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Development of a Mobile Ultrasound-Guided Peripheral Nerve Block and Catheter Service

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Abstract

Ultrasound guidance is associated with improved efficiency and success of peripheral nerve blockade and a decreased incidence of vascular puncture, making these interventions safer. Patients with peripheral nerve blocks report decreased pain and increased satisfaction scores. We present the development of a mobile ultrasound-guided block service that allows for the safe and efficient placement of nerve blocks and perineural catheters at the nontraditional location of the patient's bedside and in the emergency department.

Keywords

perineural catheter placement; peripheral nerve block; ultrasound-guided nerve block

The practice of regional anesthesia has evolved tremendously in the last decade. The progression from paresthesia and nerve stimulation techniques to ultrasound-guided regional anesthetics has greatly enhanced the success and quality of single-shot peripheral nerve blocks.^{1,2} Improved techniques have also facilitated the introduction and now widespread use of perineural catheters for continuous analgesia.³ Although placement of continuous nerve blocks usually occurs in the operating room or in designated preoperative block areas, there are patients who do not present immediately to these locations who might benefit from the placement of preoperative perineural catheters. Specifically, patients with traumatic or impending pathologic fractures are frequently transported throughout the hospital during their preoperative workups. They are moved from stretchers to examination sites, often multiple times and with minimal and ineffective oral, intravenous (IV), or intramuscular analgesics. We present the development of a mobile ultrasound-guided block service that allows for the safe and efficient placement of nerve blocks and perineural catheters at the patient's bedside and in the emergency department (ED).

Interventions

We began the mobile ultrasound-guided nerve block and catheter service in April 2009. Since that time, 28 catheters, including brachial plexus and femoral nerve catheters, and 6 single-shot blocks have been placed, 2 in the ED and 32 in medical or surgical units. The blocks and catheters have provided analgesia for a variety of indications, including hip fractures, pathologic and impending fractures, upper extremity dislocations, and intractable postoperative pain (Table 1). The average time that catheters remained indwelling was 48 hours (with a maximum duration of 72 hours). Over the past 20 months, there has been an increase in the frequency of requests for our intervention. At the beginning, requests occurred monthly but have now increased to weekly or biweekly. To date, no patient has reported any persistent neurologic deficits, nor has any experienced local anesthetic toxicity.

This mobile block service consists of a team of 4 anesthesiologists specializing in regional anesthesia. These physicians are American Board of Anesthesiology certified, after having completed 4 years of residency. At least 1 of these members is available at all times during weekday work hours (6:45 AM–4 PM). While being available for this service, they continue to have responsibilities in the operating room. After hours and on weekends, the service is reachable via electronic mail, and placement of a nerve block or catheter is arranged for a time convenient for the patient as well as the anesthesiologist but always within 24 hours of the surgical request. If the request is received during work hours, the procedure is performed on the day of request. If the request comes in during the evening, after regular work hours, the procedure is performed before the start of the operating rooms' scheduled cases. Except for the portable monitor, the equipment used is identical to that routinely used for nerve blocks and catheters placed in the operating room (Table 2 and Figure 1). Reimbursement for blocks and catheters placed in non–operating room locations does not differ from reimbursement for ones placed in operating room settings.

The 2 cases presented below highlight the capabilities of this innovative service.

Case Descriptions

Case 1

A 78-year-old man presented to the ED with a dislocated elbow that required a closed reduction. The regional anesthesia team was consulted and came to the ED with the mobile block cart, a portable ultrasound machine (M-Turbo; SonoSite, Inc, Bothell, WA), and additional equipment necessary to perform a peripheral nerve block. The patient's nothing-by-mouth status was confirmed; the risks, benefits, and alternatives of a supraclavicular nerve block were explained, and written informed consent was obtained. Supplemental oxygen via a nasal cannula and standard American Society of Anesthesiologists monitors including a pulse oximeter, electrocardiogram, blood pressure cuff, and side stream capnography were supplied by the ED and applied to the patient. A procedure time-out was performed to confirm the patient's name, medical record number, date of birth, and correct anatomic side.

Subsequently, 1 mg of IV midazolam was administered for sedation. After a sterile chlorhexidine preparation, using an in-plane lateral-to-medial approach and a 22-gauge block needle, an ultrasound-guided supraclavicular brachial plexus nerve block was performed using 40 mL of 1.5% mepivacaine. Visualization of the spread of the local anesthetic surrounding the brachial plexus nerve divisions, located lateral to the subclavian artery, was acceptable. Once an adequate level of anesthesia was obtained, the elbow was reduced, splinted, and placed in a sling. Radiography was performed to confirm elbow reduction. The patient remained in a monitored setting for an additional 30 minutes after block placement and was discharged home, having avoided substantial procedural pain and the side effects of the long-acting IV analgesics that are traditionally used for the elbow manipulation and are often associated with nausea, vomiting, and prolonged sedation.

Case 2

A 60-year-old woman with metastatic breast cancer was admitted to the hospital with a pathologic fracture of the femur and had intractable hip pain despite IV fentanyl patient-controlled analgesia. The orthopedic oncologic surgeon requested preoperative placement of a femoral nerve catheter for the treatment of pain and to facilitate patient cooperation during magnetic resonance imaging of the femur. At the patient's bedside on the orthopedic surgical hospital ward, written informed consent was obtained, and a time-out was performed confirming the location of the injury and the type of block to be performed.

After application of standard American Society of Anesthesiologists monitors and supplemental nasal cannula oxygen, the patient was placed in the supine position and given 2 mg of IV midazolam and 1 g of IV cefazolin. The site was prepared with chlorhexidine and draped. A sterile sleeve was placed on the 25-mm linear ultrasound probe, and using an out-of-plane approach and a 17-gauge, 9-cm Tuohy needle, a 19-gauge femoral nerve catheter was placed and secured at the skin 5 cm past the needle tip. Thirty milliliters of 0.25% bupivacaine was injected through the catheter. The patient remained hemodynamically stable for 30 minutes after the initial injection of the local anesthetic, and a continuous infusion of bupivacaine, 0.1%, was then started at 8 mL/h in combination with IV hydromorphone patient-controlled analgesia. The patient reported decreased overall pain scores and felt that the catheter alleviated the pain associated with washing, toileting, examinations, and procedures. The femoral nerve catheter was used intraoperatively and postoperatively. The patient required minimal intraoperative opioids, and she reported adequate postoperative analgesia.

Discussion

Ultrasound imaging permits direct visualization of the block needle, nerves, blood vessels, and adjacent structures, as well as the distribution of the local anesthetic during and after injection. The quality of an ultrasound-guided block is equal to or better than that of blocks performed with nerve stimulator techniques. The use of ultrasound also decreases the time to perform both block and perineural catheter placement, hastens the time to onset of anesthesia and analgesia,^{1,2} and lowers the pain scores associated with catheter placement.³

Minimizing or avoiding pain is an important concern for patients and practitioners. In 2001, The Joint Commission on Accreditation of Healthcare Organizations deemed pain the “fifth vital sign.”⁴ In fact, pain management is such a large component of overall patient satisfaction that it is evolving into a direct and public measure of the quality of care. Multimodal approaches to pain management are often the most efficacious but are usually initiated once pain is present and the body has already initiated its response. It is possible that either pain or the body’s response to it then sensitizes the nervous system, leading to increased postprocedural pain and hyperalgesia.⁵ The concept of preemptive analgesia is based on blocking the body’s response to noxious stimuli before it has a chance to fully develop.

The ability of preemptive analgesia to reduce postoperative pain has been difficult to demonstrate in studies. A meta-analysis comparing nonsteroidal anti-inflammatory drugs, preincision opioids, *N*-methyl-D-aspartic acid receptor antagonists, and regional anesthesia showed conflicting results. Other than the beneficial effect of epidural anesthesia at certain postoperative times, there was little advantage to using any of the attempted preemptive interventions.⁶ Specifically, in orthopedic oncologic patients, epidural analgesia better reduces pain and has been found to be more efficacious compared to IV patient-controlled analgesia after resection of bone malignancy.⁷

Perioperative pain is undoubtedly substantial in orthopedic patients. Chung et al⁸ examined pain patterns in a recovery unit and found that orthopedic patients had the highest incidence of pain in the ambulatory setting. By extension of the aforementioned results with epidural analgesia, peripheral nerve catheters should also be efficacious in the orthopedic setting by preemptively blocking pain and the body’s stress response. An added advantage with superficial perineural and plexus catheters is the avoidance of the potential problems associated with thromboprophylaxis that can occur with neuraxial or deep catheter techniques.

The implementation of a continuous peripheral nerve blockade has indeed improved patient satisfaction by decreasing postoperative pain scores, the use of opioids with their associated side effects, and the incidence of sleep disturbances.^{9–11} Perineural catheters are now used in a variety of clinical settings to provide expeditious preoperative, intraoperative, and postoperative analgesia. For example, femoral nerve blocks and catheters have been shown to provide effective early analgesia for femur fractures, permitting repeated clinical examinations as well as affording intraoperative and continued postoperative pain management.¹² However, because of cumbersome logistics, their preoperative use has not been widespread. With the development of a mobile block service, we have been able to place perineural catheters at the patient’s bedside and provide preoperative analgesia that continues into the operative and postoperative periods. In addition to improved patient satisfaction, our surgeons are also pleased with this new service, as evidenced by the increased frequency with which they request our intervention.

It is unclear whether the local anesthetic concentration or total dose is the main determinant of the effects of continuous peripheral nerve blocks. It seems that for continuous popliteal-sciatic nerve blocks, high volumes of diluted solutions (ropivacaine, 0.2%; basal, 8 mL/h;

bolus, 4 mL) more commonly result in insensate limbs than do low volumes of highly concentrated solutions (ropivacaine, 0.4%; basal, 4 mL/h; bolus, 2 mL).¹³ However, for continuous infraclavicular brachial plexus catheters, the opposite relationship exists: insensate limbs are more common with smaller volumes of relatively concentrated ropivacaine.¹⁴ Although the primary goal for preoperative and postoperative analgesia using perineural catheters is to inhibit pain fibers, local anesthetics currently available also block other afferent and efferent nerve fibers, resulting in undesirable side effects, such as muscle weakness.¹⁵ Therefore, it is optimal to use the lowest dose possible to prevent unwanted side effects without compromising analgesia. If using the perineural catheters intraoperatively, before surgical incision, a larger volume of a more concentrated local anesthetic can be administered through the catheter to provide surgical anesthesia to the affected limb.

It is important to remember that patients still require IV analgesics to complement the pain relief they receive from perineural catheters during the entire perioperative period. It is also important to consider the role of antibiotic prophylaxis for peripheral nerve catheter placement, specifically when catheters are placed well in advance preoperatively or outside the operating room setting when there are no surgical antibiotic requirements. Many studies support the use of at least 1 dose of antibiotics when placing peripheral nerve catheters. The optimum duration of antibiotic prophylaxis is unknown, but postoperative administration of antibiotics for at least 24 hours has been shown to substantially reduce the incidence of nerve catheter colonization. The use of routine antibiotic therapy for nerve catheters in nonsurgical patients has yet to be studied.

Despite the many advantages, a potential disadvantage of the recent boom in nerve block and catheter placement is the possibility of wrong-sided blocks, especially when blocks are placed outside the operating room. Initiated by the Joint Commission, the Universal Protocol is now used to prevent wrong-site, wrong-procedure, and wrong-person surgery. The Universal Protocol includes a time-out, which is used to verify the patient's identity, the correct site, and the procedure to be performed. This protocol has recently been extended to include a separate time-out for peripheral nerve block and catheter placement. Immediately before block placement, the patient's identity, correct surgical side and site, and block or catheter to be placed is confirmed with a nonanesthesia team member.

At the inception of this mobile service, up to 45 minutes was required to obtain informed consent, place the monitors, prepare the equipment, perform a time-out, and insert the block or catheter. The patients were then monitored for 30 minutes after the procedure. As the service was used more frequently and the anesthesiologists became more proficient at working in remote locations, the time for completion of the procedures decreased. On average, it now takes approximately 45 minutes to prepare and perform the peripheral nerve block or perineural catheter placement and postprocedural monitoring. Once the catheter has been successfully placed, the practitioner has several options for securing the catheter. Inadvertent catheter removal occurs at a rate of 1% when tunneled under the skin¹⁶ and 1.4% when secured with adhesive strips or transparent dressings alone.¹⁷ Suturing the catheter in place has also been shown to decrease the rate of premature catheter removal.¹⁸ We have found that affixing catheters with 2-octyl cyanoacrylate (Dermabond topical skin adhesive; Ethicon, Inc, Somerville, NJ) and a transparent adhesive dressing with an

integrated gel pad containing chlorhexidine gluconate (Tegaderm dressing; 3M Health Care, St Paul, MN) has substantially increased our catheter retention rates.

After catheter fixation and local anesthetic administration, patients must be monitored for adverse effects for a minimum of 30 minutes.¹⁹ While monitoring the patient, charting may be completed. The consent and time-out verification should be placed in the patient's chart as well as a note documenting the procedure and medications administered.

When performing peripheral nerve block and catheter placement in non-operating room locations, the delivery of anesthesia must be provided in a safe manner. Standard American Society of Anesthesiologists monitors, prophylactic antibiotics, consent and time-out verification, adequate charting, and postprocedural nursing instructions should be used. Sedation may be provided if necessary and the patient is to receive nothing by mouth. Lipid infusion must be immediately available in the event that local anesthetic systemic toxicity occurs.^{20,21} It is also important to secure perineural catheters in a sterile manner, choose the proper local anesthetic solution and infusion rate, and provide complementary IV analgesics. We have described the safe and efficient implementation of a mobile nerve block and perineural catheter service, which was instituted to provide superior analgesia to patients in locations other than the operating room.

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Abbreviations

ED	emergency department
IV	intravenous

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Figure 1.
Equipment used for nerve block and catheter placement. BP indicates blood pressure; ECG, electrocardiography; and ox, oximetry.

Table 1

Characteristics of Patients and Interventions

Age, y	Sex	Diagnosis	Block or Catheter Type
38	Female	Pathologic femur fracture	Femoral nerve catheter
43	Male	Shoulder arthroscopy	Interscalene brachial plexus block
41	Female	Total knee replacement revision	Femoral nerve catheter
50	Female	Shoulder arthroscopy	Interscalene brachial plexus catheter
66	Male	Pathologic femur fracture	Femoral nerve catheter
25	Male	Elbow contracture after release	Infraclavicular brachial plexus catheter
33	Female	Elbow debridement	Infraclavicular brachial plexus catheter
46	Female	Metastatic femur lesion	Femoral nerve catheter
74	Female	Total knee replacement	Femoral nerve catheter
63	Female	Total knee replacement	Femoral nerve catheter
62	Female	Total shoulder replacement	Interscalene brachial plexus catheter
56	Female	Ankle tumor	Popliteal sciatic catheter
70	Female	Hip fracture	Femoral nerve catheter
29	Male	Dislocated shoulder	Interscalene brachial plexus block
47	Male	Total knee replacement	Femoral nerve catheter
71	Female	Total knee replacement	Femoral nerve catheter
67	Female	Malignant shoulder tumor	Interscalene brachial plexus catheter
71	Female	Pathologic femur fracture	Femoral nerve catheter
29	Male	Tibia fracture	Sciatic and femoral nerve block
17	Male	Malignant femur tumor	Femoral nerve catheter
42	Male	Knee osteochondral allograft	Popliteal sciatic nerve block
39	Male	Elbow infection	Supraclavicular brachial plexus block
71	Female	Hip fracture	Fascia iliaca catheter
90	Female	Hip fracture	Fascia iliaca catheter
82	Female	Hip fracture	Fascia iliaca catheter
71	Female	Hip fracture	Fascia iliaca catheter
89	Female	Hip fracture	Fascia iliaca catheter
86	Male	Hip fracture	Fascia iliaca catheter
78	Female	Hip fracture	Fascia iliaca catheter
75	Female	Hip fracture	Fascia iliaca catheter
80	Female	Hip fracture	Fascia iliaca catheter
79	Female	Hip fracture	Fascia iliaca catheter

Table 2**Components of the Mobile Block Cart**

1.	Portable monitor with electrocardiography, pulse oximetry, blood pressure, and end-tidal carbon dioxide capabilities
2.	Nasal cannula
3.	Secondary intravenous (IV) tubing (for prophylactic antibiotics to be obtained from refrigerator immediately before proceeding to patient's bedside)
4.	Syringes and needles for administration of IV medications
5.	Chlorhexidine preparation
6.	Sterile gloves and drapes
7.	Local anesthetics, including 1.5% mepivacaine, 0.25% bupivacaine, and 0.5% bupivacaine (for skin wheal or bolus)
8.	Sterile saline for hydrodissection
9.	Catheter placement kit
10.	Sterile ultrasound probe cover and gel
11.	Liquid adhesive and sterile dressing
12.	Lipid infusion
13.	Resuscitation equipment, including self-inflating resuscitation bag, laryngoscope, endotracheal tube, laryngeal mask airway (emergency IV agents obtained from pharmacy or anesthesia workroom, eg, midazolam, propofol, and succinylcholine)