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Prolonged continuous infraclavicular brachial plexus perineural infusion following replantation of a mid-humeral amputation

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Abstract

Replantation of a traumatic upper extremity amputation is a complex process accompanied by prolonged hospitalization, extended rehabilitation, and potential for graft failure secondary to poor perfusion to the distal extremity. The patient is faced with repeat visits to the operating room in addition to severe acute and chronic pain issues. We present the case of an 18-year-old male treated with prolonged continuous peripheral nerve blockade following traumatic left mid-humeral amputation and subsequent replantation. The patient maintained infraclavicular brachial plexus catheterization until hospital discharge, a course spanning 33 days and six follow-up surgical procedures. The patient was pain free and had been weaned off all opioids at a 4-week outpatient surgical debridement. Prolonged continuous infraclavicular brachial plexus blockade following replantation surgery has numerous potential benefits including augmentation of perfusion to the injured extremity, management of severe acute post-traumatic pain, and prevention of the chronic pain associated with transected nerves.

Keywords

Anesthesia/pain, regional anesthesia, continuous peripheral nerve catheter, replantation, traumatic amputation, chronic pain, prolonged perineural infusion

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Introduction

Continuous peripheral nerve block (CPNB) of the brachial plexus is most commonly performed to provide post-operative pain relief for surgical procedures involving the upper extremity. Other indications for continuous perineural local anesthetic infusion include treating chronic cancer pain, phantom limb pain (PLP), complex regional pain syndrome, and intractable hiccups.[1] In addition, case reports and small series have demonstrated CPNBs being used to induce a sympathectomy and vasodilation with the intention of improving blood flow after vascular injuries, transplantation, and replantation surgeries.[1–4]

While CPNB has been the common therapy for digital replantation and toe-to-hand transfer,[1,5] description of this technique after traumatic arm amputation and subsequent replantation is limited to short-term catheterization post forearm replantation following a crocodile bite.[6] Descriptions of prolonged use of CPNB (greater than 30 days) is also rare in the literature and linked to treatment of chronic cancer pain[7,8] and PLP.[9] Prolonged brachial plexus perineural infusion has been described in one report of limb salvage in a pediatric patient.[10]

We report the prolonged use (33 days) of continuous infraclavicular brachial plexus blockade in an 18-year-old male that suffered traumatic amputation of the left arm. Goals of the therapy included the provision of targeted pain management while reducing narcotic requirements, augmentation of profusion in the replanted limb, and prevention of the development of chronic pain commonly associated with this type of injury. The patient was released on hospital day 34 with successful replantation of his severed limb and a numeric rating scale (NRS) pain score of 0/10. He was successfully weaned off all narcotics four weeks following discharge.

The patient detailed above provided written permission for this report.

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Case description

An 18-year-old male with no significant medical history presented to our operating room following a traumatic left mid-humeral amputation. The injury occurred following inadvertent activation of factory equipment that entrapped the patient's arm as he was working. On presentation, the patient was hemodynamically stable with a tourniquet above the injury site. The amputated limb accompanied the patient in a bucket of ice (Figures 1 and 2).

The surgical team opted to attempt replantation although they were not initially optimistic for success secondary to the damage incurred in the amputated limb. The extensive initial surgery included shortening osteotomy of proximal and distal humerus, open reduction and internal fixation (ORIF) of the distal humerus, reanastamosis of the severed vessels, repair of the ulnar and radial nerves, repair of biceps brachialis, closed reduction of the second and fifth metacarpals, closed reduction of the distal radius, and reanastamosis of the second common digital artery. A fasciotomy was also performed in the volar area as there was significant tension within that compartment.

On the morning following surgery, the patient reported NRS pain scores of 9/10 to 10/10 and required numerous administrations of intravenous (IV) hydromorphone and fentanyl. In the eight hours following his initial surgery, the patient had been given a total of 150 mg oral morphine equivalents (OMEs) of IV opioids with minimal relief of pain. Our Acute Pain Service was consulted to evaluate the patient as he and his mother were extremely concerned about the side effects of the opioids and potential for addiction. After discussing several options with the patient and the surgical team, the decision was made to perform a dense infraclavicular block with 0.5% ropivacaine for profound immediate pain relief as well as insert a continuous infraclavicular brachial plexus catheter to provide enhanced circulation to the replanted limb and long-term targeted analgesia in the distribution of the patient's pain. As the surgeons had performed a fasciotomy in the forearm area and left the upper arm incompletely closed, they were not concerned regarding the potential for a dense nerve blockade to mask compartment syndrome in this instance.

After sterile prep and draping of the left upper chest, the ultrasound transducer (SonoSite; S-nerve, 6 cm, 15-6 MHz) was used to obtain a transverse cross-sectional view of the brachial plexus and axillary artery. Following administration of local anesthetic at the skin, an 18-gauge, Tuohy needle (B Braun Contiplex) was inserted using an in-plane technique and directed in a caudad fashion toward the plexus. Although the needle had stimulating capacity, neurostimulation was not performed as ultrasound guidance provided appropriate needle and plexus visualization. A solution of 0.5% ropivacaine was injected in divided doses circumferentially around the brachial plexus cords. A 20-gauge catheter was subsequently passed through the needle and positioned immediately posterior to the axillary artery. A small aliquot of the local anesthetic solution was administered through the catheter after negative aspiration, and perineural placement of the catheter tip was confirmed using real-time ultrasound assessment during injection. In total, 30 mL of 0.5% ropivacaine was administered during the block and catheterization process. The catheter was secured in place and attached to an elastomeric pump (On-Q; Halyard Health, 400 mL) set to infuse 0.2% ropivacaine at 6 mL per hour.

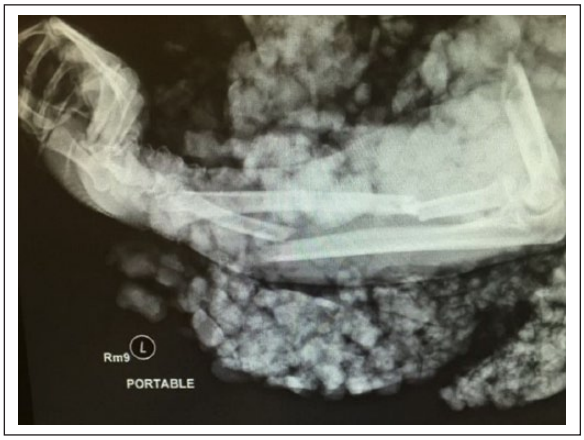

Figure 1. X-ray image of the amputated left upper extremity.

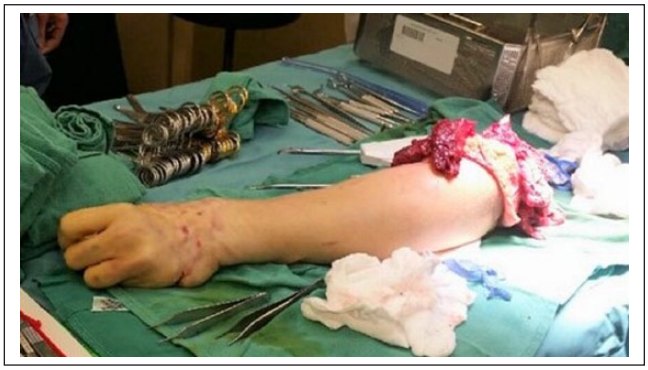

Figure 2. Amputated left upper extremity prior to replantation.

Prior to the brachial plexus blockade, the patient had severe generalized pain that extended from the proximal humerus throughout the left distal forearm and hand. Following placement of the infraclavicular block, the patient had a dramatic improvement in his pain levels and stated that his left arm "felt like a log." Once the initial dense block wore off, the perineural infusion continued to provide significant pain relief, although the patient maintained persistent muscular discomfort in his upper back and neck as well as pain in the proximal humerus and axilla area consistent with the intercostobrachial nerve sparing expected with infraclavicular plexus blockade.

The patient experienced a total of seven operations during his inpatient care including debridements, washouts, vacuum

dressing changes, fasciotomy closure, ORIF of the left radius and ulna, revision of the left distal humerus fixation, and ulnar-to-median nerve graft. The infraclavicular catheter was bolused with 0.5% ropivacaine prior to many of these surgical manipulations to supplement general anesthesia. In total, an infraclavicular perineural infusion was utilized for 33 out of the 34 days of hospitalization.

The catheter was replaced in a sterile fashion approximately once per week as a precaution against infection given the duration of catheterization. An experienced anesthesiologist guided resident siting of each catheter. Although variability existed in the proceduralist for each exchange, effort was made to copy the protocol described in the initial catheter placement with the goal of maintaining continuous superb analgesia. On days in which the catheter exchange coincided with a surgical procedure, the indwelling catheter would be aseptically removed, the skin cleansed with 0.5% chlorhexidine solution, and a new catheter inserted as described above. In contrast, saline would be injected to open up the perineural space, and the patient would not receive a local anesthetic bolus prior to catheter insertion on a non-surgical exchange day. Correct placement was confirmed by injecting saline through the catheter tip under direct ultrasound visualization. A total of five catheters were inserted (post-operative days (PODs) 1, 8, 14, 21, and 29). Each procedure was well tolerated and no complications including vessel puncture or paresthesia were encountered. During the period of indwelling catheterization, the patient did not demonstrate symptoms of site irritation or infection.

The concentration and rate of local anesthetic infusion were altered periodically throughout the hospital course. While initially set at 0.2% ropivacaine at 6 mL per hour, the rate was increased to 8 mL per hour on POD 4 with noted improvement in pain symptoms. On POD 21, the rate was reduced to 6 mL an hour in an attempt to wean the patient from the infusion. On POD 31, the concentration was lowered to 0.1% ropivacaine as the date of discharge approached. The catheter was discontinued on POD 33.

On initial presentation, the patient required multiple large doses of IV hydromorphone and fentanyl without significant improvement of pain. After insertion of the infraclavicular catheter, the IV narcotics were quickly transitioned to oral opioids and adjuvants including acetaminophen and gabapentin were initiated in the pain medication regimen. By the end of his first hospital week, the patient was requiring approximately 100 mg OME per day using scheduled and as-needed dosing of oral opioids. This total opioid dose was steadily weaned in half by the end of the third hospital week, and as discharge neared, the patient only required small doses of oxycodone for breakthrough pain on an infrequent basis and had numerous extended periods without opioid use. Following discharge, the patient returned for an outpatient debridement 58 days after his initial injury. Through extensive physical therapy, the patient had obtained meaningful use and mobility of his arm at the elbow, wrist, and hand while successfully weaning off all opioid medication.

Discussion

Following the initial surgery, our patient faced numerous obstacles in his immediate and long-term recovery. Significant concerns included compromised circulation to the replanted extremity requiring future amputation, severe acute pain with high-dose opioid consumption and potential for addiction, and high likelihood for the development of chronic pain. We present the case of a mid-humeral replantation and novel use of extended infraclavicular brachial plexus catheterization with perineural infusion (33 days) as the therapy to prevent the undesirable outcomes described above.

Replantation of an upper extremity is considered an absolute surgical indication for both functional and psychological reasons. Most authors conclude that the assumed benefits in quality of life after replantation of an upper extremity justify the medical challenges required for successful salvage.[11,12] Patients have demonstrated high rates of subjective satisfaction after replantation even though the majority of replanted limbs do not regain normal levels of functionality and often have associated paresthesia and pain. In one long-term follow-up of 16 patients, each would undergo the replantation process again despite the initial surgeries and long-term issues.[12]

Our surgeons were not initially optimistic about the success of replantation secondary to the significant trauma to the amputated limb; however, they felt that it was in the best interest of the patient to attempt the reattachment. Following the initial procedure, the surgical and anesthesia teams agreed that the patient would benefit from a continuous brachial plexus perineural infusion of local anesthetic. From the surgical perspective, circulation in the replanted extremity is of vital concern. Vascular spasm, thrombotic occlusion, and other mechanisms of decreased perfusion put the limb in constant jeopardy, and managing the blood flow to the replanted extremity is critical.[2] Continuous plexus blockade has been shown to produce beneficial effects after vascular reconstructive surgery as the sympathectomy and subsequent vasodilation increases the blood flow to the injured limb.[1–5,13]

Pain management was also a vital component in the patient's recovery plan. No matter the success of the replanted extremity, the patient was destined to have a prolonged hospital course interspersed with surgical manipulation. As the immediate post-operative period demonstrated, controlling the patient's pain with opioids alone was ineffective, and the patient and his family were extremely concerned about the side effects of opioid use with the potential for addiction and abuse. Thus, in addition to providing circulation benefits, the continuous perineural blockade functioned to decrease the amount of opioids needed for patient comfort in hopes of minimizing long-term dependence. The catheter also served as an adjunct to general anesthesia during follow-up procedures.

Long-term pain issues are a major concern in both replant and amputee patients. The incidence of chronic pain has been estimated at 39%–79%[5] in replant patients and 50%–95%[14] in amputees. Secondary to the complexity of our patient's wound and replant, we also considered approaches to manage potential PLP if amputation became inevitable. PLP is notoriously difficult to treat and prolonged relief with any therapy is rare. It has been proposed that extended use of CPNB may permanently reorganize the cortical pain mapping that occurs after nerve transection and thus provide lasting pain relief. Although data are limited at this point, early results have been promising.[9,14,15] We felt that long-term perineural infusion had the potential to reduce the likelihood of chronic pain whether successful replantation or not, and therefore maintained catheterization until discharge.

Selecting the most suitable site for CPNB catheter placement was an important consideration as well. The patient noted pain near his shoulder all the way throughout the distal extremity; it seemed unlikely that any one specific site for catheterization would cover the extent of his pain. The axillary approach was not an option secondary to its proximity to the injury and the inability to position the patient's arm. While an interscalene technique may have ameliorated the patient's shoulder and proximal humerus complaints better than more distal approaches, it was not chosen due to the concern that it would fail to completely cover the patient's significant distal forearm and hand pain. Both supraclavicular and infraclavicular approaches would be expected to deliver appropriate analgesia throughout the distribution of the arm. When comparing single-injection versions of each technique, the supraclavicular approach demonstrates better analgesia of the axillary nerve, while the infraclavicular approach demonstrates better analgesia of the median and ulnar nerves.[16] This would suggest that a supraclavicular block would provide better analgesia for the proximal humerus and musculature around the shoulder joint, while the infraclavicular approach would provide better analgesia for osteotomal and myotomal structures in the distal arm. Although a supraclavicular catheter may have provided our patient enhanced pain coverage at his site of amputation, an infraclavicular approach was ultimately selected due to the extended distribution of the patient's pain complaints, ease of catheter placement, and decreased risk of catheter dislodgement in comparison to the supraclavicular approach. In addition, randomized control data have suggested superior analgesia of the arm with usage of an infraclavicular perineural infusion versus supraclavicular infusion.[17] As recent evidence expressly favors ultrasound guidance in comparison to electrical stimulation for perineural catheterization, we used ultrasound visualization to direct our infraclavicular catheter placement.[4] Following catheterization, our patient received outstanding analgesia distal to the proximal humerus, and we did not experience technical issues with catheter placement or dislodgement.

Serious complications related to indwelling nerve catheters and perineural infusions are unusual, and minor complications occur at a rate similar to single-injection blocks.[1] Our primary concern regarding extended perineural catheterization was the potential for infection. The risk of infection with perineural catheterization is rare, but the incidence is increased with extended duration and infections typically arise from skin flora.[8,18–20] We tunnel each of our catheters subcutaneously as this technique increases the distance from the catheter insertion site to the nerve as well as anchors the catheter in place. While case reports and small series have demonstrated catheters remaining in situ without complication for extended periods (up to 88 days) in select patients,[8,9,21,22] many have shown concern regarding infectious issues with extended catheter duration, and it is unclear as to how long a catheter can safely stay in place for all patients.[7,10,18] Due to this uncertainty, we chose a conservative approach and replaced the infraclavicular catheter approximately once per week to minimize the risk of infectious complications that could have devastating consequences for our patient and his replanted extremity.

Replacing the catheter at frequent intervals introduced an increased risk for complications such as block failure, pneumothorax, and vascular puncture in comparison to leaving the catheter in situ for a longer period. However, there is a preponderance of evidence that suggests that ultrasound technology has significantly reduced the rate of catheterization failure in addition to greatly improving the safety of these procedures.[4] A large prospective study demonstrated the rate of symptomatic pneumothorax to be only 0.06% for ultrasound-guided infraclavicular blocks.[23] Our team believed that the risk of infection from not replacing the catheter outweighed the risks of repeating the ultrasound-guided procedure on a weekly basis. The patient experienced neither complication from the repeated procedures, nor inflammation or infectious issues from the indwelling catheters.

In conclusion, we describe the post-replantation management of an 18-year-old male that suffered traumatic amputation of the left arm at the level of the mid-humerus. Continuous infraclavicular brachial plexus blockade with an indwelling catheter was chosen for this patient with the goals of enhancing circulation to the replanted limb, optimizing pain control while decreasing post-operative dependence on opioids, and reducing the risk of chronic pain and its subsequent physiologic and psychologic sequelae. This prolonged CPNB technique provided excellent analgesia over a 5-week hospital course which included six operations following the initial replantation. The patient was released on hospital day 34 with minimal pain, and he was successfully weaned off all narcotics a few weeks later. Upon the last follow-up, the patient had very little pain, was opioid free, and had experienced meaningful recovery in his repaired limb.

Declaration of conflicting interests

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Ethical approval

Our institution does not require ethical approval for reporting individual cases or case series.

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Informed consent

Written informed consent was obtained from the patient(s) for their anonymized information to be published in this article.

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