

# Chapter 21

## ADVANCED PAIN MANAGEMENT TECHNIQUES

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## INTRODUCTION

Advanced battlefield pain management offers anesthesiologists multiple options for managing perioperative pain from surgery or battlefield trauma. Because combat casualty injuries range from simple to complex, the initiation of pain management options will depend on the patient's injury pattern and subjective pain. For instance, a soldier with a superficial tissue injury may report adequate analgesia with intravenous (IV) acetaminophen and nonsteroidal antiinflammatory drugs (NSAIDs). More extensively injured patients with extremity injuries or traumatic amputations may require morphine patient-controlled analgesia (PCA) combined with an epidural or con-

tinuous peripheral nerve block (CPNB). Effective battlefield analgesia requires physician understanding of each patient's physiology, injury pattern, and pain threshold to provide an individualized and effective pain plan while minimizing unwanted side effects of pain medications in the challenging military evacuation environment. On the modern battlefield, technology now allows individualized pain management, which supports casualty evacuation and enhances rehabilitation and recovery of the wounded service member. This level of care requires physicians and nurses at all roles of care who are dedicated to managing pain.

## PATIENT-CONTROLLED ANALGESIA

PCA has become commonly used in the deployed military setting in recent conflicts. It involves the use of a pump, which allows the patient to administer a bolus of an analgesic drug, most commonly morphine, via an IV line when he or she requires analgesia. A lockout mechanism controls the time between boluses and helps prevent excessive sedation and respiratory depression. Use of PCA has increased as pumps have become safe, reliable, and robust enough for use in a military environment and during aeromedical evacuation.

### Types of Drugs

A range of drugs may be used in PCA, although morphine is the most frequently chosen. Hydromorphone, fentanyl, and ketamine (a nonopioid *N*-methyl-D-aspartate receptor antagonist) may also be used, and antiemetics such as cyclizine or droperidol may be added. Morphine has been the standard choice for PCA in recent deployments due to supply constraints on other drugs, sustainability, and the need for standardization. As new drugs are developed in the future, the use of morphine as the standard PCA drug may change.

### Indications

IV dosing of opiates provides analgesia to pain arising from sites throughout the body. While regional techniques provide excellent analgesia to specific anatomical areas, systemic opiate administration provides analgesia to patients with multiple wounds, including four-extremity trauma, thorax, and head and neck, areas that may not be covered by regional techniques.

### Contraindications

Allergy to opiates is an absolute contraindication

for opiate-based PCA. Patients may need analgesic options other than PCA if appropriate management techniques do not suppress opiate side effects.

Consideration also needs to be given to the ability of the patient to understand the concept of a PCA, which may not be the case for some foreign national patients. In these circumstances, a continuous opiate infusion may be more appropriate when the patient is in the intensive care unit and on continuous monitoring.

The success of PCA depends on the ability of the patient to press the bolus button on the device. Most PCA devices require a certain force to push the bolus button in order to prevent accidental bolus delivery. Therefore, individual consideration needs to be given to patients with bilateral upper limb injuries, cognitive impairment, or neurological deficits.

### Benefits

With PCA, patients control their own analgesia. This reduces any delay in provision of pain relief on the ward or evacuation aircraft, ideally keeping the patient comfortable and minimizing escalation of pain. Passing control of analgesia to the patient may also have psychological benefits and reduce the fear of being left in pain.

PCA is technically easy to establish in comparison to other techniques. Although the IV cannula access may be displaced, this is relatively easy to correct, even during an aeromedical evacuation flight.

### Complications

The complications of PCA are usually secondary to the use of opiates, and these are well documented (Table 21-1). All patients need to be monitored for these side effects and treated as appropriate. Patients

**TABLE 21-1**  
**SIDE EFFECTS OF OPIATES**

Side Effects	Management of Side Effect
Respiratory depression	Give O <sub>2</sub> . If respiration rate < 8 breaths/min, call on-call doctor or anesthetist and give 400 µg naloxone IV (repeat as necessary).
Hypotension	Give O <sub>2</sub> . Lie patient flat. Stop PCA. Give fluid bolus as prescribed. Consider other causes hypotension and call physician.
Nausea and vomiting	Consider antiemetics. Can be scheduled with breakthrough opioids as needed.
Sedation	Monitor respiration rate and BP. Stop further use of PCA. If patient is unrousable, call physician. If restarting PCA, consider increasing demand interval.
Pruritis	Consider chlorphenamine maleate (UK) or diphenhydramine (US) and regular ondansetron. If condition persists, use low-dose naloxone.
Constipation	Consider use of laxatives.
Urinary retention	Observe urinary output and if necessary catheterize.

BP: blood pressure

IV: intravenous

PCA: patient-controlled analgesia

Reproduced from: UK Joint Force Medical Group. *Pain Management at the Role 3 (UK) Medical Treatment Facility*. Bastion Joint Operating Base, Afghanistan: Joint Medical Command; 2010. UK JF Med Gp Standard Operating Instruction.

on PCA should also receive regular nonopiate analgesia. Acetaminophen and an NSAID (if appropriate) should be prescribed regularly, and antiemetics should also be prescribed as required. Stool softeners should be prescribed to prevent constipation. In the event of respiratory depression, oxygen and naloxone should be readily available to reverse opiate effects.

### Pump Settings

The PCA pumps available for United Kingdom (UK) personnel on deployment, Baxter Infusor Elastomeric Infusion System (Baxter, Thetford, UK) are elastomeric devices with a button to deliver a bolus on demand. The standard pumps provide a 0.5-mL bolus with a 6-minute lockout. The concentration of morphine is 2 mg/mL, which provides a 1-mg bolus every 6 minutes up to a maximum of 10 mg per hour.<sup>1</sup>

The United States currently uses the ambIT Military



**Figure 21-1.** ambIT Military PCA Pump, currently used by US forces for patient-controlled analgesia, epidural, and continuous peripheral nerve block. Used with permission from Summit Medical Products, Salt Lake City, UT.

PCA Pump (Figure 21-1; Summit Medical Products, Salt Lake City, UT) for PCA, epidural, and CPNB. This pump is electronic and requires two AA batteries. The basal rate and bolus time intervals should be programmed for each individual patient. Depending on deployment drug inventory, US personnel use morphine or hydromorphone for PCA. In an opiate-naïve patient, the initial hydromorphone PCA dose is 0.2 mg IV every 10 minutes with a 1.2-mg per hour lockout. In the event the patient still reports intolerable pain after 1 or 2 hours, the ambIT pump can be evaluated and titrated appropriately.

If a morphine infusion is required for patients unable to use or understand PCA, then for UK personnel a standard infusion pump is used, the Braun Perfusor (Figure 21-2; B Braun, Melsungen, Germany). (The ambIT pump has a continuous infusion setting as well.) For the Braun Perfusor, the standard morphine concentration is 1 mg/mL in a 60-mL syringe with a clearly defined maximum infusion rate.<sup>1</sup> Patients using this device must be closely monitored for any adverse effects because a continuous infusion may cause unrecognized sedation and respiratory depression.



**Figure 21-2.** Braun Perfusor pump, used by UK personnel when morphine infusion is required for patients unable to use or understand patient-controlled analgesia. Used with permission from B Braun, Melsungen, Germany.

### When to Initiate

PCA can be commenced in the immediate postoperative period once the patient is alert enough to understand how to use the device. PCA should be initiated if the patient does not report adequate analgesia despite scheduled opiate boluses (every 4–6 hours). PCA should also be prescribed for patients being repatriated with either CPNB or epidural in situ in case of in-flight failure of these techniques.

Prior to air evacuation, PCA settings should be evaluated to ensure that the patient reports tolerable pain relief and to minimize side effects such as seda-

tion or respiratory depression. Due to the austere environment of aeromedical evacuation, monitoring in conditions of excessive noise and poor lighting should be considered.

### Nursing Guidelines

Patients using a PCA should have clinical observations monitored on an hourly basis for the first 4 hours after initiation. If they remain stable after this period, observations should be carried out every 2 hours for the next 8 hours and then every 4 hours for the duration of the time the PCA is used.<sup>1</sup> In addition to routine physiological observations, pain scores should be monitored and entered on a specific PCA chart.

Clear instructions should be provided to the nursing staff for recognizing and managing complications such as respiratory depression, hypotension, increasing pain, or change in mental status. Nursing staff who work on surgical wards are likely to be familiar with PCA use, although the pump device may vary. Predeployment education about the specific pumps and PCA charts will be necessary. If drugs other than morphine are being used, dosages need to be clearly documented and communicated to ward staff to prevent drug errors. Documentation of the PCA device, the medication infused, and the PCA program should be clearly identified on the patient's evacuation chart and communicated to evacuation personnel.

## EPIDURAL ANALGESIA

The use of epidural analgesia in military deployments has increased in recent years. The technique involves inserting a catheter into the epidural space and infusing a solution of local anesthetic to provide a central neuraxial block for pain. Epidurals are being used to provide analgesia for abdominal and lower limb wounds at the field hospital, during aeromedical evacuation, and in the patient's home nation.

### Indications

Epidurals provide analgesia for abdominal, thoracic, pelvic, and lower limb wounds.

Epidurals can be inserted in patients with injuries amenable to epidural analgesia and patients woken from general anesthesia. An epidural in the field environment is not appropriate if the patient is to remain intubated and anesthetized or is unable to cooperate with neurological assessments during postoperative management.

### Contraindications

Absolute contraindications to epidural anesthesia include patient refusal, infection at the needle insertion site, hypovolemia, elevated intracranial pressure, and allergy to local anesthetics.

Relative contraindications include coagulopathy, sepsis, and vertebral fractures. Severely injured patients presenting with a coagulopathy should not receive an epidural in the acute setting; however, placement may occur once the coagulopathy resolves. Patients with fever and an elevated white blood cell count should undergo further evaluation for bacteremia or sepsis prior to placement. After initiation of antibiotic therapy, epidural analgesia should be considered in patients with clinical improvement (ie, afebrile, declining white blood cell count). Although traditionally considered a contraindication, patients presenting with vertebral spinal fractures should be handled on a case-by-case basis. Vertebral radiographs describing the spinal level as well as the type of fracture

(spinous process, transverse process, vertebral body) may permit placement of an epidural under fluoroscopy or ultrasound guidance.

### Benefits

Successful epidurals provide profound analgesia to the abdominal area and lower extremities. Epidurals have the added advantage of treating incisional pain. Additionally, epidurals tend to provide an opiate-sparing effect and thus reduce the side effects of opiate analgesia, particularly respiratory depression, nausea, vomiting, and pruritus. In patients with compromised respiratory function, the reduction in opiate dose associated with an epidural may be of particular benefit in preserving vital capacity. Other benefits include a reduction in the autonomic stress response to surgery, reduced incidence of hypercoagulability, and improved gastrointestinal motility.<sup>2</sup>

### Complications

Patients with epidurals should be monitored for risks and complications (Table 21-2). Epidural hematoma and abscess can cause permanent spinal cord injury and require an emergency neurosurgical evaluation. The site of the epidural insertion should be monitored daily for any evidence of infection such as localized redness, swelling, tenderness, or obvious pus. Signs of central neurological infection such as meningitis should be aggressively managed. Epidural hematoma symptoms include increasing motor block, increasing back pain, or a change in bowel or bladder control and should prompt immediate imaging studies and neurologic consultation.

### When to Initiate

Insertion of epidural catheters in the elective setting is usually carried out with the patient awake in order to obtain cooperation for positioning and allow the patient to alert the practitioner to any nerve root pain or paresthesia. In the deployed environment, this is unlikely to be an option due to the urgent need for surgery, and epidurals may be inserted at the end of the operation with the patient still anesthetized. This allows analgesia to be established prior to waking the trauma patient from general anesthesia, avoiding the pain stress response and “wind-up” (see Chapter 16, Physiology of Pain). Epidurals can be considered at any time following surgery to improve pain management. The use of ultrasound to identify the spinous process and estimate the depth of the epidural space may be of benefit, especially in the anesthetized pa-

**TABLE 21-2**  
**COMPLICATIONS OF EPIDURALS**

Risks and Complications	Management
Dural puncture and postdural puncture headache	Lie patient flat, encourage oral fluids including caffeine. Consider blood patch.
Failure or patchy block	Establish sensory level. Provide top-up dose (anesthetist). Consider patient positioning for patchy or unilateral blocks.
Hypotension	Give O <sub>2</sub> and lie flat. Stop epidural infusion. Give fluid bolus as prescribed. Call anesthetist. Consider other causes of hypotension. Consider use of vasopressors.
Itching (opiate related)	Consider chlorphenamine maleate and ondansetron. If condition persists, use low-dose naloxone.
Nerve damage (needle damage, epidural hematoma, epidural abscess, anterior spinal artery syndrome, or arachnoiditis)	Observe for increasing back pain, increasing motor weakness, or change in bowel or bladder function. Inform anesthetist immediately; patient may need spinal imaging (CT or MRI).
Urinary retention	Consider need for catheterization if not already in situ.
Motor weakness	Consider reducing infusion rate. Also consider epidural hematoma.

CT: computed tomography

MRI: magnetic resonance imaging

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tient. The timing of epidural insertion and removal should reflect the latest guidelines for anticoagulation medication.

### Securing the Catheter

When securing epidurals in the deployed environment, consideration should be given to tunneling the epidural catheter. Tunneling of epidurals has been shown to reduce the chance of catheter displacement,<sup>3-5</sup> which is important when the epidural may be in situ for a prolonged period, including the multiple moves involved in aeromedical evacuation. Although there is some evidence that tunneling of epidurals may reduce

the rate of bacterial colonization,<sup>6</sup> there is very little evidence that tunneling reduces epidural infection rates. Tunneling of caudal catheters has been demonstrated to reduce colonization rates to the same as those of lumbar epidurals.<sup>7</sup>

Skin glue (medical cyanoacrylate adhesives) can also be used to reduce the chance of accidental removal of the epidural catheter<sup>8</sup> and should be considered in conjunction with tunneling to reduce the risk of catheter displacement. The site should then be covered with a clear dressing to allow easy inspection while the catheter remains in situ.

### Drugs and Infusion Settings

For UK personnel, the standard infusion is bupivacaine 0.125% infusing at 7 to 15 mL per hour. Because of the increased risk of respiratory depression from combining epidural and IV PCA opiates, the current recommended policy is to use an opiate-free epidural solution. If opiates are added, the infusion would be 0.1% bupivacaine with 2 µg/mL fentanyl.<sup>1</sup> For US personnel the standard infusion is 0.2% ropivacaine infusing at 6 to 12 mL per hour. A typical initial epidural setting includes a basal rate of 8 mL per hour with a 3-mL demand bolus every 20 minutes.

Although these are the standard choices for UK and US epidurals, whichever drug is available may be used if there are supply constraints.

### Pumps

Pumps used for an epidural infusion should always be clearly labeled to prevent medication errors, which may include incorrect drug as well as incorrect route of administration. Labeling is of particular importance where infusion devices may have more than one use and are not for sole epidural or nerve catheter use.

The US military currently uses the ambIT PCA Military Pump for epidural infusions as well as for PCA and CPNBs. Deployed UK military personnel currently use Braun Perfusor pumps to provide epidural infusions. The drug is made up in 50-mL syringes (rather than the pre-prepared bags common in civilian practice).

### Daily Rounding Considerations

All patients with an epidural should have an epidural chart as well as regular physiological observations. The level of the block should be measured and recorded, and leg strength should also be documented. Pain scores should be assessed and

recorded on the epidural chart, and there should be clear instructions about who to contact in the event of side effects, complications, or increasing pain. If there are any signs of infection or epidural hematoma, an anesthetist should be called immediately. If pain is increased an anesthetist may deliver a top-up bolus through the epidural (prior to the top-up bolus, the level of the block and sensory deficit should be assessed). Patients with epidurals should also receive regular simple analgesia such as acetaminophen and an NSAID if appropriate to support a multimodal pain management plan.

For patients who are not being evacuated, providers will need to decide when to remove the epidural catheter. Removal will depend on the clinical situation and is likely to be about 3 days after insertion if the catheter is not tunneled. If the patient requires an epidural beyond 3 days, the non-tunneled catheter should be removed and replaced via a tunneled technique. Tunneled catheters have been managed for up to 14 days. In these circumstances, daily examination of the catheter insertion site is very important to detect any evidence of infection.

### Nursing Guidelines

Many nursing staff working on surgical wards will be familiar with managing patients with epidurals in situ, although the pumps may be unfamiliar. Predeployment training should help increase confidence using the specific pumps seen on deployment. Epidural charts should also be discussed in predeployment training. Nurses unfamiliar with epidural infusions should receive training in basic epidural management as well as interpretation of epidural charts prior to deployment. The complications associated with epidural use should be emphasized, and the signs and symptoms of a complication should be checked for with each set of nursing observations. In the event of any questions or emergency, clear instructions to contact the duty anesthetist should be emphasized. Prior to deployment, anesthetists should also receive instructions and standard protocols on the pumps to be used during their deployment.

### Epidural Equipment Changes

In the next 2 years, UK safety guidelines will call for a change in epidural catheter connectors so they are no longer compatible with IV devices. Currently the pumps and syringes are not specific to epidurals, so this may result in significant changes in the equipment available during deployment.

## CONTINUOUS PERIPHERAL NERVE BLOCK

Because of advancements in body armor during the Iraq and Afghanistan conflicts, the vast majority of battlefield injuries now involve extremities. Due to the unpredictable injury patterns caused by combat trauma, CPNB is commonly used to manage acute pain on the battlefield. CPNB can provide postoperative analgesia to multiple extremities by the perineural administration of local anesthetic.

### Indications

The opportunity to apply CPNB should be considered when patients present with single or multiple extremity injuries or rib fractures with chest tubes, as well as during abdominal surgery when epidural anesthesia is contraindicated. The application of CPNB therefore requires the acute pain physician to understand the patient's injury pattern as well as the pathophysiology caused by the trauma and resuscitation. Although CPNB is commonly used for one to two extremity injuries, the analgesic plan may be expanded to cover three extremities (Exhibit 21-1).

### Contraindications

Compared to epidural analgesia, CPNB has relatively few contraindications. Absolute contraindications include patient refusal, allergy to local anesthetics, systemic infection, and infection at the site of needle entry. Relative contraindications include preexisting neurological deficit and coagulopathy.

Battlefield traumatic injuries may result in neurologic deficits, which may be masked or exacerbated by regional anesthesia. Prior to placing a regional block, the acute pain physician should discuss the injury

and neurologic deficit with the surgeon. However, the risk of neurologic injury from CPNB is small, and the benefits of optimal pain control may outweigh the potential risk. Trauma patients with lower extremity fractures at risk for compartment syndrome should have a prophylactic fasciotomy prior to transport. If a patient develops compartment syndrome, the likelihood of CPNB masking ischemic pain is extremely low when a dilute local anesthetic is infused.

Coagulopathy should be considered a relative contraindication for CPNB when the procedure is performed under ultrasound guidance by a skilled practitioner who demonstrates appropriate needle visualization. Trauma patients with a coagulopathy should not receive a deep block such as a lumbar plexus or posterior sciatic nerve block with a nerve stimulator until the coagulopathy is corrected. If a patient requires therapeutic anticoagulation after placement of CPNB, most catheters (with the exception of a lumbar plexus catheter) may remain in place, assuming that a risk-benefit analysis is communicated to the patient and surgeon. Similar to epidural technique, the latest guidelines on regional anesthesia, coagulopathy, and anticoagulation medications should be considered when performing a CPNB.

### Benefits

Similar to epidural anesthesia, the goals of CPNB involve achieving a tolerable level of postoperative analgesia while minimizing the side effects of opioids. Recent studies have reported on the systemic effects of uncontrolled pain as well as increased stress response.<sup>9</sup> Compared to epidural analgesia, patients with CPNBs may receive twice daily prophylactic anticoagulants (enoxaparin) and do not require a urinary catheter.

### Complications

The complications of CPNB are similar to those of epidural anesthesia and include failed block, bleeding, infection, local anesthetic systemic toxicity (LAST), and nerve injury. Pneumothorax is a potential complication of paravertebral as well as upper extremity blocks including supraclavicular and infraclavicular blocks, although this event is rare. Patients requiring bilateral brachial plexus CPNB should not receive two blocks that will cause bilateral phrenic nerve involvement.

The acute pain physician must guard against LAST during placement and management of CPNB. Proper technique involves slow injection (5 mL every 5–10 seconds) combined with gentle aspiration for blood ev-

#### EXHIBIT 21-1

#### CONTINUOUS PERIPHERAL NERVE BLOCK OPTIONS FOR MULTIPLE EXTREMITY INJURY

- Epidural + brachial plexus
- Femoral/sciatic +/- brachial plexus
- Sciatic (bilateral) +/- brachial plexus
- Paravertebral +/- brachial plexus or lower extremity
- Brachial plexus (avoid bilateral phrenic nerve)

**EXHIBIT 21-2**

**SYMPTOMS AND SIGNS OF LOCAL ANESTHETIC SYSTEMIC TOXICITY**

- Lightheadedness
- Dizziness
- Acute anxiety
- Vision changes
- Disorientation and drowsiness
- Tremor, shivering, twitching, and tics
- Seizure
- Cardiac arrest

ery 5 mL with constant surveillance for any side effect (Exhibit 21-2). An emergency cart with resuscitation equipment and medications including lipid emulsion therapy (Intralipid [Fresenius Kabi, Bad Homburg, Germany]) should be readily available. If the patient develops a seizure, the acute pain physician must provide immediate airway support and supplemental oxygen, and terminate the seizure with a benzodiazepine or propofol (25–50 mg). Patients progressing to cardiovascular collapse should immediately receive advanced cardiac life support and lipid emulsion therapy (Exhibit 21-3).

The incidence of permanent neurologic injury for regional anesthesia has previously been documented at 0.4%.<sup>10</sup> Unique to the battlefield, this adverse sequela may not manifest until after multiple evacuations and catheter removal. If a patient presents with a neurologic injury such as residual numbness or a motor deficit, a focused neurologic history and physical examination should be obtained. A chart review including the regional anesthesia used and operative records should be analyzed to establish preexisting injury, block complication, or use of a tourniquet. Patients should describe their neurologic symptoms in their own words. A brief neurologic examination to confirm motor strength, residual numbness, and reflexes provides an opportunity to map the lesion anatomically with a drawing.

With specific information from the history and physical, the physician should attempt to identify a mechanism of injury that matches the neurologic deficits with the nerves involved. Multiple etiologies of nerve injury exist, including compression, stretch, laceration, needle involvement, and chemical local anesthetic. The traumatic component often complicates the clinical presentation, which should prompt consultation with a neurologist for further neurologic testing. For patients with persistent neurologic deficits who

**EXHIBIT 21-3**

**TREATMENT RECOMMENDATIONS FOR LOCAL ANESTHETIC SYSTEMIC TOXICITY**

1. Airway management.
2. Seizures: Treat quickly with benzodiazepines. Avoid propofol with cardiovascular compromise.
3. Cardiac arrest:
  - a. Epinephrine, small initial doses (10- to 100- $\mu$ g boluses).
  - b. Avoid vasopressin.
  - c. Avoid calcium channel blockers and  $\beta$ -adrenergic receptor blockers.
  - d. Amiodarone is preferred in presence of ventricular arrhythmia.
4. Lipid emulsion therapy:
  - a. 1.5 mL/kg 20% lipid emulsion bolus.
  - b. 0.25 mL/kg/min, continued for at least 10 minutes after patient is hemodynamically stable.
  - c. Hemodynamically unstable? Consider repeat bolus and increasing infusion to 0.5 mL/kg/min.
  - d. Maximum upper dose: 10 mL/kg over 30 minutes.

Data source: Weinberg GL. Treatment of local anesthetic systemic toxicity (LAST). *Reg Anesth Pain Med.* 2010;35:188–193.

are in the evacuation process, the current acute pain physician must provide detailed documentation and recommend appropriate consultation with neurology, physical medicine, and physical therapy at the next level of medical care.

**When to Initiate**

In the setting of elective surgery, CPNB placement commonly occurs prior to surgery. Because combat surgical patients may present with hemorrhagic shock, the primary focus should remain on facilitating the start of the surgery and fluid resuscitation. After completion of the surgery and adequate fluid resuscitation, the acute pain physician will have to decide whether to place the block in either the operating room (OR), postanesthesia care unit, ward, or intensive care unit. In an unpredictable mass casualty scenario, the decision to transfer the patient out of the OR should always remain a high priority.

Assuming that the immediate use of the OR is not required, recent developments in ultrasound technology permit an acute pain physician to place CPNB prior to extubation. Although placing a CPNB at this time does not permit the patient to report a transient paresthesia, appropriate needle visualization combined with normal syringe resistance greatly reduces the incidence of a neuronal injection. The underlying rationale for utilizing regional anesthesia prior to emergence from general anesthesia is to prevent severe pain and the detrimental systemic effects of uncontrolled pain.<sup>9</sup> The safety of regional anesthesia in patients under general anesthesia has previously been discussed in the field of pediatric regional anesthesia.<sup>11</sup>

### Securing the Catheter

As the battlefield anesthesia environment fluctuates from austere ORs to more modern combat hospitals, the acute pain physician's ability to adequately secure a regional catheter will maintain the functionality and longevity of the catheter. A trauma patient's exposure to harsh weather as well as air evacuation should prompt the provider to minimize the risk of catheter migration. Military anesthesiologists have commonly tunneled catheters for CPNBs lasting more than 3 days. Because CPNBs may be placed outside the OR, tunneled catheters may reduce infections.<sup>6,7</sup> CPNB in the military environment may increase the risk of inadvertent catheter removal because evacuation via airplane or helicopter contributes to catheter migration through provider handling and vibration associated with these aircraft. Multiple techniques are available to secure a catheter, but the recommended process involves tunneling with angiocatheter needle, skin adhesive (eg, Dermabond [Ethicon Inc, Sommerville, NJ]), adhesive spray (eg, Medical Adhesive, Hollister, Libertyville, IL) and a transparent dressing (eg, Tegaderm [3M, St Paul, MN]).<sup>12(ch24)</sup>

### Drugs and Infusion Settings

Continuous infusions of local anesthetics may consist of either 0.2% ropivacaine or 0.125% bupivacaine. Buckenmaier and Bleckner<sup>12(ch3)</sup> have previously described infusion rates for standard ropivacaine doses for continuous regional anesthesia at Walter Reed Army Medical Center. In the UK, patients receive single catheter infusions of 0.2% ropivacaine at 10 mL per hour. In the United States, single catheter infusion settings may vary, with a continuous infusion between 8 and 10 mL per hour combined with a patient-controlled bolus rate of 2 to 3 mL every 20 minutes. Multiple catheter infusions require detailed attention

to prevent LAST. In patients with two catheters, the continuous infusion may range from 5 to 10 mL per hour, with a patient-controlled bolus rate of 2 to 3 mL every 20 minutes for one of the catheters. Rate and bolus options may vary depending on the patient's pain location. Although there is no exact formula to prevent LAST, total infusions (continuous plus bolus) greater than 20 mL per hour are typically avoided.

Although multiple options exist for delivery of local anesthetic infusion, device selection depends on the respective governing departments' air evacuation safety certification (US Air Force or UK Ministry of Defence). The approved US infusion device for CPNB, as for PCA and epidural catheters, is the AmbIT PCA Military Pump. The approved UK CPNB infusion device is the elastomeric Braun Perfusor pump (Figure 21-3).

### Daily Rounding Considerations

The ultimate goal of providing superior analgesic relief with CPNB to combat patients depends heavily on the ability to monitor the catheters each day. CPNB and other advanced pain modalities are best used under the management of a dedicated acute pain service (APS). The APS consists of specially trained anesthesiologists and nurses who are responsible for the day-to-day management of pain within the Role 3 (or higher) military care facility. The US military has established a Joint Theater Trauma System Clinical Practice Guideline on the management of pain, anxiety,



**Figure 21-3.** Braun Perfusor pump, the approved UK continuous peripheral nerve block infusion device. Used with permission from B Braun, Melsungen, Germany.

and delirium in injured service members that mandates an APS activity at all Role 3 (or higher) military healthcare facilities.<sup>13</sup>

The APS should review the pump infusion settings at each patient encounter. Catheter functionality should initially be assessed by asking the patients how they are doing. The benefits of asking an open ended question will allow patients to declare the severity of their pain without prompting them to immediately comment on their pain score. Depending on the patient's response, the APS can direct the patient interview toward pain scores. If the patient reports pain, the location and quality of the pain must be established to determine the functionality of the catheter. Depending on the severity of the injury, the incision injury may extend beyond the dermatomes of the blocked nerves. The anesthesia provider should consider contacting a surgeon if there is any suspicion of compartment syndrome.

If the patient reports pain in the anatomic distribution of a specific CPNB, the APS must determine if the patient has a sensory deficit with the affected dermatomes. Assuming that the patient does not have a sensory deficit to ice in the affected area, the physician should obtain vital signs every 5 minutes for 15 minutes after the administration of a 10-mL bolus of local anesthetic (1.5% mepivacaine or 0.5% ropivacaine). If the patient reports significant analgesic relief with the bolus, the provider should consider increasing the rate of the infusion by 2 mL per hour. If the patient reports persistent pain and no sensory deficit 15 to 20 minutes after the bolus, strong consideration should be given to catheter removal with potential replacement. Daily considerations for catheter removal should be reviewed; however, the APS should attempt to maintain the catheters as long as the patient has scheduled surgery because catheters can be used to reestablish surgical anesthesia with local anesthetics for repeated surgical interventions.

The APS's ability to monitor side effects and complications is a high priority as the patient is evacuated and obtains a new set of providers. During rounds, a focused chart review should include maximum temperature, coagulation labs (platelets, prothrombin time, partial thromboplastin time) and anticoagulation medications (enoxaparin, heparin, clopidogrel). The transparent dressings must be assessed at least once a day with emphasis on the following:

1. Does the site have any sign of infection such as tenderness, erythema, or purulent discharge?
2. Is there any evidence of blood in the catheter?
3. Finally, symptoms of local anesthetic toxicity such as tinnitus, metallic taste in mouth, central nervous system agitation, or thoughts of impending doom should be excluded (see Exhibit 21-2).

### Nursing Guidelines

Prior to or shortly after the beginning of the deployment, the APS should provide a brief orientation to the ward or critical care nurses about regional catheters. Although the APS is directly responsible for the catheters, well-educated nurses will positively impact the patient's analgesic plan. Specifically, nurses should be educated on basic pump features such as turning the device on and off, changing batteries, and resetting the device when local anesthetic is replaced. Even though an APS may visit a patient once or twice a day, the ward nurse who attentively identifies a pump malfunction, suspicious skin rash, or early sign of local anesthetic toxicity will ultimately benefit the patient. The benefits of an established relationship between the APS and nursing team will help identify these issues sooner rather than later.

### CONCLUSION

The regular use of advanced analgesic techniques is now commonplace in the deployed field hospital and

is responsible in a large part for the improvements in analgesia for injured service personnel.

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