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Raju, Pavan Kumar B. C.; Bowness, James

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Upper limb nerve blocks

Pavan Kumar B C Raju FRCA is a Consultant Anaesthetist at Ninewells Hospital and Medical School, Dundee, Scotland, UK. Conflicts of interest: none declared.

James S Bowness FRCA is a Clinical Lecturer in Anaesthesia at the University of Dundee and a Specialty Registrar in Anaesthesia at Ninewells Hospital and Medical School, Dundee, Scotland, UK. Conflicts of interest: none declared.

Abstract

Brachial plexus blockade is used for a variety of upper limb surgical procedures. Ultrasound guidance is generally considered to be the gold-standard technique, although large-scale studies examining efficacy and complications of ultrasound-guided techniques compared with nerve stimulation are still needed. Interscalene block remains the approach of choice for shoulder surgery, although phrenic nerve blockade is common even using low volumes of local anaesthetic. Of the currently available studies comparing the other approaches, there seems to be little difference in efficacy between axillary, supraclavicular and infraclavicular approaches for elbow, forearm and hand surgery when equivalent levels of expertise are used. The major features influencing block choice and performance are discussed.

Keywords

Brachial plexus block; regional anaesthesia; technique; ultrasound

Royal College of Anaesthetists CPD Matrix: 1D02,2E01,2G01,3A09

Learning Objectives

After reading this article, you should understand the:

- indications and potential benefits of upper limb blocks
- understand the limitations of individual upper limb blocks
- appropriate brachial plexus block for upper limb surgery
- principles of four major techniques of brachial plexus block
- principles of specific forearm peripheral nerve blocks

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Upper limb nerve blocks

Nerve blocks remain central to the practice of intra-operative analgesia/anaesthesia and post-operative analgesia for upper limb surgery. Brachial plexus blockade can simplify the anaesthetic management for a variety of patients with increasing medical co-morbidities. This is particularly important in patients with respiratory or cardiovascular disease, obesity, diabetes, chronic pain and those with anticipated difficulty in airway management. The excellent analgesia, which can be prolonged by the insertion of continuous infusion catheters, and early readiness for post-operative discharge facilitates earlier mobilisation, and may reduce hospital stay and improve functional outcome[1]. The use of ultrasound-guided approaches has stimulated interest amongst anaesthetists who previously considered regional anaesthesia to be a preserve of the specialist. Although well-controlled large-scale studies examining block efficacy and complications compared with peripheral nerve stimulation are lacking, there is a growing volume of literature to support routine use of ultrasound. Potential advantages of ultrasound guidance have been discussed elsewhere[2]. To perform these techniques safely it is vital for the anaesthetist to obtain adequate supervised training, and then maintain experience by continuing to use a few select techniques frequently rather than attempting to master all approaches or reserving them only for the most medically compromised patients. Equally, careful patient selection plays a crucial role in achieving maximum benefit.

Choice of technique

Choice of technique (Table 1) is important to optimise success for any procedure. The interscalene approach will reliably block the higher brachial plexus nerves and cervical plexus, necessary for successful awake shoulder surgery. The supraclavicular and infraclavicular approaches are useful when arm abduction is limited, with the former useful for humeral surgery and the latter excellent for infusion catheter placement. The axillary approach can be used for most hand, forearm and elbow surgery, with the added advantage of being safe in relatively inexperienced hands. The blockade of more peripheral nerves in the distal arm and forearm is useful for block rescue or postoperative analgesia with reduced motor blockade.

Interscalene block

This technique is recommended for shoulder surgery due to its ability to successfully block the upper trunk (C5/6) and its proximal branches. It also provides anaesthesia in the C3/4 cutaneous distribution/blockade of the supraclavicular nerves, through proximal spread to the cervical plexus, although the posterior port site for laparoscopic shoulder surgery often needs local supplementation. Surgery can be carried out awake using, but is more frequently used in combination with general anaesthesia to provide intra and post-operative analgesia. However, performing the block in an awake or mildly sedated patient is highly recommended, even if general anaesthesia is planned.

Positioning

With the patient supine, face turned to the contralateral shoulder, position the pillow to allow adequate space for manipulation of the needle and ultrasound probe on the side to be blocked. Arrange the ultrasound machine so the operator's line of sight includes the needle, patient and screen.

Practical points

The C5/6 nerve roots or upper trunk are generally seen as hypoechoic round structures lying between scalenus anterior and medius muscles (Figure 1), with the probe scanning transversely at the level of C6. The number of nerve structures seen varies, from two to four, as the nerve roots or proximal upper trunk may be visible depending on the level scanned, as well as the C7 nerve root and variable visibility of branches such as the dorsal scapular and suprascapular nerves. The needle can be introduced in-plane, from posterolateral to anteromedial, or out of plane from superior to inferior. The latter is preferred for catheter insertion due to the more favourable needle direction relative to the plexus. However, with e-catheters, a safer in-plane approach can be utilised for continuous infusions. Blockade of the plexus (for post-operative analgesia) has been demonstrated using very small volumes with this approach[3] (<5 ml), although the minimum volume necessary to also block the cervical plexus needs to be determined. Our regular practice combines general anaesthesia and interscalene block, using 8 – 10 ml of 0.2% - 0.75% ropivacaine, for analgesia during the intra-operative and early post-operative period.

Limitations and complications

The major limitation of this approach is inevitable blockade of the phrenic nerve (100%) with large volume injections: this is reduced (47%) but not eliminated with low-volume technique and extra-fascial techniques. Diaphragm-sparing nerve blocks have been described although these techniques have not been fully refined[3]. Patients with limited respiratory reserve are at higher risk of developing respiratory compromise with the resulting hemidiaphragmatic paresis, and careful consideration should be given to the use of this block in such patients. It should not be performed bilaterally. Horner's syndrome (50%), and hoarseness are not uncommon, but more significant complications such as seizure from inadvertent vertebral artery injection, total spinal anaesthesia from dural puncture or intra-spinal cord injection are rare.

Diaphragm sparing blocks

These approaches have the advantage of minimising phrenic nerve blockade without significantly compromising analgesic efficacy. However, they are novel and evidence is limited when compared to more common (e.g. interscalene) blocks. The "shoulder block" (combining separate blocks to the suprascapular and axillary nerves) is presently the most utilised alternative. The suprascapular nerve is blocked in the supraspinous groove of the scapula, where it lies adjacent to the suprascapular artery having branched from the superior trunk of the plexus, coursing postero-laterally towards the suprascapular notch. The axillary nerve is blocked on the posterior aspect of the humerus, looking to view the axillary nerve and circumflex artery in cross section (short axis) deep to the deltoid muscle. A deficiency in this approach is the potential to spare the lateral pectoral nerves. Suggestions to combat this include combining a suprascapular nerve block with a costoclavicular approach to an infraclavicular block, specifically targeting the lateral and posterior cords to block the axillary and lateral pectoral nerves which arise at this level of the brachial plexus. Alternatively, depositing local anaesthetic lateral and posterior to C7 nerve root appears to be an attractive approach to reduce phrenic nerve blockade, although evidence is currently limited.

Supraclavicular block

Once a very popular approach due to its efficacy, density of block and rapid onset, the supraclavicular approach had fallen out of favour - largely due to the risk of pneumothorax (quoted at up to 8%). However, the development of ultrasound visualisation has led to a renewed interest in this approach for many upper limb procedures as the risk of pneumothorax has dropped significantly (although still remains).

Positioning

This is the same as for the interscalene block, with the ultrasound machine on the opposite side of the patient, with the probe, needle and screen are aligned.

Practical points

A coronal-oblique probe orientation in the supraclavicular fossa usually gives an excellent view of the subclavian artery, first rib, pleura and plexus. The nerve trunks/divisions are seen as a collection of hypoechoic round structures (likened to a bunch of grapes) lying superior and postero-lateral to the artery (Figure 2). An in-plane needle approach, from lateral to medial, is most commonly used to carefully place up to 30 ml of local anaesthetic within the neurovascular sheath. Needle position is modified to ensure local anaesthetic spread around the whole plexus, optimising the likelihood of a complete block, and block onset is rapid due to the plexus being tightly packed within this area.

Limitations and complications

The risk of pneumothorax has been mentioned above. Phrenic nerve blockade may occur resulting in hemidiaphragmatic paresis in up to 30% of patients. This can be limited by depositing the majority of injectate at the intersection of the first rib and subclavian artery[4]. The technique is usually reserved for in-patient use and best avoided in patients with significant respiratory dysfunction.

Infraclavicular block

The infraclavicular block is used for elbow, forearm and hand surgery. Unlike the axillary block, it can be performed without moving the relevant limb (e.g. after trauma) with a single injection technique, and is therefore utilised by some anaesthetists as the standard approach for surgery involving these areas.

Positioning

The patient lies supine, head turned to the contralateral side. The operator is positioned at the head end of the bed, facing the screen of the ultrasound machine, which is placed next to the ipsilateral side of the patient’s trunk (below the axilla).

Practical points

The infraclavicular fossa is bounded anteriorly by the pectoral muscles, medially by ribs one-three (with the intervening intercostal muscles and overlying serratus anterior), and superiorly by the clavicle and coracoid process. Subscapularis forms the posterior wall and inserts onto the humerus, which forms the lateral wall of the fossa. An ultrasound-guided approach in the pericoracoid area (lateral sagittal infraclavicular block) has simplified this block and improved efficacy, whilst reducing the risk of vascular puncture and pneumothorax[5]. In this location, the cords of the brachial plexus are blocked deep to pectoralis minor muscle as they surround the artery in lateral (9-11 o'clock), posterior (6 o'clock) and medial (2-3 o'clock) positions (Figure 3). Successful single-shot blockade with 30 ml of local anaesthetic is best achieved with injection posterior to and around the axillary artery. It remains the block of choice for catheter fixation when continuous infusion analgesia is employed post-operatively.

Limitations and complications

As the brachial plexus lies more deeply at this level, and the needle must traverse the clavicle, the angle of insertion is necessarily steep making visualisation of the needle more difficult. However, the risk of pneumothorax is lower (although arterial and venous vessels may be punctured) and this approach is less likely to cause phrenic nerve paresis than a supraclavicular block.

Axillary block

This has a similar distribution to the infraclavicular block, as well as providing anaesthesia for proximal vascular access procedures on the medial aspect of the upper arm (e.g. brachio-basilic fistula formation). It is an ideal block for the relative novice as there is a lower potential for significant complications when compared with the more proximal blocks. The location and injection around a number of nerve structures during each block helps develop ultrasound-related skills, and the presence of the easily visualised axillary artery (and its relationship to the terminal nerves, although variable) facilitates performance (Figure 4).

Positioning

The patient lays supine, with the shoulder abducted and externally rotated by 90 degrees. The elbow is flexed to a right angle so the forearm can be supported on the bed. The anaesthetist can sit in the axilla, facing the site of block with the ultrasound screen beyond, or again position themselves above the shoulder with the ultrasound machine in the axilla. Whichever position is selected, as with all other blocks, the operator, probe, needle and screen must be in alignment.

Practical points

The artery is usually visualised as proximally as possible, allowing the probe to be supported against the chest wall in a transverse orientation. The structures targeted are relatively superficial allowing a high-frequency (10 MHz) probe to be used with the depth set at approximately 3 cm for best clarity and appreciation of the surrounding structures. The nerve appearances are variable but usually more hyperechoic in this region, with the musculocutaneous nerve found in the fascial plane between short head of biceps and coracobrachialis (Figure 4). Scanning along the arm will help in identifying it, as the nerve moves laterally in this plane as it travels distally in the arm. The median nerve is usually visualised supero-lateral to the artery, in the 9-12 o'clock position. The ulnar nerve may lie in the corresponding supero-medial (1–3 o'clock) position but more commonly lies at a discrete distance from the artery beneath the axillary vein at a similar level. The radial nerve is the most difficult to visualise and is generally located below the ulnar nerve (5 o'clock). To help with identification, all the nerves can be traced from more distal positions to their final locations relative to the artery. Needle insertion can be in-plane (needle visualised) or out of plane (ideally needle tip alone visualised). A word of caution; with an out of plane approach, the needle tip and shaft both appear as a hyperechoic dot. Hence, the needle tip position is best confirmed by the incremental spread of local anaesthetic. Visualisation of the entire needle with the in-plane approach is recommended, but also the most demanding ultrasound skill to acquire. This is crucial with the more proximal plexus blocks, to avoid needle-related complications such as pleural puncture, and becomes easier with practice and the development of new technology[6]. Complete blockade of all nerves is usually rapid (often within 10 min) using lidocaine 1.5% with epinephrine 5 mcg/ml, 20–30 ml depending on spread, although volumes as low as 1 ml/nerve have been successfully employed[7]. Lidocaine will generally provide a block of 2–3 hours. Longer acting agents such as levobupivacaine or ropivacaine in similar volumes can be used for more major procedures such as total elbow arthroplasty or complex fracture fixation and will provide around 14 hours of analgesia. Perineural injection of adjuncts to prolong block duration have been suggested[8,9], although it is not our practice to use them routinely. The speed of onset, efficacy[5], and absence of pneumothorax risk or phrenic nerve blockade, continue to favour this technique for most hand, forearm and elbow procedures.

Limitations and complications

This block level requires movement of the limb and is likely to remain a multiple-injection technique as circumferential spread of injectate around the artery is often limited. Furthermore, the musculocutaneous and radial nerves leave the axillary sheath most proximally, and so are often missed with single-injection approaches.

Peripheral nerve blocks

These blocks, supplemented where necessary by local infiltration, are becoming more popular as an analgesic supplement in conjunction with general anaesthesia. They also enable the use of low volumes of higher concentration local anaesthetic to achieve a rapid onset with prolonged analgesia and minimal proximal motor block, facilitating early physiotherapy and effective rehabilitation. Furthermore, they can be very useful in patients with significant co-morbidities by reducing the use of systemic analgesic agents. Individual peripheral nerves can be blocked at various locations along their course in the upper limb, although the nerves blocked and the optimal point to block each one should be carefully considered as anatomical variation may lead to inadequate coverage of the intended site if branches are missed[10]. The median nerve can be blocked between flexor digitorum superficialis and flexor digitorum profundus in the mid-forearm (Figure 5), whilst the ulnar nerve is usually blocked at or just proximal to its juncture with the ulnar artery at the same level. The lateral cutaneous nerve of the forearm (terminal cutaneous branch of the musculocutaneous nerve) can be blocked in the cubital fossa: it emerges on the lateral side of the biceps tendon, and block here will lead to a purely sensory block. The radial nerve is blocked at the elbow, between brachioradialis and brachialis muscles, before it divides into its superficial and deep components.

Table 1: Techniques of upper limb block

Technique	Sensory block	Advantages	Disadvantages
Interscalene	Shoulder, humerus, elbow, lateral aspect forearm and hand	Blocks deep structures of shoulder and upper arm	C_8, T_1 often missed, phrenic nerve palsy inevitable, occasional serious complications
Supraclavicular	Whole limb except shoulder	Widest area of block	Risk of pneumothorax, phrenic nerve palsy
Infraclavicular	Hand, forearm, elbow	Ease of arm positioning, secure site for catheter fixation	Risk of pneumothorax, Landmarks not always obvious
Axillary	Hand, forearm, elbow	Easy technique, low risk of complications	Difficult to position painful limb, need for multiple injection technique
Peripheral nerves	Individual nerve territories	Easy techniques, long duration	Limited area of block, may need multiple injections, tourniquet pain

Figure 1: Interscalene block view on ultrasound (right) and structures demonstrated on cadaver (left)

Figure 2: Supraclavicular block view on ultrasound (right) and structures demonstrated on cadaver (left)

Figure 3: Infraclavicular block view on ultrasound (right) and structures demonstrated on cadaver (left)

Figure 4: Axillary block view on ultrasound (right) and structures demonstrated on cadaver (left)

Figure 5: Peripheral/forearm median nerve block view on ultrasound (left) and ulnar nerve block (right)

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Further Reading

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