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Use of Peripheral Nerve Stimulation and Perineural Catheter to Treat Phantom Limb Pain in a Multiple Limb Amputee: Case Report

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Background: Limb loss is a debilitating condition affecting many Americans and approximately 80% go on to suffer phantom limb pain (PLP). Peripheral nerve stimulation (PNS) and perineural catheter (PC) placement are promising treatment options for PLP.

Case Report: We present a 36-year-old man, who underwent right transhumeral and right transtibial amputations following a work-related accident. He developed significant PLP of both limbs. The right upper extremity PLP was treated first during the inpatient hospital course with a 5-day infusion of 0.5% ropivacaine via a PC. The right lower extremity PLP was later addressed in the outpatient setting with a diagnostic right sciatic/saphenous nerve block followed by a 60-day PNS lead placement, which provided > 50% pain relief from baseline. The patient continues to have > 50% pain relief in his RLE nearly 9 months after the initial procedure.

Conclusions: Our case adds to a growing body of evidence that supports the utility of PNS and PC. Future studies should explore whether early intervention with PNS could improve long-term outcomes. In addition, clinicians could consider the use of a PC for intractable PLP as an opioid-sparing strategy in the inpatient setting where close monitoring is feasible.

Key words: Phantom limb pain, traumatic amputation, peripheral nerve stimulation, perineural catheter

BACKGROUND

Limb loss is a debilitating condition affecting 1.6 million Americans (1). Of these, approximately 80% go on to suffer phantom limb pain (PLP), a neuropathic condition characterized by throbbing, burning, or electric shock-like sensations in the absent limb (2). A wide range of treatment options exist - pharmacologic agents, such as anticonvulsants (i.e., gabapentin, pregabalin), antidepressants (i.e., amitriptyline, duloxetine), and opioids, are commonly used but are often inadequate to provide acceptable analgesia (3). Mirror therapy and transcutaneous electrical nerve stimulation units are easily accessible and affordable treatment options with generally good therapeutic effects against PLP (4,5). Alternatively, targeting of the dorsal root ganglion with low-dose lidocaine infusion could be another promising treatment option (6). For those who fail pharmacologic and alternative therapies,

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peripheral nerve stimulation (PNS) and perineural catheter (PC) placement are promising treatment options for PLP. We present a case of a 36-year-old man who underwent 5-day PC placement and 60-day PNS lead placement (SPRINT, SPR Therapeutics, Cleveland, OH) for the treatment of PLPs.

CASE REPORT

A 36-year-old man presented to the trauma bay in critical condition following a 15-foot fall from a telephone pole that subsequently fell on top of the patient resulting in traumatic partial amputation of the right upper extremity (RUE) and crush injury of the right lower extremity (RLE). The patient was taken emergently to the operating room where both limbs were determined to be unsalvageable. He subsequently underwent right transhumeral amputation and partial right foot amputation involving toes 1 through 4. The patient's hospital course was prolonged by multiple returns to the operating room for additional debridement, right transtibial amputation due to infection, and issues of difficult pain management throughout the care continuum. In the initial period, the patient experienced significant PLP of the RUE worse than the RLE despite a strong multimodal regimen, including high doses of opioids, anticonvulsants, and antidepressants. The inpatient acute pain service team performed a single-shot (0.2% ropivacaine) brachial plexus block a week after the initial surgery, which provided significant pain relief for 24 hours. A PC was subsequently placed and remained near the right brachial plexus for 5 days providing significant pain relief and reduction in opioid requirements during this time. The patient was successfully transitioned to a rehabilitation facility after a 23-day hospital stay.

Upon follow-up clinic visit, the patient was suffering significant PLP of the RLE (worse than RUE). Diagnostic right sciatic nerve block (12 mL of 1:1 mixture of 0.5% bupivacaine and 2% lidocaine) via the subgluteal approach and saphenous nerve block (5 mL of 1:1 mixture of 0.5% bupivacaine and 2% lidocaine) via the adductor canal were performed providing 75% to 80% pain relief for up to 1.5 hours. This was followed by a 60-day PNS lead placement providing > 50% pain relief from baseline.

As of today, the patient continues to have > 50% pain relief in his RLE nearly 9 months after the initial procedure. However, the patient now suffers from worsened RUE PLP. A diagnostic RUE brachial plexus block was performed in recent months achieving complete pain relief for several hours. We are currently waiting for approval from workers' compensation to proceed with RUE PNS lead placement.

DISCUSSION

The pathophysiology of PLP is complex. Prevailing theories cite somatosensory reorganization at the cortical level, neuroma formation of injured PNs, and aberrant signaling from the neuronal cell bodies as underlying mechanisms of PLP (7). PNS is a potential treatment option for PLP that works by directly applying electrical stimulation to the injured nerve thereby altering nociceptive signaling (8).

The data regarding the short-term efficacy of temporary PNS is generally positive; however, more data is needed to elucidate the long-term efficacy. A randomized controlled trial by Albright-Trainer et al (9) showed a significant reduction in PLP, residual limb pain , and opioid consumption at 3 months for those who underwent PNS lead placement in the acute postoperative period following LE amputation. The data collection and analysis are ongoing for 6-month and 12-month time points (9). Similarly, a randomized controlled trial by Gilmore et al (10) showed that 67% of patients (6 of 9) who underwent a 60-day PNS trial went on to experience significant pain relief at 12 months compared to placebo. These findings suggest the effects of temporary PNS could be long-lasting and a permanent device implantation could be avoided altogether. However, a more recent case series (11) of 3 patients who underwent temporary PNS placement suffered reemergence of PLP within 1 to 3 months suggesting the positive effects of PNS may be short-lived in some.

Our patient underwent a 60-day RLE PNS lead placement approximately 2 months after the initial surgery and continues to experience sustained pain relief of > 50% from baseline after 9 months from PNS lead placement. There are several proposed mechanisms of PNS. It involves direct stimulation of large diameter nonnociceptive Aβ nerve fibers, which interfere with neuronal signals from smaller nociceptive Aδ and C nerve fibers thereby preventing transmission of pain signals. Other proposed mechanisms by which PNS affects pain signaling are its ability to reduce hyperexcitability of injured neurons, suppress dorsal horn activity, alter neurotransmitter levels, and modulate central nervous system activity (12). The wide-ranging effects of PNS on the nociceptive pathway could explain why

many patients go on to experience sustained pain relief from PLP.

We hypothesize that early PNS lead placement could be an important component of long-term pain relief. There is evidence showing that hyperalgesia and allodynia originate from synaptic changes in the spinal dorsal horn and gene expression contributing to lasting changes of the nociceptive pathway (13). This suggests there are learning and memory implicated in the development of long-term pain. Thus, early intervention may attenuate some of the synaptic changes involved in the pain signaling pathways thereby preventing the development of PLP altogether.

The use of a short-course PC for the treatment of PLP is another interesting aspect of this case. Borghi et al (14) first reported the use of a PC to treat severe postamputation PLP. After a 28-day course of continuous ropivacaine infusion, the patient went on to experience complete resolution of PLP at subsequent follow-up time points of 6, 12, 24, and 36 months (14). More recently, a randomized controlled trial (15) comparing a 6-day PC placement (i.e., continuous ropivacaine infusion) to a placebo (i.e., normal saline) showed a significant reduction in the intensity of PLP in the treatment group after 4 weeks. Our patient experienced significant pain relief after the placement of a PC near the brachial plexus during his inpatient hospital course. However, the therapeutic effect was short-lived and PLP returned almost immediately after removal of the catheter. Despite our experience, evidence supporting the utility of PCs seems promising. The use of PCs can be a useful adjunct to manage acute PLP, particularly in the inpatient setting where close monitoring is feasible, rather than as a component of the management of this pain in the outpatient chronic pain setting.

CONCLUSIONS

Overall, our case adds to a growing body of evidence that supports the utility of PNS in treating PLP, with several proposed mechanisms. Future studies should explore the temporal relationship between this therapy and pain-related outcomes. In addition, clinicians could consider the use of PCs in intractable PLP, especially in the acute setting where close monitoring is feasible.

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