reports

4.1. Case 1

Born 1980. CRPS started after two minor trauma to the left foot in 1993. There was no beneficial effect of physiotherapy, several local anaesthetic blocks, four sympathetic blocks, transcutaneous electric stimulation (TENS), psychiatric consultations, explorative surgery, analgesics, and amitriptyline. The patient presented with a very prominent allodynia. At the age of 13 years, a percutaneous SCS electrode was inserted, with the patient awake in a sitting position. Trial stimulation for about 10 days provided partial pain relief and a permanent SCS system was implanted. Gradually, the spontaneous as well as the evoked pain were suppressed and the dysautonomic signs subsided. She used the stimulation daily, but less and less. After 45 months, she was still pain-free without the SCS and the device was removed. At follow-up in March 2006, she had no pain problems.

4.2. Case 2

Born 1984. CRPS-I developed after a biking accident in 1996 leading to skin abrasion of the volar part of the hand. A first SB was performed 24 days after the trauma and a total of 10 SBs were given from 1996 to 1998. The pain-free period after each SB varied from days to several months. On four occasions, the SB provided no pain relief. All pharmacological therapies failed (NSAIDs, morphine, adenosine, ketamine, amitriptyline, gabapentin). In 1998, a percutaneous SCS electrode was implanted and after a few days of trial stimulation, she was pain-free. She was scheduled for a permanent system but a local subcutaneous infection necessitated removal of the electrode. Pain recurred seven months later. A SB gave no pain relief and she was scheduled for a new SCS in 1999. However, at that time the pain had resolved spontaneously and she has had no further recurrences. At follow-up in March 2006, she had no pain but occasionally she experiences some swelling of the hand and arm, which, however, is not associated with pain.

4.3. Case 3

Born 1985. The patient was referred to the unit because of diffuse musculo-skeletal pain in 1999. Soon thereafter, she suffered a minor trauma while playing soccer and subsequently developed a CRPS-I condition in the left knee. However, this appeared to be just a part of a widespread pain syndrome. Her condition deteriorated and she also developed an eating disorder and was examined by a paediatric psychiatrist. Physical therapy and amitriptyline produced no pain reduction. Eventually, a SCS device was implanted and stimulation provided partial pain relief during the first year. Subsequently, the psychiatric symptoms became more prominent and she was diagnosed as suffering from anorexia nervosa and an obsessive–compulsive disorder. The pain in the knee slowly disappeared and after about three years of SCS, the electrode was removed in 2004. At follow-up in March 2006, the patient had no pain, but she conveys that she needs to exercise regularly as she otherwise gets pain in the knee. If pain would recur, she would not have another SCS because she now believes more in alternative medicine.

4.4. Case 4

Born 1986 (from Greece). Without any trauma or other reasonable cause, she started to have pain in both knees in 1998 and soon developed contractures and became confined to a wheelchair. She had extensive psychiatric treatment and physiotherapy. She was first seen in 1999 and then presented with severe contractures of both knees with severe allodynia extending into the upper part of the lower legs. Even in general anaesthesia, there was a knee-stretching deficit of 60°. A SB had no effect. Intrathecal adenosine and baclofen were tried and the latter produced some pain relief such that a pump for continuous i.t. infusion was considered. However, instead SCS was tried in 2000. After one week, there was only a modest effect. In the following

three weeks, she reported a progressive relief with a reduction of spontaneous pain from VAS 7/10 to 2.5/10. She was sent back home for further physiotherapy, and she could then have her lower legs freely hanging down when seated in the wheelchair. At telephone interview after roughly six months, she claimed to be pain-free and had no knee contractures. Her good condition and walking ability were verified during a visit to the department in April 2002. She was still using the stimulator most of her waking-time. She was pain-free and had no dysautonomy, allodynia, or any other sensory disturbances. At a new telephonic contact in May 2006, she reported that she still used the stimulator every day and had no spontaneous pain or allodynia. Occasionally, she had moderate pain after physical exercise, but that pain was of another character than the original CRPS-I-pain.

4.5. Case 5

Born 1987. Pain in right foot started without preceding trauma in 2000. Five SBs were performed and two of them produced complete but transitory pain relief. Her pain appeared in periods lasting for about four weeks and it was accompanied by dystonic movements in the lower leg and foot. SCS treatment was started in 2001 concomitantly with the beginning of such a pain period and the pain was effectively suppressed after a few days of stimulation. However, pain later recurred in the *contralateral* foot (left) for periods lasting 2–4 weeks. Follow-up in March 2006: she has had 4–5 recurrences in the contralateral leg and two in the SCS-treated leg. All recurrent pain periods had been much milder than before SCS with a maximum VAS 50/100 compared to 100/100 before SCS. There is a hyperhidrosis in right foot. She would not have SCS again because she feels that she can now handle the pain much better but she would recommend this treatment to a close friend.

4.6. Case 6

Born 1991. In 2001, she suffered a trauma to the left lower leg causing a minor wound that did not heal properly. Pain, moderate allodynia and forced flexion of the knee and hip developed gradually (Fig. 1). At an orthopaedic surgery unit, a cast was applied in general anaesthesia keeping the leg in the extended position. As a result of this procedure, the pain and the allodynia became much worse and dysautonomic signs appeared. In 2002, she was subjected to two SBs and subsequently to continuous epidural infusion of bupivacaine but with no benefit. A year after the beginning of the pain, SCS treatment was decided. Two 4-polar electrodes were implanted in general anaesthesia because she was unable to tolerate the procedure awake. Because of poor paraesthesia coverage, the electrodes had to be repositioned

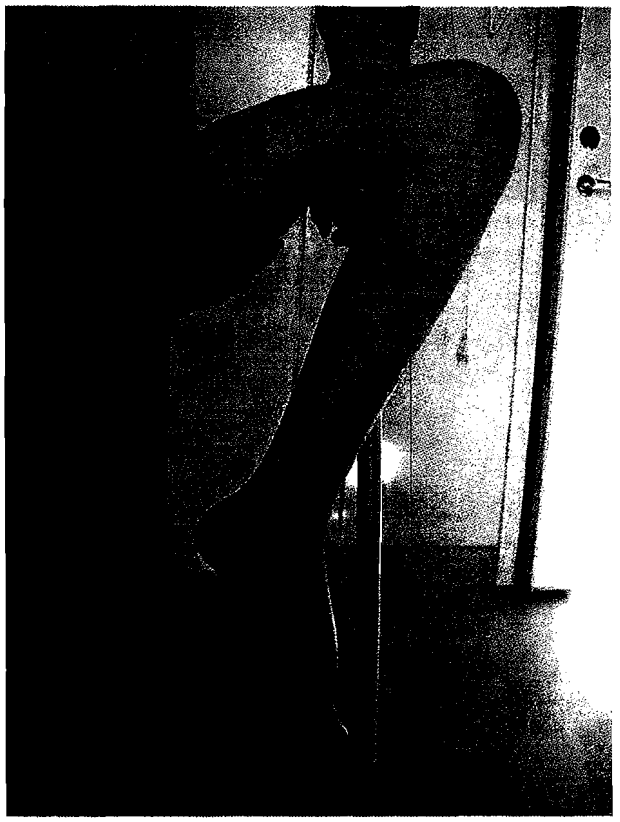

Fig. 1. An example of CRPS-I affecting a foot in a 11 years old girl (case 6) who also presented with contractures of knee and hip. When standing and sitting, the leg was supported by the crutch handle.

but without effect. Therefore, a laminotomy plate electrode was implanted eight days later. However, even with high voltage stimulation, eliciting motor effects, paraesthesias could be elicited in only a small portion of the painful leg. Nevertheless, in the following weeks, some pain relief was reported. After another six weeks, she was completely pain-free and allodynia as well as the dysautonomic signs disappeared. The SCS device was removed one year later. Follow-up in March 2006: no recurrence of pain or of dysautonomy. Minor allodynia appears occasionally in the affected foot. She has no problem using stockings or shoes but certain kinds of stocking material may give rise to a burning sensation.

4.7. Case 7

Born 1992. After a minor distortion of left ankle while playing soccer in 2004, she developed persisting pain, severe allodynia and dysautonomic signs in the foot and lower leg. She was treated with physiotherapy, amitriptyline as well as with four SBs. Continuous epidural infusion of levobupivacaine caused a temporary suppression of the spontaneous pain, but had no effect on the allodynia. She was also examined by the paediat-

ric psychiatrist. SCS was decided and about a year after the start of the pain, an electrode was implanted. It was not possible to produce paraesthesias in the affected area and the electrode was therefore repositioned. Subsequently, a laminotomy electrode was implanted but still no adequate paraesthesias could be evoked. After another month, the girl was admitted to the emergency unit after a suicidal attempt and it appeared that she had been subjected to sexual abuse for several years. Intensive psychiatric therapy was instituted. Remarkably, after five months it was possible to elicit paraesthesias covering the painful area, and four days later she woke up in the morning with a warm, red leg and completely pain-free. At follow-up in March 2006 (three months later), she had no pain, allodynia, or dysautonomy. Because of the major psychosocial problems, she has not yet been able to resume school.

5. Results

Seven girls, 11–14 years of age, presenting with severe and treatment resistant CRPS-I, were subjected to SCS. As shown in Table 1, five of the patients enjoyed complete pain relief and in two, there was a partial, but useful pain reduction. There was no relationship between outcome and length of time after the beginning of pain until SCS treatment was initiated. Although they were all instructed to evaluate their pain, both spontaneous and evoked, using a visual analogue scale (VAS), it was not possible to obtain regular assessment data to the extent that they could be utilized for an "objective" evaluation of the treatment (SCS effects). The reason for the incompleteness of the VAS data was also that, during the trial stimulation period, all patients stayed at home and they simply failed to comply with given instructions and to perform regular evaluations. We therefore had to rely on the patients' and parents' unstructured evaluations of the SCS effects and reports on whether or not they were able to put load on the affected foot and/or resume walking, with or without crutches. Their ability to resume school attendance was also investigated.

The patients classified as having "complete effect of SCS" correspond to the statement of being pain-free and able to walk normally and without recurrences. This implies that these cases can in fact be regarded as cured and they used the SCS less and less; in five cases the stimulation device was eventually removed.

One girl (case 2) suffered a local, subcutaneous infection that necessitated removal of the trial electrode. Otherwise, there were no complications or side effects.

It was a common feature that the beneficial effect of SCS first appeared with a delay of 1–2 weeks and thereafter the pain suppression developed gradually until it was complete after another 2–3 weeks.

Relief of spontaneous, ongoing pain paralleled a successive reduction of touch allodynia. However, that latter effect was difficult to assess by sensory testing because the initial hypersensitivity was so extremely severe that the patients refused any physical examination of the affected limb (Fig. 2). In several of the patients, the skin of the painful foot was markedly discoloured (bluish, reddish or bleached) but was successively normalized concomitantly with the pain relief.

Prior to the decision to try SCS treatment, all the patients had been subjected to thorough psychiatric/psychological examinations but no psychic aberrations with possible relationship to the pain condition had been detected. Notwithstanding, in case 7 it was discovered, after the permanent implantation of the stimulation system, that the girl had suffered sexual abuse which may have played a major role in the generation of the incapacitating CPRS-I condition. It was also a puzzling observation that in this case, it was not possible to produce paraesthesias in the affected limb in spite of several electrode revisions. Eventually, a laminotomy plate electrode was implanted but nevertheless in the initial phase of stimulation, no adequate paraesthesias could be produced. However, at a second trial of reprogramming, when psychiatric therapy had commenced, good paraesthesia coverage was achieved and the patient soon experienced complete pain relief. It is difficult to interpret these observations because at a late stage while the stimulation produced adequate paraesthesias, the patient was undergoing intensive psychiatric care. Also puzzling was this girl's reaction to epidural continuous block with bupivacaine. A first bolus dose alleviated the spontaneous pain but not the allodynia. A good motor block, making it impossible to raise the legs, verified the catheter position and proper effect. When the effect of the

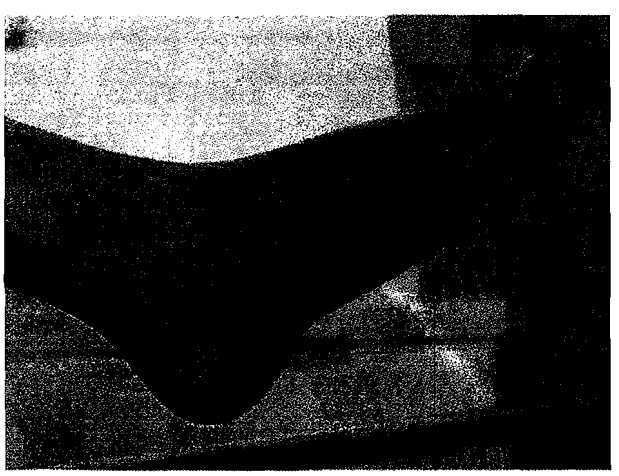

Fig. 2. Due to the extreme mechanical allodynia, she could not tolerate wearing stocking or shoe, even in winter. The foot was cold and markedly discoloured.

bolus dose wore off and a continuous infusion was used, the spontaneous pain returned.

In another case also (no. 6), all efforts to produce complete paraesthesia coverage failed. The patient reported the perception of "tingling sensations" only in a narrow band stretching from the knee and down to the dorsum of the foot. This bizarre paraesthesia distribution was claimed to persist even when the stimulation intensity was augmented to above the motor threshold. Nevertheless, the final outcome of the treatment in this case was very successful with complete and persisting pain relief.

6. Discussion

In the present study, it has been documented that it is possible to apply SCS as an effective treatment for CRPS-I in adolescents also (in this series girls), and in some of the cases, the incapacitating condition eventually seemed to be cured. It should be emphasized that the patients reported here presented with exceptionally severe forms of the CRPS-I condition. All patients recorded VAS-scores of 8-10/10 before SCS. A large number of VAS-ratings were collected during the "pre-SCS" examination, but we do not think it is appropriate to chose any single one amongst these, to be presented as a pre-SCS score. They had all failed to benefit from any other form of treatment modalities. A spontaneous remission of symptoms during this period is even less likely. Though all the patients fulfilled the diagnostic criteria for CRPS-I according to the IASP classification (Merskey and Bogduk, 1994), the symptom characteristics were variable. In two cases, it was eventually disclosed that there were major psychological/psychosocial problems that conceivably were of importance in the generation and maintenance of the pain condition (cf. Olsson et al., 1990).

Although the invasive nature of SCS may have a strong placebo effect, the severity and chronicity of the pain condition makes it less likely that the long-lasting and eventually curative outcome to a major extent was due to placebo.

It should also be noted that all patients had been subjected to invasive treatments in the form of SBs prior to SCS. Moreover, several of them regularly used stimulation for long periods of time, several years, until they eventually could abandon it without reappearance of the pain.

Many studies have demonstrated that in adults, SCS may effectively relieve CRPS-I though there is only one single randomised controlled trial (Kemler et al., 2004; reviews, see Grabow et al., 2003; Turner et al., 2004; Taylor et al., 2006). No curative effect of SCS has been reported. To the best of our knowledge, the application of SCS for this condition in children and adolescents has not been previously reported. However, there are few reports on trials with transcutaneous electric stimulation (TENS) (Stilz et al., 1977; Richlin et al., 1978) but this form of stimulation is not feasible in the presence of severe allodynia, and it was not tried in the present study.

It is generally agreed that paediatric CRPS-I differs somewhat from that encountered in adults. Thus, there is a significantly higher proportion of lower than upper limb involvement, a female predominance is more marked and the long-term outcome is more favourable (Berde and Lebel, 2005). It has also been contended that only in a minority of the paediatric cases, can a precipitating trauma be identified (Sherry et al., 1999).

There are several studies evaluating and reviewing the management of CRPS-I in children and adolescents (Olsson et al., 1990; Wilder et al., 1992; Dangel, 1998). The most effective and commonly applied treatment modalities are physical therapy and cognitive-behavioural therapy, and it is contended that better outcome can be expected if the treatment is instituted at an early stage (Finniss et al., 2006). Invasive procedures such as peripheral nerve blocks are advised against but may provide a solution in the most advanced cases (Dadure et al., 2005). In adults, sympathetic blocks, also as regional intravenous sympathetic (Bier) blocks, are a traditional part of the routine therapeutic armamentarium for CRPS-I (Bonica, 1990; Stanton-Hicks et al., 1995; Cepeda et al., 2002). All the patients presented here had been subjected to repeated sympathetic blocks but without lasting benefit. It has been claimed that a positive response to a sympathetic block in CRPS-I is a reliable predictor for the outcome of SCS (in adults) (e.g., Kumar et al., 1997; Hord et al., 2003; Harke et al., 2005) but this does not apparently apply to the present group of patients.

The mechanism behind the beneficial effects of SCS are largely unknown but reviews of the present knowledge and some hypotheses relating to CRPS are found in e.g., Meyerson and Linderoth (2006).

7. Conclusions

SCS is a minimally invasive and reversible method that in adults has proven to be very effective for certain forms of neuropathic pain. To the best of our knowledge, SCS has hitherto not been tried in children, but in our experience, it can also be a useful treatment for severely incapacitated paediatric cases of otherwise therapy-resistant CRPS-I conditions. However, due to the small and non-controlled design of this case series, further studies are needed to confirm that SCS can be recommended for use both in children and adolescents.

References

Barbier O, Allington N, Rombouts JJ. Reflex sympathetic dystrophy in children: review of a clinical series and description of the particularities in children. Acta Orthop Belg 1999;65(1): 91–7.

Bennett DS, Brookoff D. Complex regional pain syndromes (reflex sympathetic dystrophy and causalgia) and spinal cord stimulation. Pain Med 2006;7(Suppl 1):S64–96.

Berde CB, Lebel A. Complex regional pain syndromes in children and adolescents. Anesthesiology 2005;102:252–5.

Bonica JJ. Evolution and current status of pain programs. J Pain Symptom Manage 1990;5(Dec):368–74.

Cepeda MS, Lau J, Carr DB. Defining the therapeutic role of local anesthetic sympathetic blockade in complex regional pain syndrome: a narrative and systematic review. Clin J Pain 2002;18:216–33.

Dadure C, Motais F, Ricard C, Raux O, Troncin R, Capdevila X. Continuous peripheral nerve blocks at home for treatment of recurrent complex regional pain syndrome I in children. Anesthesiology 2005;102:387–91.

Dangel T. Chronic pain management in children. Part II: reflex sympathetic dystrophy. Paediatr Anaesth 1998;8:105–12.

Finniss DG, Murphy PM, Brooker C, Nicholas MK, Cousins MJ. Complex regional pain syndromes in children and adolescents. Eur J Pain 2006;10:767–70.

Forouzanfar T, Koke AJ, van Kleef M, Weber WE. Treatment of complex regional pain syndrome type I. Eur J Pain 2002;6:105–22.

Grabow TS, Tella PK, Raja SN. Spinal cord stimulation for complex regional pain syndrome: an evidence-based medicine review of the literature. Clin J Pain 2003;19:371–83.

Harke H, Gretenkort P, Ladleif HU, Rahman S. Spinal cord stimulation in sympathetically maintained complex regional pain syndrome type I with severe disability. A prospective clinical study. Eur J Pain 2005;9:363–73.

Hord ED, Cohen SP, Cosgrove GR, Ahmed SU, Vallejo R, Chang Y, et al. The predictive value of sympathetic block for the success of spinal cord stimulation. Neurosurgery 2003;53:626–32.

Irazuzta JE, Berde CB, Sethna NF. Laser Doppler measurements of skin blood flow before, during, and after lumbarsympathetic blockade in children and young adults with reflex sympathetic dystrophy syndrome. J Clin Monit 1992;8:16–9.

Kemler MA, De Vet HC, Barendse GA, Van Den Wildenberg FA, Van Kleef M. The effect of spinal cord stimulation in patients with chronic reflex sympathetic dystrophy: two years' follow-up of the randomized controlled trial. Ann Neurol 2004;55:13–8.

Kumar K, Nath RK, Toth C. Spinal cord stimulation is effective in the management of reflex sympathetic dystrophy. Neurosurgery 1997;40:503–8.

Lee BH, Scharff L, Sethna NF, McCarthy CF, Scott-Sutherland J, Shea AM, et al. Physical therapy and cognitive-behavioral treatment for complex regional pain syndromes. J Pediatr 2002;141:135–40.

Merskey H, Bogduk N. Classification of chronic pain; description of chronic pain syndromes and definition of pain terms. Seattle: IASP Press; 1994.

Meyerson BA, Linderoth D. Mode of action of spinal cord stimulation in neuropathic pain. J Pain Symptom Manage 2006;31(suppl1): S6–S12.

Olsson GL, Arnér S, Hirsch G. Reflex sympathetic dystrophy in children. In: Krane EJ, Tyler DC, editors. Advances in Pain Research and Theraphy, vol. 15. New York: Raven Press; 1990. p. 323–31.

Richlin DM, Carron H, Rowlingson JC, Sussman MD, Baugher WH, Goldner RD. Reflex sympathetic dystrophy: successful treatment by transcutaneous nerve stimulation. J Pediatr 1978;93:84–6.

Sherry DD, Wallace CA, Kelley C, Kidder M, Sapp L. Short- and long-term outcomes of children with complex regional pain syndrome type I treated with exercise therapy. Clin J Pain 1999;15:218–23.

Stanton-Hicks M, Janig W, Hassenbusch S, Haddox JD, Boas R, Wilson P. Reflex sympathetic dystrophy: changing concepts and taxonomy. Pain 1995;63:127–33.

Stilz RJ, Carron H, Sanders DB. Reflex sympathetic dystrophy in a 6-year-old: successful treatment by transcutaneous nerve stimulation. Anesth Analg 1977;56:438–43.

Taylor RS, Van Buyten JP, Buchser E. Spinal cord stimulation for complex regional pain syndrome: a systematic review of the clinical and cost-effectiveness literature and assessment of prognostic factors. Eur J Pain 2006;10:91–101.

Turner JA, Loeser JD, Deyo RA, Sanders SB. Spinal cord stimulation for patients with failed back surgery syndrome or complex regional pain syndrome: a systematic review of effectiveness and complications. Pain 2004;108:137–47.

Wilder RT, Berde CB, Wolohan M, Vieyra MA, Masek BJ, Micheli LJ. Reflex sympathetic dystrophy in children. Clinical characteristics and follow-up of seventy patients. J Bone Joint Surg Am 1992;74:910–9.