PAIN MEDICINE CASE REPORTS

ISSN 2768-5152

Volume 5, Number 8, pp. 385-388

Dorsal Root Ganglion Stimulation Therapy in Pediatric Patients: A Case Series

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Background: Dorsal root ganglion (DRG) stimulation therapy has been shown to provide effective relief in controlling chronic regional pain syndrome (CRPS)-related pain; however, there is little information on its efficacy and safety in pediatric patients.

Case Report: Following Institutional Review Board approval, a review of pediatric patients who underwent DRG therapy at a single university pain center was conducted.

Five patients under 18 years old with CRPS or intercostal neuralgia who failed prior therapies received DRG stimulation therapy. Three of 5 patients (60%) reported 50% or more relief with DRG therapy. Secondary outcomes including resolution of allodynia, sudomotor and vasomotor dysfunction, and tropic changes as well as school/work attendance and reduced physical restrictions at the longest follow-up were improved in responders.

Conclusion: In our limited series we found substantially improved analgesia, reduction in symptoms of CRPS, and improved functional outcomes in pediatric patients treated with DRG neuromodulation for unresponsive chronic pain.

Key words: Chronic regional pain syndrome, intercostal neuralgia, neuromodulation, pediatric

BACKGROUND

Neuromodulation, via spinal cord stimulation (SCS) or dorsal root ganglion (DRG) stimulation, is an effective therapeutic modality for a growing number of chronic pain conditions, including CRPS and other neuropathic pathologies (1). These are often last-resort therapies that can provide long-term pain relief for patients who have failed more conservative therapies. Because these disease processes tend to occur more frequently in adult populations, the use of SCS or DRG has not been significantly studied in pediatric populations. In 2007, Olsson et al (2) published a review of the use of SCS in 7 pediatric patients suffering from CRPS-I with largely favorable outcomes.

DRG therapy has been shown to be more targeted for specific sensory nerve fibers and somatotopic areas and may be associated with reduced paresthesias compared to SCS therapy (3-5). However, DRG therapy has not yet been studied in pediatric patients. Our interventional chronic pain practice has treated 4 pediatric patients with severe chronic pain from CRPS-I and one patient with intercostal neuralgia with SCS followed by DRG therapy or DRG therapy alone. The aim of this report is to provide a case series highlighting the efficacy and safety of DRG therapy in pediatric patients.

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Disclaimer: The study was supported by Department of Anesthesiology funds.
Conflict of interest: Dr. Lubenow reports personnel fees from Abbott Laboratories during the conduct of the study; and personnel fees from Boston Scientific Corporation, Nevro Corporation, Medtronic, Inc., Avanos Medical, and Flowonix Medical outside the work of the study. All other authors certify that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.
Accepted: 2021-08-24, Published: 2021-11-31

METHODS

This study was approved by the Institutional Review Board of Rush University (20100707-IRB01). The study was granted a waiver of informed consent because it evaluated existing records, did not pose greater than minimal risk, and was deemed to be Health Insurance Portability and Accountability Act-compliant because safeguards were in place to protect the personal health information of the patients. The study design was a retrospective cohort of pediatric patients who received DRG neuromodulation at the Rush University Pain Center between February 1, 2017 and September 1, 2020.

Inclusion criteria were patients less than 18 years old with a diagnosis of CRPS-I in accordance with the Budapest criteria or a similar chronic neuralgia (6). All patients had failed conservative therapies, including physical and occupational therapy, psychotherapy, multimodal pharmaceutical analgesia and, for some patients, SCS therapy.

Data collected included the patient's age, gender, diagnosis, location of the pathology, Numeric Rating Score for pain (NRS 0 to 10), nature of the trauma that occurred prior to the chronic pain pathology (designated as minor if it only involved soft-tissue injury or major if it included bone fractures), and the presence of signs and symptoms of CRPS upon initial presentation—including vasomotor dysfunction (temperature or skin color asymmetry), allodynia or hyperesthesia, sudomotor changes (edema or sweating asymmetry), and motor or trophic changes (decreased range of motion, weakness, tremor, dystonia, or changes in nails/skin/hair of the affected limb). For patients who had had prior SCS therapy, the percentage of pain relief achieved with the SCS therapy was also noted. Pain relief in all patients is reported at 6 weeks after DRG implantation. Other outcomes are reported at the time of the longest follow-up.

RESULTS

Case 1

A 14-year-old girl presented with CRPS-I of the left foot after a crush injury during a basketball game. She described sharp pain on the dorsum of her left foot and ankle, associated with a violet discoloration, increase in temperature compared to her contralateral foot, markedly decreased range of motion at the ankle, hyperhidrosis, and allodynia. She failed conservative therapies, various pharmaceutical regimens, and lumbar sympathetic blockade. Two years after the injury the patient failed 2 SCS trials, one continuous and one high-frequency. She underwent DRG placement at levels L4 and L5 3 years after her injury (when she was 17 years old). This provided the patient > 50% pain relief and eventually resolved her allodynia and allowed her to return to athletic extracurricular activities.

Case 2

A 16-year-old boy who underwent a tibial tubercle ossicle excision for Osgood-Schlatter disease subsequently developed chronic left lower extremity pain. This was exacerbated when he participated in a strenuous golf camp. He was diagnosed with CRPS-I and presented with burning pain from his left hip to his foot, mottling of his skin with significant darkening discoloration, increased sweating, and hyperalgesia. After failing conservative treatments, he underwent the placement of a DRG at levels L3, L4, L5, and S1 at age 17. After the procedure he described 60% relief in pain. The discoloration in his foot largely improved. Although the therapy has been very beneficial for him, he remains limited in his ability to participate in athletic activities.

Case 3

A 15-year-old girl sustained an injury to her right ankle playing soccer and underwent imaging that showed a stable 9-mm x 10-mm osteochondral lesion over the talar dome. Her condition quickly worsened over several months, as she began developing chronic pain in her entire right lower extremity with weight-bearing, skin mottling from her hip to her foot, and severe cold intolerance. She was diagnosed with CRPS-I and failed conservative therapies. About 12 months after her injury, she underwent a DRG trial placement at levels L5 and S1 at age 17, which was removed after 3 weeks when no symptom improvement was evident. A year later, another DRG trial was attempted, with similar results and subsequent removal.

Case 4

A 12-year-old girl sprained her left ankle after falling from a 3-foot ledge. Several months later she was diagnosed with CRPS-I with constant burning pain that was worse in her left thigh, with visible red-to-grey skin changes and allodynia throughout her left lower extremity. Her condition progressively worsened despite a diverse pharmaceutical regiment, sympathetic blocks, pamidronate and ketamine infusions. Seven months after her injury, she underwent SCS placement. Two

weeks post implantation she had 75% improvement in allodynia, but only 20% improvement overall in pain with movement and weight-bearing. After 2 years the condition spread to her contralateral lower extremity. Her SCS was explanted and replaced with a DRG at bilateral L5, right L3, and left L2 levels at age 15. She later began developing symptoms of CRPS in her right upper extremity and perineum, and her DRG was explanted 3 months after implantation. The patient's clinical course continued to deteriorate as she became bedbound and began experiencing seizure-like episodes.

Case 5

A 9-year-old girl experienced a snowboarding accident resulting in 2 left-sided rib fractures. She began to develop a chronic left-sided shooting pain and associated skin discoloring that did not resolve with conservative therapies. She was diagnosed with a chronic intercostal neuralgia and referred to our pain clinic. She had initially responded well to 2-level intercostal cryoablative therapy, but her symptoms returned sooner with each subsequent treatment. At age 14 she underwent placement of a DRG with leads at levels T8 and T10. Following this procedure, the patient immediately expressed > 90% sustained relief in pain and resolution of allodynia and skin discoloration. She was able to fully return to participate in afterschool activities.

All patients in our series had chronic pain that was resistant to medication and conservative therapies (Table 1). Four of the 5 patients admitted to a NRS pain score of 10 at initial presentation. In addition, all of the patients demonstrated vasomotor dysfunction and allodynia, with 4 of 5 (80%) demonstrating tropic changes. The majority of patients (3 of 5, 60%) in this study, however, experienced significant remission in signs and symptoms of disease, as evidenced by VAS pain scores, and symptom decrements (Table 2). The patients with < 50% pain relief were able to return to school, work, or engage in extracurricular activities after DRG implantation.

DISCUSSION

This study supports the further investigation of DRG neuromodulation as an effective treatment modality in the pediatric patient population. All of the cases reported began with significant pain scores and functional limitations. In addition, these patients experienced little to no relief from extensive conservative treatments, and so they represent cases of neuropathology, mostly CRPS, that are advanced, refractory to effective conservative therapies, and therefore less likely to remit altogether.

While the exact mechanism of spinal cord stimulation is not known, electrical stimulation seems to mask pain. Working theories suggest that SCS alters local levels of γ-aminobutyric acid (GABA), serotonin, and excitatory

Table 1. Clinical characteristics prior to dorsal root ganglion stimulation.

Subject/Case ID:	**A**	**B**	**C**	**D**	**E**
Age at presentation (y)	14	17	15	12	9
Age at DRG implantation (y)	17	17	17	15	14
Gender	Female	Female	Female	Female	Female
Diagnosis	CRPS-I	CRPS-I	CRPS-I	CRPS-I	intercostal neuralgia
Location	LLE	LLE	RLE	RLE	left ribs
Trauma	Minor – crush injury	Major – post procedure	Major – sport injury	Minor – ankle sprain	Major – rib fractures
Vasomotor Dysfunction	Yes	Yes	Yes	Yes	Yes
Allodynia / Hyperesthesia	Yes	Yes	Yes	Yes	Yes
Sudomotor Dysfunction	Yes	No	Yes	Yes	No
Motor / Trophic Changes	Yes	Yes	Yes	Yes	No
NRS score (0 to 10) prior to implantation	10	10	7	10	10
Prior neuromodulation therapies	SCS HF-SCS	-	-	SCS	-
Effect of prior spinal cord stimulator (percent decrease in NRS pain score)	30%	-	-	20%	-

CRPS, complex regional pain syndrome; LLE, left lower extremity; RLE, right lower extremity

Table 2. Pain, secondary findings, and activities of life following dorsal root ganglion therapy.

Patient ID:	A	B	C	D	E
NRS score (0 to 10) at 6 wks post implantation	5	4	7	10	0
Effect of DRG (percent change in NRS pain score)	50%	60%	0%	0%	100%
Duration of last follow-up (mos)	48	48	12	3	9
Additional procedures (time from implant)	Added one lead (2 y) Replaced leads (2.5 y and 4 y)	-	Not permanent	Explanted at 3 mos	Replaced leads x 2
Vasomotor dysfunction	Yes	No	Yes	Yes	No
Allodynia/ hyperesthesia	No	Yes	Yes	Yes	No
Sudomotor dysfunction	No	No	Yes	Yes	No
Motor/ trophic changes	No	No	Yes	Yes	No
Regular school/work attendance	Yes	Yes	No	No	Yes
Athletic limitations	No	Yes	Yes	Yes	No

amino acids such as glutamate and aspartate in the dorsal horn, suppressing neuron hyperexcitability. Activation of large-diameter, myelinated afferent fibers suppresses the response to small, unmyelinated afferent neuron input in the dorsal horn. The DRG stimulation mechanism is thought to be similar to that of SCS; however, it has been shown that DRG stimulation does not induce GABA release but does still work via this "gate-control theory."

It is well established that neuromodulation is an effective modality in adult patients with CRPS or other neuropathies that may have central mediation. However, neuromodulation has not been extensively studied in pediatric populations. Olsson et al (2) reported the use of SCS in pediatric patients with CRPS, with profoundly positive outcomes. Most literature agrees that CRPS does differ in presentation in the pediatric population when compared to the adult population; it often presents more commonly in female patients, in the lower extremities, and has a more favorable outcome (7). However, treatment modalities, including a combination of physical and cognitive-behavioral therapies, conservative analgesic regimens, and interventions including sympathetic blockade, seem to be the most efficacious means of management in both the adult and pediatric populations (8). It is therefore logical that if a pediatric patient has failed this same therapeutic ladder, they may qualify for a more advanced therapy such as SCS or DRG, particularly as more similar studies are published.

CONCLUSION

CRPS and other chronic pain conditions are often debilitating disease states that are refractory to most therapies. Neuromodulation, via SCS or DRG, has been successfully utilized in treating adult patients with many such pathologies. These therapeutic modalities have not been sufficiently studied in pediatric patients. While there is growing research to support SCS as an efficacious treatment modality for pediatric patients, our case series is an initial study to suggest DRG therapy may also benefit pediatric patients with CRPS and intercostal neuralgia that is refractory to other therapies.

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