Peripheral regional techniques for acute pain treatment

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Abstract

Regional anaesthesia has many advantages over systemic analgesia alone for postoperative pain, enhanced recovery and rehabilitation. Advances in continuous peripheral nerve block techniques enable the benefits of single injection blockade to be extended, providing prolonged, site-specific analgesia. A wide range of equipment, local anaesthetic solutions and adjuvants can be used to provide peripheral nerve blockade. In this article we review equipment, drugs, techniques, indications, benefits and potential complications of peripheral nerve blockade.

Keywords Acute pain; adjuvants; complications; indications; infusion pumps; local anaesthetics; nerve block; perineural catheters; ultrasonography

Royal College of Anaesthetists CPD matrix: 1A02; 2E01; 3A09

Learning objectives

After reading this article you should be able to:

- name the indications for and benefits of peripheral nerve blockade
- describe the equipment used to provide continuous peripheral nerve block
- name adjuvants commonly used in conjunction with local anaesthetics for peripheral nerve blockade
- understand the role of ultrasonography

Acute pain can have considerable impact on patient morbidity and delay postoperative recovery.[1] Regional anaesthesia improves outcome when incorporated into a structured enhanced recovery after surgery (ERAS) programme.[2] Compared to systemic analgesia alone regional anaesthesia provides improved postoperative analgesia, reduced pain intensity, less nausea and vomiting, improved patient satisfaction and reduced anxiety. In addition to postoperative analgesia, regional techniques can be an important treatment option for trauma patients, prior to surgery or in cases managed conservatively, for example, intercostal or paravertebral blocks for rib fractures and fascia iliaca blocks for hip fractures. Patients with chronic pain in the perioperative period present special challenges. Their pain is poorly controlled by the routine administration of opioids alone. It is critical that such patients are identified early and an analgesia plan, including a regional anaesthetic technique where possible, is formulated.

Peripheral regional techniques

Injecting the operative site with local anaesthetic (LA) is a simple way to enhance pain control. More specifically LA can be injected around targeted peripheral nerves or plexuses, into fascial planes, the paravertebral space or joints. In this respect peripheral regional techniques can be used to provide analgesia for head, neck, upper and lower limb, thoracic and abdominal acute pain. Single injection peripheral nerve blocks with long acting LAs can provide excellent analgesia. The benefit is usually limited to a maximum of 24 hours and after this patients may require opioid analgesia, which can induce unpleasant side effects. To reduce the need for supplemental pain treatments, continuous peripheral nerve blockade (CPNB) techniques can be employed to offer prolonged, site-specific analgesia.

Ultrasonography

The introduction of portable ultrasound machines has been a paradigm shift in performing regional anaesthesia. The practitioner is no longer limited to surface landmarks and can chose the most convenient position. The block needle and catheter are visualized and safely guided in the plane of the ultrasound beam to the area of interest while avoiding vital structures (Figure 1). Refinement of the needle position is possible, ensuring accurate deposition of LA around and along the nerve. The ability to block sensory nerves, not amenable to neurostimulation is a particular advantage of ultrasound guidance. Variations in anatomy are common but can be identified by ultrasonography thus ensuring optimal needle placement for block success while avoiding complications. Ultrasonography provides other advantages such as reduced onset time and improved block efficacy.[3] Ultrasound has been shown to improve block efficacy in less experienced hands, achieving success rates in excess of 90%.[3]

Continuous peripheral nerve blockade

The duration of regional analgesia may be extended to several days by inserting a catheter through which LA may be continually infused. This is especially useful following major surgical procedures to the limbs and in cases where parenteral opioid avoidance is preferred. The use of CPNB in ambulatory patients has increased over the past few years, permitting day-case hospital stays for procedures that once required an inpatient bed.

Important criteria in the ambulatory setting include:

- patient acceptance
- ability of patient and care providers to understand how to use the infusion pump, recognize early signs of LA toxicity and to be aware of potential complications
- Support from the acute pain service.

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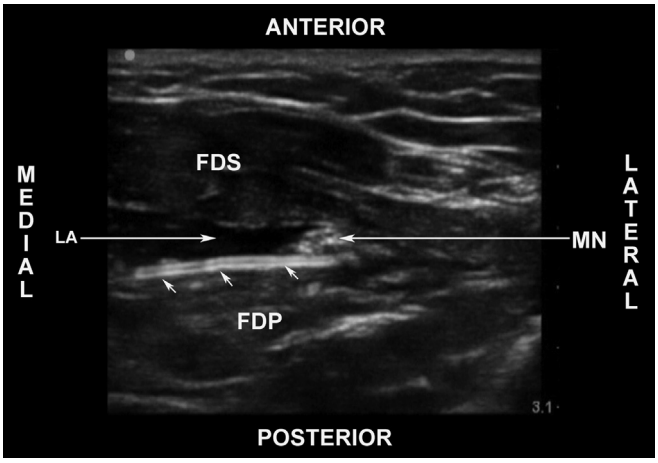

Figure 1 Ultrasound-guided median nerve catheter in the forearm. FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; LA, local anaesthetic; MN, median nerve. The unlabelled arrows indicate the continuous perineural catheter.

Equipment

There are a number of different regional anaesthetic needles available on the market. A typical needle is 22 gauge (G), insulated, attachable to a nerve stimulator and has an extension port for injection. Larger gauge, stimulating needles (typically 18 or 19 G) are required for catheter insertion. Echo-enhanced needles are also available to improve visibility during ultrasound-guided procedures. There are three different catheter set designs: catheter-through-needle, cannula-over-needle and stimulating catheter systems. Once the catheter has been inserted it needs to be securely fixed and again there are different methods. As yet there is no evidence to support one type of catheter set or fixation method. The steps to performing regional anaesthetic techniques are listed in Table 1.

Infusion pumps

Ideally pumps for CPNBs should:

- be light weight to permit early mobilization
- permit a wide range of infusion rates
- include patient-controlled analgesia
- have safety features (i.e. infusion should stop if the pump is opened or if a high infusion pressure is encountered).

There are two types of ambulatory pumps, electronic and elastomeric. If various rates of infusion, bolus volumes and lockout periods are required then an electronic pump is preferred. A temperature-sensitive valve regulates the infusion rate of most elastomeric pumps but provides no warning of pump malfunction or catheter occlusion. Advantages of elastomeric pumps include portability, ease of use and fewer technical problems.

Techniques for local anaesthetic delivery

There are three approaches to delivering LA for CPNB following insertion of a percutaneous catheter:

- clinician-led boluses of LA at fixed times.
- continuous perineural LA infusion at a predetermined rate.
- patient-controlled perineural LA boluses (predetermined lockout period) with a basal rate infusion.

Steps for performing a regional block

- Explain procedure to patient, describing side effects and risks
- Obtain consent
- Consider risk/benefit of performing block awake or asleep
- Have the aid of a trained assistant
- Choose regional anaesthetic needle or catheter set you are familiar with
- Check the working function of nerve stimulator and/or ultrasound machine
- Obtain intravenous access
- Patient monitoring
- Position patient optimally
- Sterile preparation
- Calculate appropriate local anaesthetic (LA) dose
- Be aware of the location of intralipid emulsion in department
- Identify anatomy and location of target nerve/plexus (using nerve stimulator, ultrasound or both)
- Inject LA slowing after initial aspiration. Keep verbal communication with patient throughout (if awake) and watch electrocardiography monitor. Aspirate again after every 5 ml injected. Stop injection if painful
- Catheter insertion is usually performed after injection of LA to avoid trauma. Thread the catheter through the needle (similar to epidural technique) and then remove the needle. Pull the catheter back to where the needle tip was initially at optimum position or guide pull back by ultrasound. Catheter fixation is a critical factor to maximize the success rate and prevent postoperative displacement

Table 1

Local anaesthetics

Factors to be considered in the choice of LA for CPNBs are: onset speed, duration of action, ability to produce a differential sensory-motor block and the potential for toxicity. A number of LA solutions are available and can be classified into short- (chloroprocaine), intermediate- (lidocaine, mepivacaine) and long-acting agents (ropivacaine, bupivacaine). There is no evidence to support the superiority of one LA over another when used for continuous techniques.

Adjuvants

Adjuncts may be used to enhance the efficiency of perineural blocks through an increase in depth and duration of the sensory block induced by LA. These include epinephrine, bicarbonate, clonidine, dexamethasone, opioids, midazolam, magnesium, steroids and hyaluronidase.[4] Studies involving other peripheral nerve blockade adjuncts such as neostigmine, ketamine and tramadol have not been convincing. Suggested infusion regimes are given in Table 2.

Epinephrine: causes vasoconstriction reducing LA clearance from site of action, prolonging duration of action. Solutions such as 1:200,000 or 1:400,000 are commonly used. Since the microcirculation of peripheral nerves is under adrenergic control adding epinephrine has the potential to cause neuronal ischaemia. Caution needs to be given particularly in patients with

Concentrations and infusion rates suggested for continuous peripheral nerve blocks with considered anaesthetic solutions

Local anaesthetic	Concentration (%)	Infusion rate (ml/hour)	Additives
Lidocaine	1	5–10	Clonidine (1 μg/ml)
Bupivacaine	0.125–0.25	5–10	Fentanyl (1–2 μg/ml)
Ropivacaine	0.2–0.3	5–10	Sufentanil[a] (0.1 μg/ml)
Levobupivacaine	0.125–0.25	5–10	Morphine sulphate (0.03 mg/ml)

From Putzu M, Casati A. Local anesthetic solutions for continuous nerve blocks. In: Hadzic A, ed. Textbook of regional anesthesia and acute pain management, 1st edn. New York: McGraw Hill, 2007 with kind permission.
[a] Not yet available in the UK.

Table 2

chemotherapy-related neurotoxicity, diabetic neuropathies and atherosclerosis.

Bicarbonate: the addition of bicarbonate raises the pH of LA solution thereby increasing the proportion of unionized LA available to cross the phospholipid membrane, increasing speed of onset. The benefit of alkalizing plain LA solutions is dependent on the preparation of LA used. The recommended dose is 1 ml of 8.4% of sodium bicarbonate per 10 ml of LA. The stability of LAs with added bicarbonate is not well studied and such mixtures cannot be recommended for continuous perineural infusions.

Clonidine: An α2 receptor agonist whose effect may be mediated by inhibiting action potentials. Its effect is dose dependant, increasing the duration of anaesthesia and analgesia when used with intermediate acting LAs. A dose of 0.5–1.0 μg/ml is recommended to limit systemic side effects.[5] Despite its utility in cases of inflammatory pain and neuropathic conditions, there is no evidence to support its use in improving postoperative pain management.

Dexamethasone: perineural dexamethasone has been shown to prolong the duration of peripheral blocks. While its toxicity profile is promising, further studies are required to confirm its safety in perineural use.

Opioids: various studies have supported the existence and functional significance of opioid receptors on primary afferent neurons.[6] The benefit of adding opioid agonists to LAs for PNBs is unclear.

Safety and complications

The frequency of significant adverse complications for single shot and continuous PNB is low. Common complications of peripheral nerve block include failed or partial block requiring supplementation, vascular puncture and transient neuropathy (3:100).[7] Despite advantages it is yet to be proven whether ultrasound-guided regional anaesthesia is safer than traditional methods, particularly as the incidence of complications with landmark and neurostimulation techniques is already low. Importantly ultrasonography has not completely eliminated adverse events. Block-specific complications are well recognized, including pneumothorax following interscalene blockade. LA toxicity is a rare but serious complication resulting in possible cerebral and cardiovascular sequelae. Catheter insertion increases the risk of localized haematoma formation, infection (3:100) and nerve injury (3:2000), although all risks remain extremely small.[8] Other potential complications include catheter kinking and dislodgement (up to 5.5% risk), leaking at the catheter insertion site (<10%), pump failure and disconnection.

Future directions

The push towards ERAS programmes has encouraged clinicians to adopt alternative techniques that can provide analgesia whilst enabling rapid mobilization. Ultrasound-guided blocks of the rectus sheath (RS) and transversus abdominis plane (TAP)[9] (Figure 2) can establish anaesthesia and analgesia of the trunk whilst avoiding the leg weakness and hypotension associated with epidural blockade. Research is on going to determine if these blocks are a genuine alternative to epidural anaesthesia. Local infiltration analgesia (LIA) has recently been introduced to reduce postoperative pain and aid mobilization after lower limb arthroplasty. Controlled studies are required to compare LIA with traditional analgesic regimes.[10] Finally, the development of liposomal delivery systems promises to transform regional anaesthesia by offering a slow-release vehicle of LA at the site of

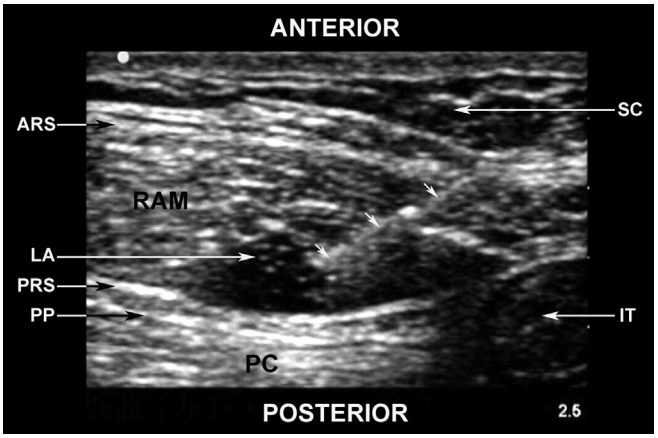

Figure 2 Ultrasound-guided rectus sheath block. ARS, anterior layer of rectus sheath; IT, intestine; LA, local anaesthetic; PRS, posterior layer of rectus sheath; PC, peritoneal cavity; PP, parietal peritoneum; RAM, rectus abdominis muscle; SC, subcutaneous tissue. The unlabelled arrows indicate the block needle.

injection that would sustain analgesia and remove the need for adjuncts and catheters. ◆

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