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PERCUTANEOUS PERIPHERAL NERVE STIMULATION FOR TREATMENT OF BRACHIAL PLEXOPATHY SECONDARY TO PANCOAST TUMOR: A CASE REPORT

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Background: Pancoast tumors can result in significant arm and shoulder pain due to invasion of the lower brachial plexus (BP). They are usually treated by chemoradiotherapy followed by surgical resection, which may alleviate the pain. When patients respond poorly to chemoradiation and the tumor is not surgically resectable, options to treat the pain are limited. We report here successful use of percutaneous peripheral nerve stimulation (PNS) with leads inserted under ultrasound (US)-guidance for treatment of brachial plexopathy in a patient with an unresectable Pancoast tumor unresponsive to chemoradiation.

Case Report: The patient was a 70-year-old woman with an unresectable poorly differentiated squamous cell carcinoma of the left lung status post chemoradiation with poor response and recently started on immune therapy who presented to her oncologist with refractory left upper extremity (LUE) pain and weakness. She was admitted for pain control, and pain management was consulted. Physical examination findings were concerning for involvement of the lower trunk of the BP, findings confirmed in imaging. Patient elected to proceed with placement of a PNS. Device was successfully placed under US guidance. Patient responded well for the first 2 weeks with significant improvement in allodynia and hyperesthesia, however, at week 3, physical examination was significantly changed and further growth of the tumor was seen on imaging. The PNS was removed at this time.

Conclusion: This case demonstrates successful use of PNS to treat refractory neuropathic pain in a patient with a locally advanced Pancoast tumor. US imaging made it possible to identify the interscalene BP and accurately place the leads. The PNS achieved its desired outcome of providing pain relief in the lower trunk distribution for the full 3 weeks it was in place. Pain from Pancoast tumors can be severe, and neural blockade via PNS to interrupt pain is an option for patients with intractable pain. Additional prospective study is warranted to determine the efficacy of this technique.

Key words: Brachial plexus, upper extremity, cancer pain, interventional pain management, neuromodulation, peripheral nerve stimulation

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BACKGROUND

Superior sulcus tumors, also termed “Pancoast tumors,” are a wide range of tumors invading the apical chest wall. They can result in significant arm and shoulder pain due to invasion of the lower part of the brachial plexus (BP), first ribs, vertebrae, and subclavian vessels (1). Traditionally, these tumors are treated with a combination of chemoradiotherapy followed by surgical resection, which may help alleviate the pain. However, when the patient responds poorly to chemoradiation and the tumor is not surgically resectable, options to treat the pain are limited. Medical therapy with opioids, anticonvulsants, and tricyclic antidepressants have limited efficacy (2). There have been case reports of successful use of local anesthetic infusion through an axillary catheter (3), as well as ultrasound (US)-guided percutaneous ablation of the cervical nerve roots (4) for treatment of brachial plexopathy caused by Pancoast tumors. There have been multiple reports of peripheral nerve stimulation (PNS) used for the treatment of brachial plexopathy due to various causes (5-9), however, none of the reported cases were due to pain from a Pancoast tumor. We report here the successful use of PNS with leads inserted percutaneously under US guidance for treatment of brachial plexopathy in a patient with an unresectable Pancoast tumor unresponsive to chemoradiation.

CASE REPORT

All information regarding the following case is reported with the informed consent of the patient. A 70-year-old woman with locally advanced, poorly differentiated squamous cell carcinoma of the left lung diagnosed approximately 1 year prior presented to her oncologist with left upper extremity (LUE) pain and weakness. The patient had already undergone chemotherapy and radiation. She had poor tolerance to the chemotherapy and elected not to continue with it. She completed the radiation therapy, however, she responded poorly, and follow-up imaging showed an increase in size of the tumor. It was determined that the tumor was unresectable, and the decision was made to initiate immune therapy with the understanding that this could take several weeks to see a response.

At the time of presentation, the patient was taking celecoxib 100 mg twice daily, oral Dilaudid 2 mg every 4 hours as needed, pregabalin 75 mg twice daily, and a 75 mcg/hr fentanyl patch without significant pain relief. The patient stated that she felt the medications were

making her lethargic. She was admitted for pain control, and pain management was consulted for further evaluation. Motor examination revealed diminished grip strength on the affected left side. Sensory examination revealed profound diminishment to pinprick in the medial arm, forearm, hand, and evidence of allodynia and hyperalgesia in this same distribution. Computed tomography (CT) scan of the thorax showed a left apical lung mass measuring 7.4 x 4.4 x 5.4 cm with destruction of the first rib and distortion in the adjacent lung parenchyma. The tumor had increased in size from a CT scan 2 months prior, which showed an anteroposterior (AP) diameter of 6.5 cm. Clinical diagnosis of left brachial plexopathy secondary to tumor involvement of the BP was made. After discussing possible treatment options, the patient elected to proceed with placement of a temporary PNS.

US guidance was utilized to facilitate access to the BP via a modified interscalene approach—the location was between the traditional interscalene approach and the supraclavicular approach to visualize the lower trunk of the BP. A portable US machine and linear array probe were used to identify the interscalene BP between the left anterior and left middle scalene muscles (Fig. 1). An introducer needle and stimulating probe were assembled, inserted, and advanced along the intended course of the interscalene groove. Multiple stimulating parameters were used to deliver stimulation at various positions around the nerve. Nerve target acquisition was confirmed noting generation of paresthesias in the upper extremity corresponding to the area being stimulated. The lead location was adjusted until the patient indicated paresthesia overlapping the typical distribution of her pain. The stimulating probe was removed from the introducer, and a percutaneous lead was guided through the needle and delivered to a location in similar proximity to the nerve. The final location was verified with electrical stimulation and documented with US (Fig. 2). The introducer needle was removed, and the percutaneous lead was attached to an external stimulator unit that was adhered externally to the skin; we were once again able to elicit paresthesia in the affected distribution. The lead exit site was covered with a sterile occlusive dressing. The patient tolerated the procedure well and reported some pain relief immediately postprocedure.

Two days postprocedure the patient reported significant improvement (50% improvement compared with baseline) of the pain in the LUE, however, she did

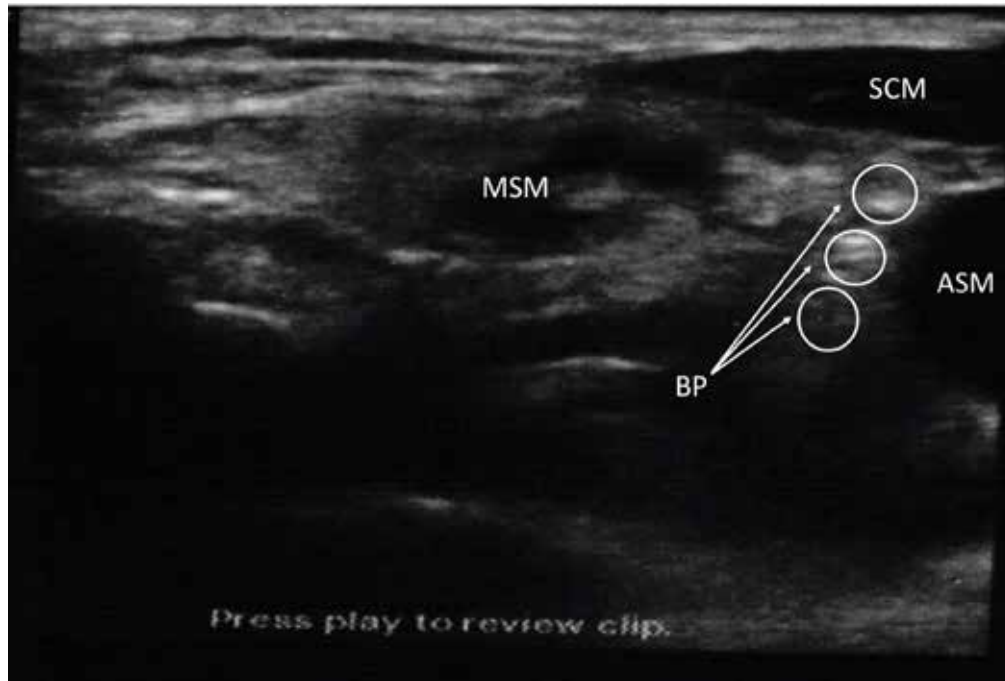


Fig. 1. US image of the interscalene BP prior to lead insertion. MSM, middle scalene muscle; ASM, anterior scalene muscle; SCM, sternocleidomastoid.

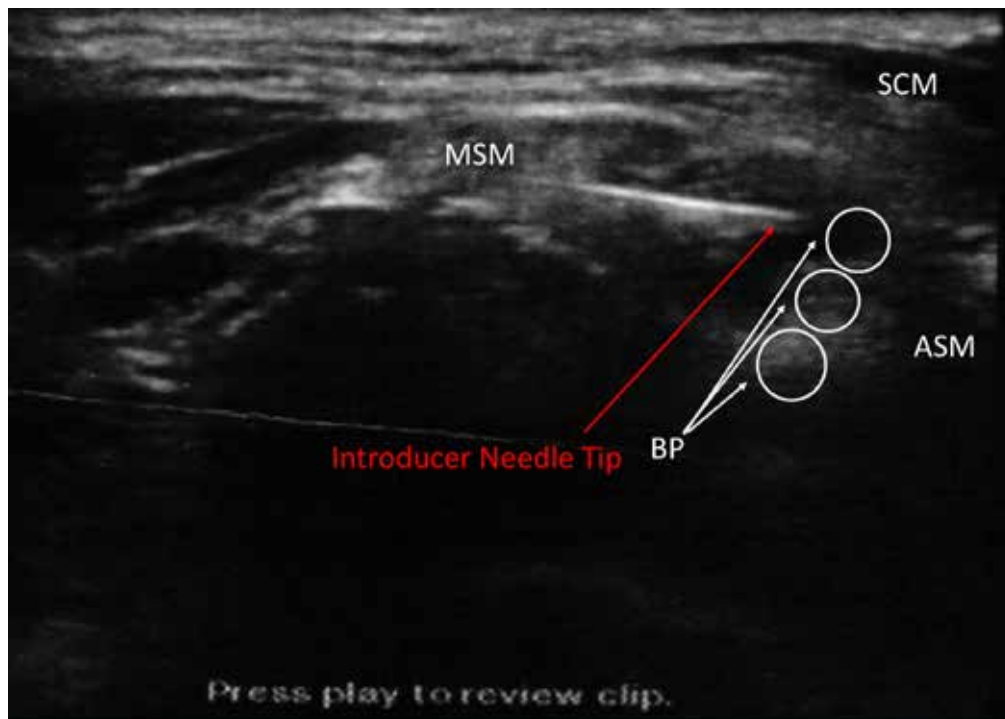


Fig. 2. US image of the interscalene BP during lead insertion. MSM, middle scalene muscle; ASM, anterior scalene muscle; SCM, sternocleidomastoid.

complain of some heaviness and continued weakness. One week postprocedure the patient stated that she had improved sensation to pinprick over the affected area and improved function in her entire LUE secondary to improved pain control (70% improvement from baseline). On physical examination, she had significantly decreased hyperalgesia and allodynia; the feeling of heaviness persisted. The patient's opioid requirement had decreased by 75% and she reported decreased lethargy. Three weeks postprocedure the patient still had good pain relief (60%–70% improvement from baseline) and decreased hyperalgesia and allodynia in the affected distribution but was now reporting severe heaviness of the arm along with significant loss of motor function and numbness in the hand. The physical examination was profoundly changed with decreased sensation in the lateral aspect of the left hand (both palmar and dorsal aspects), worsening grip strength, new-onset decreased wrist extension, and a decreased biceps reflex. The patient had also developed considerable swelling in the LUE. A repeat CT scan of the thorax was performed, which showed further growth of the tumor, now measuring 8 cm in AP diameter. The decision was made to remove the PNS per the patients' wishes.

DISCUSSION

This case demonstrates successful use of PNS to treat refractory neuropathic pain in a patient with a locally advanced Pancoast tumor. Patients with Pancoast tumors have pain that is notoriously difficult to treat. There have been reports of several modalities used to treat brachial plexopathy due to Pancoast tumor compression, but there is limited efficacy to many of these techniques. In addition, the use of certain techniques is limited due to their side effects.

Systemic opioid usage for analgesia can be effective at higher dosages, however, involve side effects such as lethargy, constipation, and opioid dependence. Opioids can also be detrimental to patients with nonresectable lung cancer as they can enhance respiratory depression leading to hypoventilation, and eventually hypoxia. Another option for delivering opioids for analgesic management of compression plexopathy is neuraxial analgesia. Neuraxial analgesia allows the use of 10- to 100-fold lower dosages of opioids, hence minimizing systemic side effects (10,11). Percutaneous cervical cordotomy afforded complete pain control to the majority of patients with Pancoast tumors who were treated in one study (2). However, side effects included dysesthe-

sia and weakness of the arm involved, in addition this intervention is irreversible. Local anesthetic BP block using an axillary catheter in patients with pain refractory to opioids, nonsteroidal anti-inflammatory drugs, and pregabalin was associated with significant reduction in Visual Analog Scale score, and 67% of patients reported an improvement in quality of life with no significant side effects (3). However, these patients required frequent refills of the local anesthetic and frequent labs to ensure the plasma concentration of the local anesthetic did not reach toxic levels.

PNS was the modality of choice in this case due to its temporary and easily reversible nature, the patient's desire to maintain functionality, and insufficient relief from prior interventions. Although the exact mechanism for PNS has not been determined, the current ideology is based on the gate control theory. This theory postulates that "gates" at the spinal cord dorsal horn laminae regulate both nociceptive and nonnociceptive stimuli. Nociceptive inputs carried by small, myelinated afferent nerve fibers cause the physiologic gates to open and give the perception of pain. Meanwhile, nonnociceptive inputs are large myelinated sensory afferents that cause these gates to close and dull the sensation of pain. PNS acts on these principals and uses electrical impulses and signals to stimulate nonnociceptive large diameter fibers to close the pain gates and increase pain relief (12). Despite this ambiguity regarding the mechanism by which PNS provides pain relief, it has been used to treat brachial plexopathy of various etiologies.

There have been several case reports describing the successful management of intractable pain following traction injury to the BP and shoulder through the percutaneous implantation of a PNS using the posterior scalene approach. This resulted in excellent pain control and beneficial sensory and motor function of the arm (6). BP or suprascapular nerve root PNS has also been used to effectively treat chronic refractory neuropathic pain of the upper limb (7). In addition, PNS has been used in the relief of chronic posttraumatic neuropathic BP pain in patients with pain refractory to analgesic and surgical management (8).

The PNS system we used in this case is designed to provide stimulation for up to 60 days before the leads are removed (13). It can stay in place for longer than the average percutaneous stimulation trial (4–7 days) because of the coil design of the leads; the internal aspect of the lead is thought to develop a fibrous tissue anchor around this coil design that prevents infection

and lead migration (13,14). After 60 days, by placing traction on the lead, the coils unwind and allow the lead to be atraumatically removed with studies showing continued pain relief postremoval (15).

US imaging made it possible to identify the interscalene BP and accurately place the leads (Fig. 2). We used a modified interscalene approach, with the patient placed in a lateral recumbent position to augment a posterior-lateral to anterior-medial approach to the inferior trunk of the BP with the PNS lead. This enabled convenient generator placement at the posterior trapezius. Due to distorted anatomy from tumor infiltration, the level of engagement of the BP with the linear array probe was between a traditional interscalene approach and a supraclavicular approach (Fig. 2).

The overall goal in this case was to decrease the patient's symptoms, namely the hyperalgesia and allodynia, and decrease her medication requirements to improve her lethargy, while providing adequate time (4–6 weeks) for the immune therapy to take effect. The immune therapy was likely not effective in this patient as the tumor had increased in size at 3 weeks. The tumor growth was likely responsible for the profound change in the patient's physical examination. From an anatomic perspective, the tumor initially appeared to be primarily involving the inferior trunk of the BP. This is consistent with the imaging showing destruction of the first rib, and the physical examination showing involvement of the medial arm, forearm, and hand. The lower trunk of the BP runs directly over the first rib (Fig. 3). The nerves branching from the lower trunk of the BP include the medial brachial cutaneous, the medial antebrachial cutaneous, and ulnar nerves, which provide sensation to the medial arm, forearm, and hand, respectively (Fig. 4). It is likely that as the tumor continued to grow there was involvement of the middle trunk leading to increasing radial and median nerve involvement, which would explain the decreased sensation over the lateral hand and decreased wrist extension observed on physical examination at week 3. For the full 3 weeks it was in place, the PNS achieved its desired outcome of decreasing hyperalgesia and allodynia over the affected distribution, decreasing medication requirements and side effects, and increasing the patient's functionality. Had the patient responded better to the immune therapy, our next step would have been to consider a permanent implantable PNS system if necessary.

CONCLUSIONS

Pain from Pancoast tumors can be severe, requiring

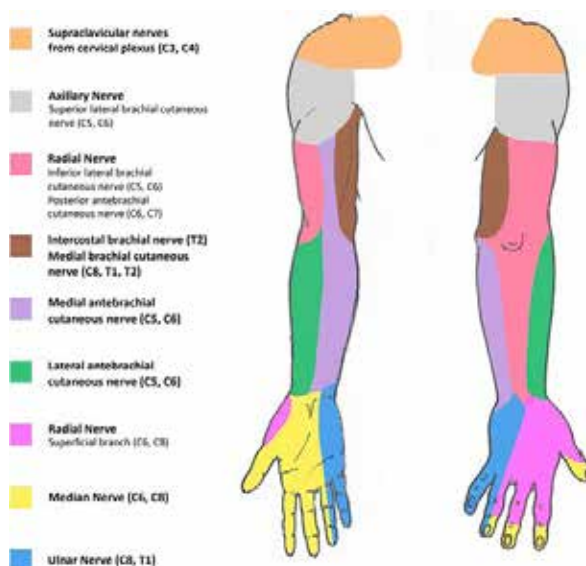


Fig. 4. Sensory distribution of the branches of the BP. Reproduced with permission from Casal D, Cunha T, Pais D, et al. A stab wound to the axilla illustrating the importance of brachial plexus anatomy in an emergency context: A case report. *J Med Case Rep* 2017; 11:6.

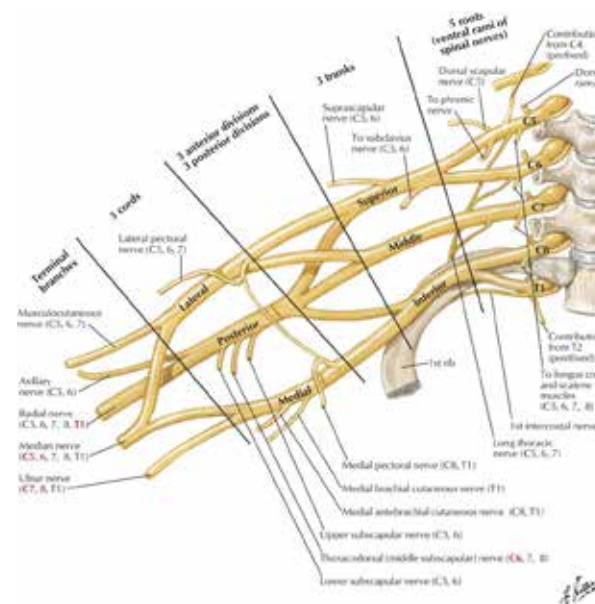


Fig. 3. Illustration of the BP with terminal branches and showing relation to first rib. Reproduced with permission from Leung S, Zlotolow DA, Kozin SH, Abzug JM. Surgical anatomy of the supraclavicular brachial plexus. *J Bone Joint Surg* 2015; 97:1067-1073.

high doses of opiates and adjuvant therapy. Neural blockade to interrupt pain transmission may be the best option for patients with intractable pain. Multiple modalities to interrupt pain pathways in these patients

have been described in the literature, however, we were unable to find any reports of PNS used for this purpose. Additional prospective study is warranted to determine the efficacy of this technique.

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