

Dorsal Root Ganglion Stimulation for Chronic Pelvic Pain: A Case Series and Technical Report on a Novel Lead Configuration

Corey W. Hunter, MD^{*,†}; Ajax Yang, MD[†]

Introduction: Chronic pelvic pain (CPP) is an elusive and complex neuropathic condition that is notoriously recalcitrant to treatment. The term “CPP” encompasses a number of treatment-resistant conditions like pudendal neuralgia, interstitial cystitis, coccygodynia, vulvodynia. CPP has been presented neuromodulators attempting to utilize conventional spinal cord stimulation (SCS), with constant frustration and high explant rates. Contrary to SCS, dorsal root ganglion stimulation (DRGS) delivers targeted target to focal areas, does not rely on paresthesias, and is able to reliably capture body parts like the pelvis making it an ideal modality for the treatment of CPP. We present seven patients with intractable CPP, resistant to conventional treatment methods, all successfully treated with DRGS.

Methods: The case series includes seven patients with severe, CPP who failed to respond to a variety interventional treatments, and in some cases SCS. All seven patients were successfully trialed with DRGS utilizing leads placed over the bilateral L1 and S2 DRG's—to our knowledge, no publications describing either this particular lead configuration, or utilizing DRG stimulation on CPP, exist.

Results: Following treatment, all seven patients experienced significant pain relief as well as reduction in opioid consumption and some cases improvement with sexual function and urination. Four of these patients have been implanted and continue to self-report sustained pain relief with high-satisfaction and functional improvement. To date no explants or instances of loss of efficacy have occurred (>1 year since implant).

Conclusion: Like most neuropathic pain states, CPP is resilient, difficult to manage, and typically unresponsive to the traditional therapeutics and SCS. Our case series demonstrates not only that DRGS is potentially effective, long-term treatment modality for CPP, but that the L1/S2 lead placement is the configuration of choice despite distinct differences in etiologies of pain and location.

Keywords: Complex Regional Pain Syndrome, DRG Stimulation, dorsal root ganglion stimulation, neurostimulation, pelvic pain, spinal cord stimulation

Conflict of Interest: Dr. Hunter is a paid consultant for Abbott (previously St Jude Medical). Dr. Yang has no conflicts to report. No financial support was received for any phase of this study or for the preparation of the manuscript.

INTRODUCTION

Chronic pelvic pain (CPP) is an elusive, and complex condition with a high socioeconomic burden. It affects both men and women with an estimated prevalence as high as 40% (1,2). In the United States, the annual healthcare costs related to diagnostic workup and treatment of CPP, in women alone, approaches nearly three billion dollars per year (3). Despite the fact that several, well-known conditions are recognized to predispose one to develop CPP, the exact cause is largely unknown (4). The term “CPP” encompasses a variety of chronic pain conditions, including coccydynia, proctalgia, pudendal neuralgia, and vulvodynia to name a few. The recognition and diagnosis of CPP from the time of symptom onset is typically delayed by as much as ten years due to CPP clinical characteristics resemble other pathologies (2). Compounded by the fact that this delay is often accompanied by treatment mismanagement due to the failure to recognize CPP, these patients are left in states of extreme emotional distress for exorbitant periods of time. Patients with CPP have been reported to use three times more medications, are four times more likely

to undergo non-gynecologic surgeries and five times more likely to undergo a hysterectomy for the treatment of their pain as compared to females without CPP (5).

CPP remains a diagnosis of exclusion and often evolves to exhibit debilitating features of a neuropathic pain state with adverse physical, behavioral, reproductive, and emotional consequences (6). Rarely is there an apparent pathologic defect or

Address correspondence to: Corey W. Hunter, MD, Ainsworth Institute of Pain Management, 115 East 57th Street, Suite 1210, New York, NY, 10022, USA. Email: chunter@ainpain.com

* Ainsworth Institute of Pain Management, New York, NY, USA; and

† Department of Physical Medicine & Rehabilitation, Mount Sinai Hospital, New York, NY, USA

For more information on author guidelines, an explanation of our peer review process, and conflict of interest informed consent policies, please go to <http://www.wiley.com/WileyCDA/Section/id-301854.html>

Source of financial support: There was no funding received of any kind for this study.

detectable abnormality one can point to as the pain generator that can be fixed procedurally (7). As an example, nearly a third of scrotal pain has an undetermined cause (8). Conventional management strategies (i.e., antidepressant, antiepileptic, analgesics, physical therapy and psychotherapy), by and large, are nonspecific and yield limited success—especially in moderate to severe cases (4).

Even in the rare situations where one can identify the cause or inciting event leading to CPP (i.e., endometriosis (9), pelvic congestion syndrome (10), pudendal entrapment (11)) the pain and associated symptoms will often persist or even worsen following treatments targeted at “fixing” the defect. Up to 30% of surgical pudendal nerve decompressions for confirmed pudendal nerve entrapment resulted in little or no symptomatic improvement (12). Sympathetic neurolysis has shown to be efficacious in treating oncologic and non-oncologic pelvic pain, alike (13–16); however, nerve regeneration may lead to the need for periodic, repeat ablations—each carrying associated procedural risks (17–19). In cases of collateral innervation, neurolytic procedures may not work at all.

Like any chronic, neuropathic pain condition shown to be unresponsive to conservative therapy, SCS is typically the next option considered in the treatment algorithm. Unfortunately, reports in the literature describing the use of SCS to treat CPP have shown limited success. A retrospective study reported an explant rate of 33.3% in cases where SCS was used to treat abdominal/pelvic pain—the leading cause of explant was loss of efficacy (20). Failures in this particular patient population are either due to an inability to consistently capture the painful area(s) of the pelvic or the presence of unwanted paresthesias in unaffected regions (21–23). Consequently, of all the diagnoses treated with SCS, CPP has the highest explant rate (20). Peripheral nerve stimulation (PNS) was tried as an alternative in an attempt to provide targeted stimulation to the pelvic area and potentially avoid collateral paresthesias (24). However, PNS has limitations of its own such as the increased propensity for lead migration and erosion; thus, the results have been mediocre (25).

The difficulty in providing consistent coverage to the pelvic region is likely due, at least in part, to the complexity of innervation in the area—as such, choosing a target along the dorsal columns is extremely difficult with SCS. The pelvic viscera are innervated by the lumbar and sacral regions of the spine, making it difficult for SCS to capture all areas of pain simultaneously. In a patient with pain over the bladder/groin region as well as the perineum, one would need to obtain coverage over the pudendal, ilioinguinal, iliohypogastric, genitofemoral, and inferior rectal nerve, all at once. The dermatomal distribution of this area is T12, L1, and L2, then skips to S2 and S3; this would present a serious challenge with a lead placed over the dorsal columns given the distribution of sacral fibers as compared to lumbar (Table 1).

Notwithstanding many publications in the literature describing the use of SCS for pelvic pain, a genuine consensus on what the correct target for stimulation should be remains to be seen. Kapural et al. described a technique whereby the physician places a lead in the mid-thoracic region, turns it on and then “trolls” down the dorsal column until the patient reports paresthesias in the desired area(s) (26). Alò et al. presented a number of articles successfully utilizing sacral nerve stimulation to treat CPP as well as technical reports on placing leads in a retrograde fashion (27–29). In 2013, Hunter et al. published the results of a case series using stimulation at the conus in one patient and mid-thoracic (T5–7) in four others (4). Most recently, Rowland et al.

Table 1. Major Nerves of the Pelvic Region and the Spinal Segments They Are Derived From. Gray Illustrates Extent of Coverage by Simultaneously Stimulating L1 and S2.

Nerve	T12	L1	L2	L3	L4	S1	S2	S3	S4	S5
Iliohypogastric										
Ilioinguinal										
Genitofemoral										
Obturator										
Posterior Femoral Cutaneous										
Inferior Rectal										
Pudendal										
Coccygeal										

published a case report on a 37-year-old female with CPP (girdle pain) successfully treated with DRGS—leads were placed at L1 and L2 (30). While there is no evidence to support why the use of SCS for CPP has not experienced more widespread adoption, the lack of agreement on where one should target has likely done little to instill confidence on would-be users and should not be overlooked.

COMPARING CPP TO CRPS

Janicki first described CPP as a type of CRPS due to the fact both conditions exhibit allodynia and hyperesthesia in the affected area(s) (31). Patients with CPP will often describe excruciating pain with activities that should either not be painful or, at the very least only mildly uncomfortable, like intercourse, defecation or sitting—at face value, this meets the definition of allodynia, the hallmark sign of CRPS. When one considers these patients may also report changes in urination, skin appearance, and regional hair growth, CRPS would be a fitting diagnosis given that they appear to meet Budapest criteria, if only in part (32). If patients with CPP do in fact have a form of CRPS, it would explain why their condition is so resistant to treatment and progressive in nature.

When one considers the striking similarities between CPP and CRPS, SCS would appear to be a valid treatment option. As it pertains just to CRPS, SCS has shown great promise as an effective treatment modality (33–35). However, there was a need for improvement. Two of the most impactful shortcomings of conventional SCS, as it pertains to CRPS, are loss of efficacy over time and the inability to capture the foot consistently (the most commonly involved body part in women, followed by men) (36–38). Evidence has shown that after two years, patients with CRPS being treated with SCS and physical therapy (PT) fared no better than those treated with PT alone (38). DRGS was a significant innovation in the neuromodulation space, mainly for its ability to provide focal coverage over specific body parts, like the foot, and for its ability to work at the level of the T-junction in the DRG to potentially reverse allodynia at the source (39). DRGS achieved a level of clinical efficacy far exceeding that of SCS for a wide range of painful, complex neuropathic conditions (39–44).

The inadequacies that plagued SCS with CRPS are also relevant with CPP: loss of efficacy over time and the inability to reliably stimulate the area(s) of need. If DRGS *could* provide bridge the gap for neuromodulation in patients with CRPS, could it do the same in CPP? And if so, where would the leads be placed?

A significant difference between DRGS and SCS is one must select specific targets to stimulate. As stated above, there was a great deal of variability with regards to SCS lead placement location for CPP; however, there is a certain amount of “cushion” with

Table 2. Patient Demographics, Pain Symptomatology, and Tentative Diagnoses.

ID	Initials	Age/sex	Presenting features	Location of pain	Tentative diagnoses
1	JM	47/F	Shooting, burning pain with allodynia, extremity swelling and trophic changes.	Inner and outer vagina, perineum, anus, legs, dorsum of feet and toes	Endometriosis, nerve injury 2 nd to surgery, rectal fistula, post surgical pain, CRPS
2	LL	49/F	Burning pain and soreness	Peri-rectal, anal and coccygeal soreness	Anal trauma, post surgical pain, coccydynia
3	SM	36/F	Burning pain	Bilateral pubis, labia, perineum and rectum	Pudendal neuralgia from coccygeal trauma
4	MS	36/M	Burning and "shockwave" pain	Penis and testicles, bilateral feet and toes	Genital pain orchialgia 2 nd to trauma
5	LL	63/M	Burning nerve pain	Plantar aspect of feet, rectum, perineum, clitoris, vagina and vulva	CRPS, S1 neuritis 2 nd to sacral abscess
6	MR	41/M	Lancinating pain	Glans of penis and the left perineum	Orchialgia, pudendal neuralgia, varicocele
7	NP	42/F	Shooting, scorching pain	Left buttock, pubis, saddle and groin	Pudendal neuralgia 2 nd to hip surgery

SCS as one can increase the pulse width to capture adjacent fibers and, in turn, increase the area of stimulation. Being that the leads in DRGS are placed over individual spinal segments, there is a limit to what one can accomplish with programming. As such, target selection is paramount with DRGS. If one were to choose only the sacral DRG's to stimulate, patients with groin and/or suprapubic pain may report incomplete coverage, as the corresponding levels are 4–5 levels higher. Conversely, if one were to place leads strictly in the L1 or L2 distribution, patients with perineal pain may experience partial coverage for the same reason.

Table 1 illustrates the innervation of the relevant nerves of the pelvis—as one can see, there is a wide distribution of spinal segments represented in the pelvic region, ranging from L1 to S5. Additionally, there are eight sensory nerves, on each side, providing innervation to the area. There is too much ground for one to cover by targeting individual regions or dermatomes, therefore broader approach is required. By selecting the L1 and S2 levels, one would theoretically be stimulating every peripheral nerve of the pelvic region except for the obturator and the coccygeal—thus increasing the odds of providing appropriate coverage to the area(s) of need, even if the exact nerve(s) affected remain unknown at the time of the trial.

The purpose of this case series is two-fold: (1) demonstrate the efficacy of DRGS in the treatment of CPP, and (2) propose a consensus location (L1/S2) for DRGS in this distinct subset of patients.

CASE PRESENTATION

We present seven patients with CPP successfully treated with DRGS. Collectively, these their pain was recalcitrant to a vast array of therapies that included medication, neurolysis, surgery, and, in some cases, SCS. Despite variations in presentation, location of pain, suspected cause/etiology, and associated signs/symptoms, they all responded to treatment with the leads placed in the same location: L1 and S2.

Each patient's presentation is described in detail below. Patient demographics, pain symptomatology, tentative diagnoses, individual and mean pre vs. post-DRG trial stimulation pain scores, as well as implant status, are summarized in Table 2, Table 3, and Figure 2, respectively.

PATIENT 1: JM

JM is a 47-year-old female with CPP following multiple pelvic surgeries (explorations, lysis of adhesion, total hysterectomy) to

treat her endometriosis. Her condition was complicated by the development of a rectal fistula that required additional surgical repairs. The patient reported her pelvic pain was initially relegated to the inner and outer vagina, perineum, anus, as well as visceral pain in the general pelvic region. The onset of her pain was four years and four months before her initial evaluation. Her presentation was further complicated by the development of CRPS in both lower extremities following an ill-performed lumbar epidural steroid injection to treat her CPP. The injection accidentally resulted a dural puncture and damaged the nearby nerve roots of the cauda equina. As a result, she suffered from additional pain, swelling and trophic changes in both legs, feet, toes as well as severe allodynia on the dorsum of her feet extending into all toes.

Her pain was unrelenting with a consistent intensity of 7–9/10 on a numerical rating scale (NRS) and her functional independence progressively declined. Since the onset of her pelvic pain in 2012, she underwent numerous medical and interventional pain procedures with outside physicians without any lasting relief. The treatments included multiple lumbar epidural injections, lumbopelvic sympathetic blocks, and SCS. Her SCS trial was unsuccessful and was complicated by a problematic lead placement as well as worsening right foot pain when she woke up from anesthesia. The SCS trial resulted in her now having an antalgic gait in addition to all of the above symptoms. Examination of her legs and feet was then significant for swelling, skin color asymmetry, allodynia, and punctate hyperalgesia.

The decision was made to pursue a DRG stimulation trial with percutaneous placement of Axiom® leads (Abbott® - Illinois, USA) at the bilateral L1 and S2 DRG's (Fig. 1). Two days following the trial, the patient reported 100% pain relief in the pelvic and lower extremities as well as improvement in her gait. The patient was subsequently implanted 12 days after trial completion with the leads placed in the same locations. Postoperatively, the patient reported the exact same coverage and pain relief as during the trial period. At the time of this manuscript, the patient is approximately 12-months post-implant and a NRS of 0/10 in the bilateral knees and 2/10 in pelvic region. The patient endorsed the following functional improvements as a result of the implant: she is able to wear long pants again and has improved sleep quality. She has successfully weaned off multiple medications, including methadone, trazodone, and piracetam.

PATIENT 2: LL

LL is a 49-year-old female with severe rectal pain after excessive self-administered enemas and manual disimpaction for chronic

Table 3. Pre vs. Post DRG Trial Stimulation Pain Scores and Implant Status.

ID	Initials	Pre-trial pain score	Post-trial pain score	Implant status	Time since implant	NRS score
1	JM	9/10	0/10	Implanted	12 months	2/10
2	LL	9/10	2/10	Implanted	7 months	0/10
3	SM	8/10	2/10	Pending	NA	NA
4	MS	9/10	4/10	Pending	NA	NA
5	LL	6/10	1/10	Implanted	12 months	2/10
6	MR	4/10	1/10	Implanted	3 months	1/10
7	NP	8/10	1/10	Pending	NA	NA

constipation. As a result of her compulsively strained bowel habits and hard stool, she developed anal fissures, rectal prolapse, and hemorrhoids with ensuing burning rectal (internal and external), peri-rectal, anal and coccygeal soreness. Despite optimizing her bowel regimen to ensure her stool were consistently soft and undergoing sphincterotomy and hemorrhoidectomy to correct her anal lesions, her CPP persisted and gradually worsened over time.

At the time of her evaluation, her pain had been ongoing for one year and five months and reported it at 8–9/10 on NRS. Bowel movements and bearing down (Valsalva) exacerbated her pain. Her quality of life was severely affected as her anxiety escalated whenever she experienced the urge to defecate or abdominal pressure. She previously underwent two pudendal nerve blocks by a prior physician that resulted only in temporary vaginal numbness but no pain relief. In our office, she received two ganglion of impar blocks and two hypogastric plexus blocks without success. We subsequently offered the patient DRGS as the potential next step in her treatment, to which she agreed.

Leads were placed over the bilateral L1 and S2 leads and upon completion of a seven-day trial, she reported 70–80% coverage over the painful areas resulting in 50–60% pain relief. Moreover, she stated complete resolution of the rectal/anal burning and the ability to sit for extended periods of time. She was later implanted with the leads placed in the same location. The patient is

currently seven months post-implant with a pain score of 0/10 and is no longer utilizing any pain medications.

PATIENT 3: SM

SM is a 35-year-old female with chronic, burning rectal and pelvic pain that was the result of two separate traumatic coccygeal fractures approximately 20 years prior. In addition, the patient reported paresthesias radiating from the bilateral pubis and labia into the perineum and occasionally into the rectum as well. Her baseline pain intensity was 4/10 on NRS that would increase to 8/10 with hot showers, sitting, friction from clothing and activities that increased intra-abdominal pressure such as exercise, straining during bowel movements and laughing. She reported the pain had become most prominent approximately two years before her initial evaluation.

Previously, she reported to having temporary relief from pudendal nerve blocks but no improvement from a ganglion of impar block—she was tentatively diagnosed with pudendal neuralgia as a result. She subsequently underwent pulsed radio-frequency neurolysis of the bilateral pudendal nerves, and later, the bilateral S2 and S3 DRG. She reported >50% relief after both procedures, however, the symptoms returned spontaneously several days later in both cases. The decision was then made to attempt DRGS. The leads were placed at the bilateral L1 and S2 levels and upon completion of a seven-day trial, the patient reported total coverage of the painful areas with 90–100% pain relief and a pain score of 1–2/10 on NRS. The patient is awaiting a permanent implant.

PATIENT 4: MS

MS is a healthy 36-year-old male with penile and bilateral testicular pain following a blunt injury to his penis during rough sexual intercourse. At the time of the injury, the patient reported the sensation of a “shockwave” in the shaft of his penis and testicles after the glans of the penis forcefully struck a bony structure in the pelvis of his partner. He sought immediate medical

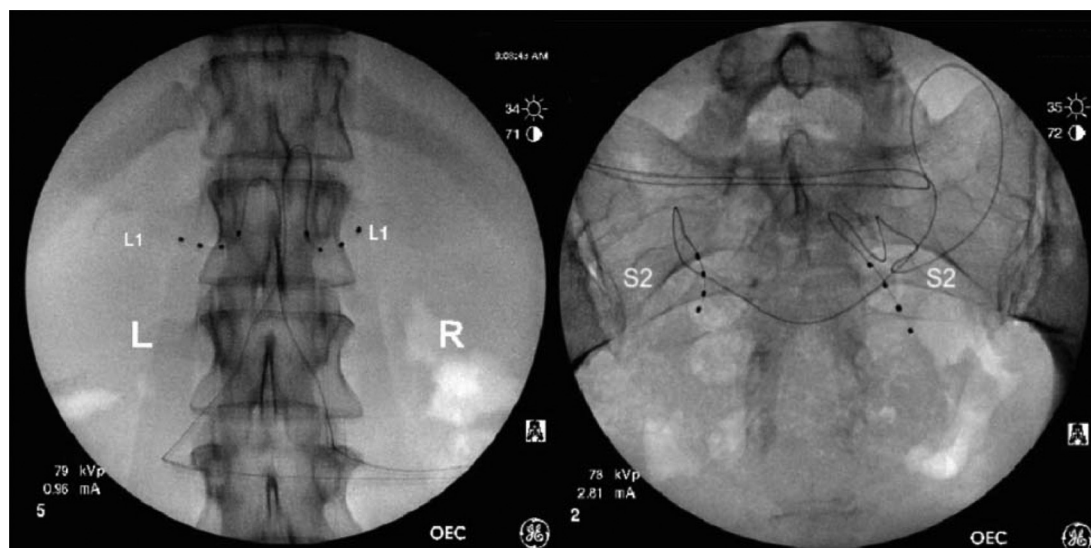


Figure 1. Left: bilateral L1 DRG lead placement; right: bilateral S2 DRG lead placement.

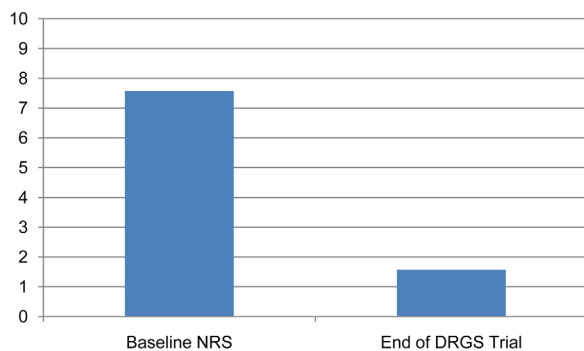


Figure 2. Mean pre- and post-trial NRS pain scores. [Color figure can be viewed at wileyonlinelibrary.com]

treatment as his penis swelled following the incident; however, he was ruled out for any trauma to his genitals that required intervention. In the seven months following the incident, he lived with a constant burning sensation in his entire penis and both testicles that seemed to alternate sides as to which felt more painful. Over time, the pain began to radiate into his toes in both feet with associated paresthesias. Furthermore, he reported experiencing a warm sensation in his genitals during defecation. He stated his pain as constant 7–8/10 on NRS and activities such as sitting, intercourse, and urination exacerbated the pain. Before his initial evaluation, he underwent a CT-guided block of the bilateral pudendal nerves with one week of pain relief—after which he reported the pain returned worse than before. During the initial consultation in our office, the patient declined pudendal nerve ablation and ganglion impar blocks as he felt they were temporizing options. DRGS was offered to which he agreed.

The patient later underwent DRGS trial with leads placed at the bilateral L1 and S2 DRG. Upon completion of a three-day trial, the patient reported complete coverage of the painful areas and a 60% reduction in pain as well as an improvement in his ability to urinate and have intercourse with minimal discomfort. The patient is awaiting a permanent implant.

PATIENT 5: LL

LL is a 63-year-old female with CPP following an infection of a sacral nerve stimulator for the treatment of chronic foot pain. The patient had a history of bilateral plantar fasciitis for which she underwent corrective surgeries in 2004. The operations were uncomplicated however her foot pain worsened. In 2007, she had SCS implanted with leads placed in a retrograde fashion into the bilateral S1 foramen. Approximately six months post-implant, she had the device explanted due to a Staphylococcal infection and epidural abscess that developed in and around the area of the leads. Upon removal of the system, her foot pain returned as well as a new onset of burning “nerve” pain at the rectum, perineum, and clitoris as well as an aching pain in the groin, vagina, and vulva. She reported having difficulty with expelling feces due to progressive weakness in her pelvic muscles. Her pain was 6/10 on NRS and exacerbated by sitting and lying supine.

In the nine years following the explant, the patient attempted oral anti-epileptics, anti-depressants and a range of interventional pain procedures (pudendal nerve, ganglion impar, hypogastric blocks, and a variety of nerve blocks in both feet)—none of which were capable of providing long-term pain relief. Given the presentation of her symptoms, we presented DRGS as an option, to which she agreed despite having some hesitation with regards to potentially developing another infection.

The patient subsequently underwent a DRGS trial with leads placed at the bilateral L1 and S2 levels. During the post-operative programming, the patient reported 100% coverage of the painful areas—this included her CPP as well as the foot pain that was previously treated with the prior SCS device. Complete pain relief lasted until the 3rd day of the trial when the left S2 lead migrated out of the correct position. The lead was revised which restored 100% coverage and resulted in 80% pain relief. Upon completion of a 10-day trial, the patient reported a global reduction in pain of 80%. The patient was implanted with a permanent device 44-days later.

At 12-months post-implant, the patient continues to report 80% pain relief (2/10) in both the pelvis and feet as well as beginning to wean off oral anti-epileptic medications she previously

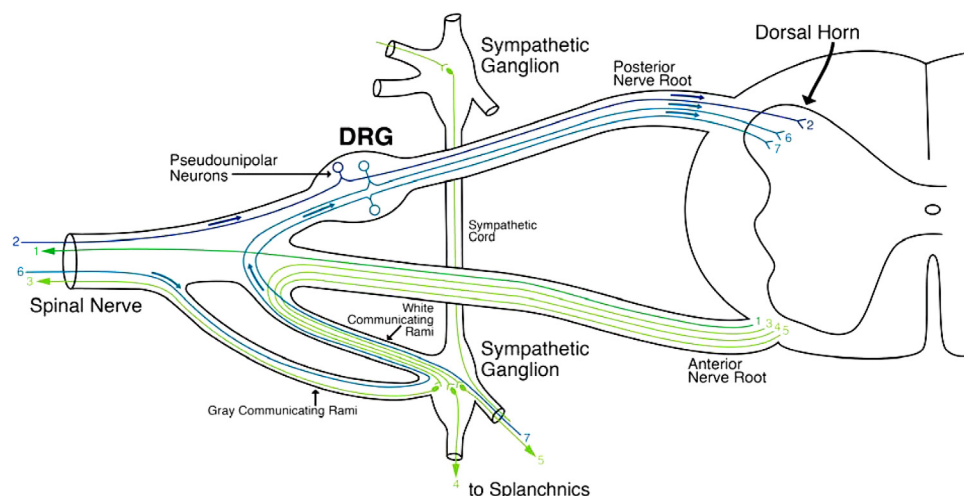


Figure 3. Illustration of the innervation of the spinal nerve, the nerve roots, and the DRG. (1. Somatic efferent, 2. Somatic afferent, 3,4,5. Sympathetic efferent, 6,7. Sympathetic afferent). [Color figure can be viewed at wileyonlinelibrary.com]

started for pain. Additionally, she reported improved sleep quality as she is now able to sleep comfortably in the supine position.

PATIENT 6: MR

MR is a 41-year-old male with chronic left testicular pain that radiates into glans penis and the left perineum. The pain began in 2004 after a fall. A pelvic MRI from 2012 was significant for “prominent varices of the pelvic floor effacing the inferior perineal branches of the pudendal distribution and coursing with the dorsal nerves to the penis.” Subsequently, the patient underwent a varicocelelectomy in 2013; the procedure successfully corrected the varices, however, the pain persisted. In 2009, he sought treatment with an outside pain physician and received repeated left pudendal nerve blocks that provided only temporary relief each time to part of the area of pain.

The patient was initially evaluated in our office in 2015 and at which time he reported his pain was 4/10 no NRS. Following a series of diagnostic blocks, he underwent a pulsed ablation to the left pudendal nerve and alcohol neurolysis of hypogastric plexus approximately two months apart. The patient reported a 50% pain reduction with each procedure. During that time, the patient also sought a second opinion from a surgeon who attributed his pain to symptomatic neuromas in the left perineal branch of the pudendal nerve and obturator nerve. The patient subsequently underwent neuroma resections a few months after the final neurolysis. The patient reported 90% improvement at two months following the neuroma resection, however at six months the original CPP returned as well as a new left groin pain. At this point, DRGS was discussed.

A DRGS trial was performed with leads placed at the left L1 and S2 levels. Upon completion of a seven day trial, the patient reported 100% pain relief. The patient is currently awaiting permanent implant.

PATIENT 7: NP

NP is a 42-year-old female with left-sided CPP following an arthroscopic debridement of the left hip in 2014 from a motor vehicle accident in 2011. The patient presented to our clinic in 2016—she described a left-sided “saddle pain” with radiation into the groin and reported her pain was 8/10 on NRS. From the time of her accident to our initial consult, the patient had received physical therapy, short-acting opioids, as well as pelvic floor injections with minimal, temporary improvement. Physical exam was significant for left ischial tenderness and decreased sensation to light touch in the left perineum.

The patient underwent a pair of left pudendal nerve blocks with >50% pain relief following each treatment for several hours—a subsequent diagnosis of pudendal neuralgia was made. A few weeks later, the patient underwent pulsed radiofrequency ablation to the left pudendal nerve that resulted in 75% pain improvement at two weeks. Approximately one month later, her pain had returned with slightly increased intensity to 9/10. Additionally, she developed a new “scorching” pain, radiating from her left buttock into the pelvic area as well as the inability to sit and worsening of symptoms with menstruation.

We discussed neuromodulation and ganglion impar ablation therapy with the patient—she chose neuroablation therapy due to the fear of an implanted device. The ganglion impar blocks

resulted in 70% pain relief however the ablation was less successful as her pain was only reduced to 6/10 at three weeks. At this point, the patient was willing to attempt a DRGS trial.

The leads were placed at the bilateral L1 and S2 levels and upon completion of a seven-day trial, the patient reported 100% coverage of the painful areas with 85% pain relief and significant improvement in her sitting tolerance. The patient is currently awaiting permanent implant.

DISCUSSION

The pelvic floor is a densely innervated region with a diverse network of somatic and autonomic fibers derived from the upper lumbar and sacral roots. It is this diversity and complexity that make it difficult to identify the lesion and/or pain generator for treatment. Combined with the frequent involvement of an extensive sympathetic nervous system (14,15), it should come as no surprise that CPP is difficult to treat. The challenge of managing a combination of somatic, neuropathic, and sympathetically-driven pain is evident by the limited success with conventional therapies—conservative, interventional and surgical, alike (4,12,21–23,25,45).

Neurolytic procedures (i.e., radiofrequency ablation, alcohol, and phenol) are effective; however, they may yield incomplete or transient relief—as found in the patients of our case series. The basic concept of neurolysis as a treatment for pain is predicated on the rationale of disrupting a pain pathway while sparing the perineurium and epineurium that allows the nerve to regenerate (17). It is this regeneration that necessitates repeated ablations.

In addition to the procedure-related risks associated with repeated nerve ablation, recurrent nerve regeneration increases the chances of misdirected or improper nerve formation—this may, in turn, result in inappropriate target connection and/or cross-talk between neuronal tissues (i.e., glia, axon and neurotrophic factors, etc.) (18). This neuronal maladaptation may explain evolving pain and new symptom manifestations following neurolysis in patients with CPP. This persistence to communicate pain is further compounded by the presence of anatomical variants within an already diverse sympathetic nervous system (46–48). We believe it is this maladaptive neuroplasticity and extensive sympathetic nervous system that causes CPP to be recalcitrant to so many treatments, most notably SCS.

When one considers the temporary and reversible nature of a DRGS trial as well as the reports of complete pain relief as demonstrated in this case series, it is justifiable to consider it before proceeding with a neurolytic procedure, even in light of a positive diagnostic block.

PROPOSED MECHANISM OF L1/S2 DRG LEAD CONFIGURATION

In 2015, Krames extensively reviewed the neuroanatomy and physiology of the DRG to demonstrate its appropriateness as a target for neuromodulation in the management of chronic, neuropathic pain (49). Since then, a number of publications has come forth, including a multi-centered, prospective trial, demonstrating the efficacy of DRGS with pain conditions and/or body parts that were traditionally thought to be implausible with SCS. Most notably, the ACCURATE study showed the superiority of DRGS over SCS in the treatment of CRPS—a condition known to be refractory

to SCS over time (39). In addition, the study demonstrated unquestionable efficacy in its ability to capture the foot—a body part that has posed a problem for neuromodulators (36,37,50).

The pelvic region, much like the foot, has been a problem with SCS insofar as capturing the region consistently and/or doing so without causing collateral stimulation in unwanted, nearby areas (37). A combination of somatic and sympathetic fibers transmitting pain signals in this particular cohort are likely to compound the failure of SCS in the setting of CPP.

The efficacy of DRGS is believed to stem from its capacity to act simultaneously at the levels of the T-junction and the spinal somatotopic organization as well as its ability to cause upstream and downstream effects (49). The DRG, itself, is considered the intersection of somatic sensory innervation and the confluence of sympathetic afferents (Fig. 3). Stimulating the “right” DRG in a patient with CPP will cause profound upstream and downstream changes in both the somatic and sympathetic pathways, thus affecting both of the involved conduits. The downstream effects on the sympathetic afferents present within the DRG are likely what gives DRGS the ability to communicate with adjacent ganglia. This “crosstalk” grants DRGS the capacity to provide the broader coverage necessary to treat CPP that would seem counterintuitive to this remarkable therapy.

The electrophysiology of the spinal cord dictates that sympathetic afferent signals originating caudal to L2 (i.e., the abdomen and pelvis) travel by postganglionic fibers to the corresponding grey rami communicans before joining the paravertebral sympathetic chain. The signals continue to move cephalad along the sympathetic chain toward L2, or possibly higher, until the white rami communicans begin. At this point the fibers will synapse within the adjacent paravertebral ganglion and transition to the white rami communicans to ultimately gain entry into the DRG and ultimately the central nervous system. Similarly, sensory afferent signals that originate from a single DRG also travel one to two segments above and below before entering the spinal cord to converge on a synaptic terminal (51,52). Therefore, stimulating a single DRG may also result in the disruption of pain at 1 to 2 level(s) above and below the index level of stimulation—thus the ability for DRGS to gain entry into adjacent pathways not being directly stimulated.

Stimulating the L1 DRG will efficiently modulate pain signals carried by the upper portion of the lumbar plexus: ilioinguinal (L1–2), iliohypogastric (L1–2) and genitofemoral (L1–2) nerves. More importantly, L1 is the most cephalad segment where pain signals from below L2 could make the transition to continue to propagate into the brain via white rami communicans. Modulating L1 DRG fundamentally “closes the gate” to pain conduits in the L1–2 somite. Similarly, stimulation of the S2 DRG will interrupt signals from the lower portion of the lumbar (L5/S1) plexus, the entire sacral plexus and S2–3; this should provide sufficient coverage to disrupt afferent input from the foot and toes as well as pelvic pain originating from pudendal nerve (S2–S4) and sacral splanchnic sympathetic plexus. At the dorsal horn, upstream from the DRG, DRGS reduces the hyperexcitable sodium channels and increases the calcium ion influx, thus decreasing the firing of both A δ and C fibers that innervate lamina I (marginal zone) and lamina II (substantia gelatinosa) in the anterolateral system (53,54).

Given the relative anatomy of the pelvic region and the collateral pathways present, the L1–S2 DRG lead configuration is a logical method to modulate signals that originate from the lower abdomen (L1–2), groin (L1–2) and pelvis (S2, S3, S4). In the course of investigating this unique array, we investigated what role these

DRG played when stimulated individually, rather than collectively. During the initial routine programming phase that immediately followed lead placement, each lead was turned on in isolation to map paresthesias and gauge the stimulation requirements at that particular level. Leads placed at the L1 level modulated L1 dermatome with involvement of the groin, just short of the genital/perineum region. Likewise, S2 lead activation preferentially involved the leg and buttock, but once again just shy of the pelvic area. It was only when these were stimulated in tandem that the relevant regions of the pelvis were acquired; this occurred in unilateral cases as well as bilateral.

Case and point: patient 5 (LL), reported a significant reduction in coverage and efficacy on trial day #3. Despite the fact that the left L1 lead was still in proper position, the fact that the left S2 had migrated out caused the overall efficacy of the treatment to drop precipitously. The efficacy was restored once the S2 lead was revised and reactivated. Our observation confers a reasonable support that stimulating both the L1 and S2 DRG simultaneously induces a synergy that augments a treatment effect otherwise unobtainable with a single-level stimulation. Further electrophysiological research is needed.

CONCLUSION

Like most neuropathic pain states, CPP is resilient, challenging to manage, and often recalcitrant to conventional therapy, including neurolysis. Our case series not only demonstrates the utility of DRGS with this particular subset of patients, but it illustrates the specific targets needed to provide comprehensive coverage to an elusive region that has plagued neuromodulators for decades. The unique lead configuration utilized here was extremely efficacious despite the distinctly different underlying etiologies of each patient. Larger comparative studies are needed to establish the applicability and future standards of DRGS for managing CPP.

Authorship Statements

Drs. Hunter and Yang designed and conducted the study, including data collection and data analysis. Drs. Hunter and Yang prepared the manuscript, jointly. The statistical analysis was performed by Dr. Yang. Drs. Hunter and Yang had complete access to the study data.

How to Cite this Article:

Hunter C.W., Yang A. 2019. Dorsal Root Ganglion Stimulation for Chronic Pelvic Pain: A Case Series and Technical Report on a Novel Lead Configuration. *Neuromodulation* 2019; 22: 87–95

REFERENCES

- Mathias SD, Kuppermann M, Liberman RF, Lipschutz RC, Steege JF. Chronic pelvic pain: prevalence, health-related quality of life, and economic correlates. *Obstet Gynecol* 1996;87:321–327.
- Green IC, Cohen SL, Finkenzeller D, Christo PJ. Interventional therapies for controlling pelvic pain: what is the evidence?. *Curr Pain Headache Rep* 2010;14: 22–32.

3. Stones RW, Selfe SA, Fransman S, Horn SA. Psychosocial and economic impact of chronic pelvic pain. *Baillieres Best Pract Res Clin Obstet Gynaecol* 2000;14:415–431.
4. Hunter C, Dave N, Diwan S, Deer T. Neuromodulation of pelvic visceral pain: review of the literature and case series of potential novel targets for treatment. *Pain Pract* 2013;13:3–17.
5. Reiter RC, Gambone JC. Demographic and historic variables in women with idiopathic chronic pelvic pain. *Obstet Gynecol* 1990;75:428–432.
6. ACOG Committee on Practice Bulletins–Gynecology. ACOG Practice Bulletin No. 51. Chronic pelvic pain. *Obstet Gynecol* 2004;103:589–605.
7. Fall M, Baranowski AP, Elneil S et al. EAU guidelines on chronic pelvic pain. *Eur Urol* 2010;57:35–48.
8. Wampler SM, Llanes M. Common scrotal and testicular problems. *Primary Care* 2010;37:613–626.
9. Blost K, Pierson R. Endometriosis and chronic pelvic pain: unraveling the mystery behind this complex condition. *Nurs Womens Health* 2008;12:382–395.
10. Ignacio EA, Dua R, Sarin S et al. Pelvic congestion syndrome: diagnosis and treatment. *Semin Intervent Radiol* 2008;25:361–368.
11. Kuponiyi O, Alleemudder DI, Latunde-Dada A, Eedarapalli P. Nerve injuries associated with gynaecological surgery. *Obstet Gynaecol* 2014;16:29–36.
12. Robert R, Labat JJ, Bensignor M et al. Decompression and transposition of the pudendal nerve in pudendal neuralgia: a randomized controlled trial and long-term evaluation. *Eur Urol* 2005;47:403–408.
13. Plancarte R, Amescua C, Patt RB, Aldrete JA. Superior hypogastric plexus block for pelvic cancer pain. *Anesthesiology* 1990;73:236–239.
14. Kitoh T, Tanaka S, Ono K, Ohfusa Y, Ina H, Otagiri T. Combined neurolytic block of celiac, inferior mesenteric, and superior hypogastric plexuses for incapacitating abdominal and/or pelvic cancer pain. *J Anesth* 2005;19:328–332.
15. Ahmed DG, Mohamed MF, Mohamed SA. Superior hypogastric plexus combined with ganglion impar neurolytic blocks for pelvic and/or perineal cancer pain relief. *Pain Physician* 2015;18:E49–E56.
16. Plancarte R, de Leon-Casasola OA, El-Helaly M, Allende S, Lema MJ. Neurolytic superior hypogastric plexus block for chronic pelvic pain associated with cancer. *Reg Anesth* 1997;22:562–568.
17. Campbell WW. Evaluation and management of peripheral nerve injury. *Clin Neuropsychol* 2008;119:1951–1965.
18. Grinsell D, Keating CP. Peripheral nerve reconstruction after injury: a review of clinical and experimental therapies. *BioMed Res Int* 2014;2014:1.
19. Yang A, Ramscook RR, Hunter, CW. Retrograde ejaculation following lumbopelvic sympathetic neurolysis - a case series. *Interv Pain Manag Reports* 2017;1:133–142.
20. Hayek SM, Veizi E, Hanes M. Treatment-limiting complications of percutaneous spinal cord stimulator implants: a review of eight years of experience from an academic center database. *Neuromodulation* 2015;18:603–608.
21. Levy RM. Anatomic considerations for spinal cord stimulation. *Neuromodulation* 2014;17 Suppl 1:2–11.
22. Holsheimer J, Barolat G. Spinal geometry and paresthesia coverage in spinal cord stimulation. *Neuromodulation* 1998;1:129–136.
23. Barolat G, Massaro F, He J, Zeme S, Ketcik B. Mapping of sensory responses to epidural stimulation of the intraspinal neural structures in man. *J Neurosurg* 1993;78:233–239.
24. Al Tamimi M, Davids HR, Barolat G, Krusch J, Ford T. Subcutaneous peripheral nerve stimulation treatment for chronic pelvic pain. *Neuromodulation* 2008;11:277–281.
25. Stuart RM, Winfree CJ. Neurostimulation techniques for painful peripheral nerve disorders. *Neurosurg Clin N Am* 2009;20:111.
26. Kapural L, Narouze SN, Janicki TI, Mekhail N. Spinal cord stimulation is an effective treatment for the chronic intractable visceral pelvic pain. *Pain Med* 2006;7:440–443.
27. Alo KM, McKay E. Selective nerve root stimulation (SNRS) for the treatment of intractable pelvic pain and motor dysfunction: a case report. *Neuromodulation* 2001;4:19–23.
28. Alo KM, Yland MJ, Redko V, Feler C, Naumann C. Lumbar and sacral nerve root stimulation (NRS) in the treatment of chronic pain: a novel anatomic approach and neuro stimulation technique. *Neuromodulation* 1999;2:23–31.
29. Richter EO, Abramova MV, Alo KM. Percutaneous cephalocaudal implantation of epidural stimulation electrodes over sacral nerve roots—a technical note on the importance of the lateral approach. *Neuromodulation* 2011;14:62–67.
30. Rowland DC, Wright D, Moir L, Fitzgerald JJ, Green AL. Successful treatment of pelvic girdle pain with dorsal root ganglion stimulation. *Br J Neurosurg* 2016;30:685.
31. Janicki TI. Chronic pelvic pain as a form of complex regional pain syndrome. *Clin Obstet Gynecol* 2003;46:797–803.
32. Harden RN, Bruehl S, Stanton-Hicks M, Wilson PR. Proposed new diagnostic criteria for complex regional pain syndrome. *Pain Med* 2007;8:326–331.
33. Gopal H, Fitzgerald J, McCrory C. Spinal cord stimulation for FBSS and CRPS: a review of 80 cases with on-table trial of stimulation. *J Back Musculoskelet Rehabil* 2016;29:7–13.
34. Geurts JW, Smits H, Kemler MA, Brunner F, Kessels AG, van Kleef M. Spinal cord stimulation for complex regional pain syndrome type I: a prospective cohort study with long-term follow-up. *Neuromodulation* 2013;16:523–529.
35. Kemler MA, Raphael JH, Bentley A, Taylor RS. The cost-effectiveness of spinal cord stimulation for complex regional pain syndrome. *Value Health* 2010;13:735–742.
36. Kellner CP, Kellner MA, Winfree CJ. Spinal nerve root stimulation. *Prog Neurol Surg* 2011;24:180–188.
37. Falowski S, Celii A, Sharan A. Spinal cord stimulation: an update. *Neurotherapeutics* 2008;5:86–99.
38. Kemler MA, de Vet HC, Barendse GA, van den Wildenberg FA, van Kleef M. Effect of spinal cord stimulation for chronic complex regional pain syndrome Type I: five-year final follow-up of patients in a randomized controlled trial. *J Neurosurg* 2008;108:292–298.
39. Deer TR, Levy RM, Kramer J et al. Dorsal root ganglion stimulation yielded higher treatment success rate for complex regional pain syndrome and causalgia at 3 and 12 months: a randomized comparative trial. *Pain* 2017;158:669–681.
40. Deer TR, Grigsby E, Weiner RL, Wilcosky B, Kramer JM. A prospective study of dorsal root ganglion stimulation for the relief of chronic pain. *Neuromodulation* 2013;16:67–71.
41. Hunter CW, Yang A, Davis T. Selective radiofrequency stimulation of the dorsal root ganglion (DRG) as a method for predicting targets for neuromodulation in patients with post amputation pain: a case series. *Neuromodulation* 2017; 20:708–718.
42. Yang A, Hunter CW. Dorsal root ganglion stimulation as a salvage treatment for complex regional pain syndrome refractory to dorsal column spinal cord stimulation: a case series. *Neuromodulation* 2017;20:703.
43. Kramer J, Liem L, Russo M, Smet I, Van Buyten JP, Huygen F. Lack of body positional effects on paresthesias when stimulating the dorsal root ganglion (DRG) in the treatment of chronic pain. *Neuromodulation* 2015;18:50–57.
44. van Bussel CM, Stronks DL, Huygen FJ. Successful treatment of intractable complex regional pain syndrome type I of the knee with dorsal root ganglion stimulation: a case report. *Neuromodulation* 2015;18:58–60.
45. Mockus MB, Rutherford RB, Rosales C, Pearce WH. Sympathectomy for causalgia. Patient selection and long-term results. *Arch Surg* 1987;122:668–672.
46. Rocco AG, Palombi D, Raake D. Anatomy of the lumbar sympathetic chain. *Reg Anesth* 1995;20:13–19.
47. Hong JH, Oh MJ. Comparison of multilevel with single level injection during lumbar sympathetic ganglion block: efficacy of sympatholysis and incidence of psoas muscle injection. *Korean J Pain* 2010;23:131–136.
48. Kim WH, Kim SK, Lee CJ, Kim TH, Sim WS. Determination of adequate entry angle of lumbar sympathetic ganglion block in Korean. *Korean J Pain* 2010;23:11–17.
49. Krames ES. The dorsal root ganglion in chronic pain and as a target for neuromodulation: a review. *Neuromodulation* 2015;18:24–32.
50. Song JJ, Popescu A, Bell RL. Present and potential use of spinal cord stimulation to control chronic pain. *Pain Physician* 2014;17:235–246.
51. Szentagothai J. Neuronal and synaptic arrangement in the substantia Gelatinosa Rolandi. *J Comp Neurol* 1964;122:219–239.
52. Kato G, Furue H, Katafuchi T, Yasaka T, Iwamoto Y, Yoshimura M. Electrophysiological mapping of the nociceptive inputs to the substantia gelatinosa in rat horizontal spinal cord slices. *J Physiol* 2004;560:303–315.
53. Amir R, Michaelis M, Devor M. Membrane potential oscillations in dorsal root ganglion neurons: role in normal electrogenesis and neuropathic pain. *J Neurosci* 1999;19:8589–8596.
54. Koopmeiners AS, Mueller S, Kramer J, Hogan QH. Effect of electrical field stimulation on dorsal root ganglion neuronal function. *Neuromodulation* 2013;16:304–311.

COMMENTS

The authors report a preliminary series of DRG stimulation for pelvic pain, utilizing a novel lead configuration i.e. a combination of L1 and S2 leads. This is an excellent study that combines an innovative idea with a logical approach. The results speak for themselves in that the combination was successful in all seven cases. The authors present a logical argument for this approach with a robust presentation of data. The authors should be commended for working out this approach which is promising for potentially millions of patients with inadequately treated chronic pelvic pain worldwide. I think a larger study with longer follow up is certainly warranted.

Alexander Green, MD, BSc, MB BS
Oxford, United Kingdom

CPP encompasses multiple different pain problems which are frequently very difficult to treat. The patients described in this series had pain of several different etiologies with varying distributions in the pelvic area and are a good illustration of this challenging patient group. DRG stimulation frequently exhibits spread of effect for at least one dermatome either side of the treated ganglion, for example pain in the foot (L4/L5/S1) can often respond to a single lead at L5.

What is particularly interesting about the treatment of pelvic pain however, is that it seems that it can be accomplished from two separate areas of the spine, the low thoracic/upper lumbar region and the sacrum. Patients with pelvic pain have been successfully treated in the past using either approach, and the use of a combination of upper lumbar leads and sacral leads to cover both possibilities as described in this article is therefore a logical step forward. A key question is whether the use of both in combination is critical to the response (i.e. is there a synergistic effect only available with both lumbar and sacral stimulation simultaneously?) or whether the dual approach is simply ensuring that we have access to the most effective levels in each case. It may be that the answer to this differs amongst the various causes or exact locations of CPP.

James Fitzgerald, MA BM BCh PhD
Oxford, United Kingdom

Comments not included in the Early View version of this paper.