Case Report

Combined Spinal Cord Stimulation and Peripheral Nerve Stimulation for Brachial Plexopathy: A Case Report

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Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: Each author certifies 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.

Manuscript received: 08-06-2015
Accepted for publication: 09-15-2015

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Brachial plexopathy usually results from an iatrogenic brachial plexus injury and can sometimes cause severe chronic pain and disability. There are a number of possible treatments for this condition, including medication, physical therapy, nerve blocks, and neuromodulation, but they are not always successful. Recently, combined spinal cord stimulation (SCS) and peripheral nerve stimulation (PNS) have been tried for various chronic pain diseases because of their different mechanisms of action.

Here, we describe the case of a 54-year-old man who was diagnosed with brachial plexopathy 8 years ago. He underwent video-assisted thoracoscopic surgery to remove a superior mediastinal mass. However, his brachial plexus was damaged during the surgery. Although he had received various treatments, the pain did not improve. For the management of intractable severe pain, he underwent SCS 2 years ago, which initially reduced his pain from numeric rating scale (NRS) 10/10 to NRS 4 – 5/10, but the pain then gradually increased, reaching NRS 8/10, 6 months ago. At that time, he was refractory to other treatments, and we therefore applied PNS in combination with SCS. The PNS electrode was positioned on the radial nerve under ultrasound guidance. After combined PNS and SCS, his background pain disappeared, although a breakthrough pain (NRS 3 – 4/10) was caused intermittently by light touch. Furthermore, the patient's need for analgesics decreased, and he was satisfied with the outcome of this combined treatment.

We concluded that combined SCS and PNS is a very useful treatment modality, which can stimulate the target nerve both directly and indirectly, and hence, relieve pain from brachial plexopathy.

Key words: Brachial plexopathy, spinal cord, peripheral nerve, stimulation, ultrasound, neuropathic

Pain Physician 2016; 19:E459-E463

The brachial plexus is a complex structure that is vulnerable to trauma due to its size and location (1-3), and in particular thoracoscopic surgery can increase the risk of a brachial plexus injury (4). In general, the management of brachial plexopathy includes medication and surgical repair (2,5,6), although many cases are refractory to these conventional treatments.

Neuromodulation through techniques, such as spinal cord stimulation (SCS), peripheral nerve stimulation (PNS), deep brain stimulation (DBS), and motor cortex stimulation (MCS), can be used to treat intractable chronic pain (7,8). SCS is based on the gate control theory proposed by Melzack and Wall, in which changes in pain perception depend on the differential activation of small and large neural fibers (9,10). PNS,

however, is based on a different mechanism, whereby pain reduction is achieved through the direct stimulation of peripheral nerves and the inhibition of primary afferents (9). Recently, combined SCS and PNS have been tried for various conditions, such as post herniorrhaphy pain and failed back surgery syndrome, because of their different mechanisms of action (11-14).

In this case, we report the successful management of recurrent pain from brachial plexopathy, which was achieved using combined SCS and PNS, despite the initial failure of SCS alone. To our knowledge, this is the first report of combined SCS and PNS for intractable brachial plexopathy.

Case Report

A 54-year-old man underwent video assisted thoracoscopic surgery (VATS) for the excision of a superior mediastinal mass (schwannoma) 8 years ago. After surgery, Honor's syndrome, left upper extremity pain, and a tingling sensation persisted. Physical examination revealed hyperalgesia, allodynia, and hypoesthesia on the medial and posterior forearm, but no motor weakness. Although thenar muscle atrophy was identified, the pain was localized to the medial and posterior forearm, especially in areas innervated by the posterior and medial antebrachial cutaneous nerves. The patient's numeric rating scale (NRS) (0, no pain; 10, worst pain imaginable) was 8 – 9/10. An electromyography (EMG) study revealed that this was compatible with left brachial plexopathy, mainly involving the medial cord. He had been treated with medications, including pregabalin 300 mg/day, nortriptyline 10 mg/day, and oxycodone 80 mg/day, and pain interventions such as stellate ganglion, brachial plexus, and cervical epidural blocks. However, his pain was refractory to these treatments; therefore, he underwent SCS 2 years ago. The percutaneous electrical lead was placed at the level of C3-C6. After SCS, the patient's NRS decreased to 3 – 4/10, and he was satisfied with the outcome of the procedure. However, his pain then worsened gradually over the following 6 months, with the NRS increasing to 6 – 7/10. The pain was mainly in his posterior forearm, reflecting the radial nerve distribution. At that time, we confirmed that the implantable pulse generator (IPG) worked well, and the position of the electrode was found not to have changed upon x-ray imaging. Therefore, we decided to add PNS to SCS for improved pain control. We tried several ultrasound guided brachial plexus blocks under local anesthetic (1 mL of 1% lidocaine) for selecting the target nerve for PNS and confirmed that the radial nerve was the most appropriate target.

The procedure was performed under intravenous anesthesia using an appropriate propofol and remifentanil mixture after administration of preventive antibiotics. An electrical lead (Medtronic Inc., Minneapolis, MN, USA) was placed on the radial nerve under ultrasound guidance (Fig. 1). An infraclavicular approach was originally planned, but was not possible due to the

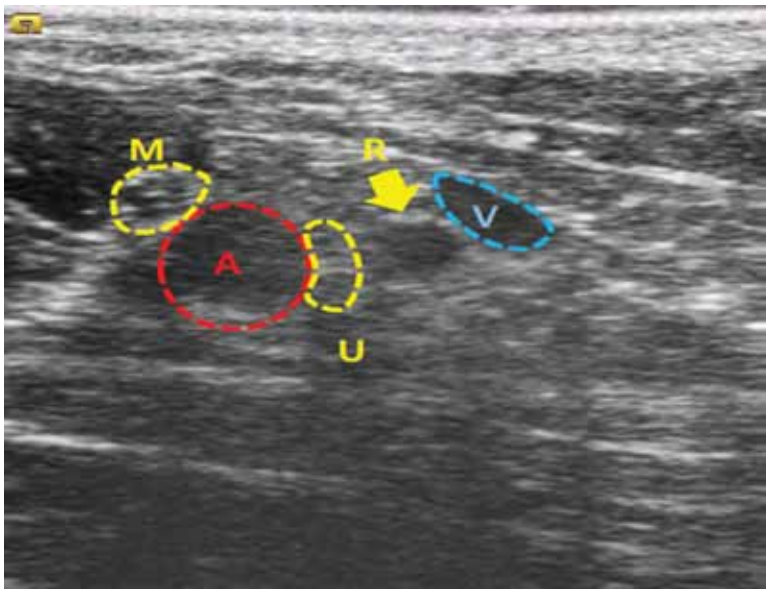

Fig. 1. *Ultrasound imaging of the brachial plexus showing the median nerve (M), ulnar nerve (U), radial nerve (R and arrow), axillary vein (V), and axillary artery (A).*

patient's muscular physique. The electrical lead was an 8-pole percutaneous type, and its correct position was ascertained by electrical stimulation. The PNS electrode was connected to the pre-existing IPG on the patient's left lower abdomen. SCS and PNS could then both be used for good coverage of the stimulation.

The patient's background pain disappeared after the procedure, and only breakthrough pain remained that was NRS 3 – 4/10 and caused by light touch. The need for medication was also reduced from oxycodone 40 mg/day and pregabalin 450 mg/day to tramadol 100 mg/day and pregabalin 150 mg/day. Six months later the electrical coverage was still maintained well, and the patient reported improved sleep and a better functional status.

Fig. 2. *Position of the spinal cord and peripheral nerve stimulation catheters.*

Discussion

Neurogenic tumors of the mediastinum such as schwannoma are known as neurilemoma, and are uncommon neoplasms arising from nerve tissues within the thorax. Surgery for a neurogenic tumor in the thorax carries a risk of brachial plexus injury due to its location and the need for associated procedures such as suction and electrocoagulation, especially in the VATS (4). The anatomically inferior trunk (C8 + T1) of the brachial plexus is close to the visceral pleura of the lung apex and connects to the medial and posterior cord, the terminal branch of which consists of the sensory nerve of the forearm, the medial antebrachial cutaneous nerve, and the radial nerve (4,15). In the case we describe here, the patient complained of pain in the medial and posterior forearm, and the EMG finding suggested a medial cord injury.

SCS is based on the gate control theory, in which the stimulation of large afferent fibers in the dorsal column causes pain signals carried by the small fibers to be blocked at the spinal cord (10). Clinically, SCS is very useful for the treatment of many refractory chronic pain disorders (16). However, SCS has a number of disadvantages, one of which is stimulation tolerance, defined as a progressive loss of pain control despite the presence of a fully functioning stimulating system (17). The onset and duration of tolerance is not definite (18). In our case, it might be reasonable to assume that the recurrence of forearm pain was mainly caused by stimulation tolerance because there were no changes in the electrical lead position.

PNS can also be explained by the gate-control theory of pain (19). In addition, repetitive electrical stimulation of peripheral nerves blocks cell membrane depolarization, which suppresses axonal conduction (20). In an experimental study, an electrical stimulation of the peripheral nerve affected not only the nerve itself, but also the spinal cord dorsal horn by delivering an inhibitory input into the pain pathways at the spinal cord (21,22). There are few well-designed studies on the effectiveness of PNS to date. A few retrospective studies

found that PNS could be useful for reducing intractable chronic pain (23-26). A conventional technique for the trial and implantation of PNS requires surgery for the detailed dissection of the target nerve under general anesthesia (19,27). However, insertion of the electrical leads for PNS is becoming easier to achieve through the use of ultrasound guidance (27-29).

It remains unclear whether SCS and PNS have additive effects on pain control, but trials of combined SCS and PNS for a variety of difficult conditions have shown them to be effective (11-14,30,31), probably because they have different mechanisms of action (11,13,30). In the case of post-herniorrhaphy pain, SCS seems to be more effective at suppressing radiating pain in the leg, while PNS seems to be more effective in treating local burning or aching sensations in the inguinal area (12,13). In this case, we confirmed the additive effects of SCS and PNS by operating each device alternatively.

This case report is limited as it only involved one patient and had a relatively short follow-up duration. Further studies on the additive effect of different neuromodulations, for example SCS vs. PNS, DBS vs. PNS, and MCS vs. PNS, are required.

Conclusion

This case demonstrates that combined SCS and PNS can offer an effective treatment option for pain from intractable brachial plexopathy and can be easily performed using ultrasound guidance.

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