Brachial plexus blockade has enjoyed great popularity since it was first reported in 1884. As the ventral primary rami of cervical nerves 5–8 and a part of the first thoracic nerve emerge from the intervertebral foramina, they are invested in a fascial sheath that runs to a point distal to the axilla. Effective regional anaesthesia can be achieved with single or multiple injections at a variety of levels of this sheath. The volume and concentration of the local anaesthetic play a crucial role in determining the outcome of the block. A thorough knowledge of the anatomy of the brachial plexus (see page 109) and the relevant surrounding structures is paramount to ensure safe and successful regional anaesthesia of the arm.

The anatomy described on page 109 is a classical layout, but seven major variations have been outlined and most people show significant left/right asymmetry. Two areas of the arm are not supplied by nerves from the brachial plexus; branches of the superficial cervical plexus supply the skin on the shoulder, and the posteromedial aspect of the arm is innervated by the intercostobrachial nerve. This is of clinical relevance because the latter may need to be blocked to prevent tourniquet pain.

**Approaches to the brachial plexus**

A variety of approaches to the brachial plexus have been described (Figure 1) but most anaesthetists, even those who regularly perform regional blocks, are familiar with only a few of them. An approach should be chosen depending on the site of the proposed surgery.
In general, the interscalene approach is the technique of choice for proximal surgery, including the shoulder; the supraclavicular route for surgery on the upper arm, elbow and radial aspect of the mid-forearm; and the axillary approach for hand, wrist and lower forearm surgery (Figure 2). Spread of the block can be altered by adjusting the volume and/or concentration of the local anaesthetic, or by applying digital pressure. Additional blocks of terminal nerves at the elbow or wrist can supplement incomplete or ‘patchy’ blocks.

### Brachial plexus blocks

<table>
<thead>
<tr>
<th>Approach</th>
<th>Level</th>
<th>Sensory block</th>
<th>Complications</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interscalene</td>
<td>Roots</td>
<td>Shoulder, upper arm, elbow</td>
<td>Phrenic nerve palsy, Horner’s syndrome, subarachnoid/epidural injection, vertebral artery injection (rare)</td>
<td>Technically difficult, many side-effects, spares the ulnar territory, phrenic nerve palsy may lead to respiratory compromise</td>
</tr>
<tr>
<td>Supraclavicular</td>
<td>Trunks and proximal divisions</td>
<td>Entire arm</td>
<td>Pneumothorax, phrenic nerve palsy, Horner’s syndrome</td>
<td>Highest pneumothorax incidence, phrenic nerve palsy may lead to respiratory compromise</td>
</tr>
<tr>
<td>Classic infraclavicular</td>
<td>Cords/terminal branches</td>
<td>Forearm, wrist, hand</td>
<td>Intravascular injection, pneumothorax</td>
<td>Painful in the awake patient, landmarks are sometimes not easy to identify</td>
</tr>
<tr>
<td>Vertical infraclavicular</td>
<td>Cords</td>
<td>Forearm, wrist, hand</td>
<td>Pneumothorax, intravascular injection</td>
<td>Lateral bony landmark must be identified correctly</td>
</tr>
<tr>
<td>Axillary</td>
<td>Terminal branches</td>
<td>Forearm, wrist, hand</td>
<td>Haematoma formation, intravascular injection</td>
<td>Easy, low complication rate, but often spares the musculocutaneous nerve</td>
</tr>
</tbody>
</table>

Drugs, such as short- and long-acting opioids, clonidine and neostigmine, have been added to local anaesthetic solutions to increase duration of analgesia, with varying success.

**Interscalene approach**

The interscalene approach to the brachial plexus has evolved from cervical paravertebral blocks and should ideally be performed in awake patients. The upper arm and shoulder are reliably blocked, but because of the vertical distribution of the roots at the point of injection, the C8/T1 roots are often missed. Therefore, interscalene blocks tend to fail on the ulnar side of the arm. Other side-effects include a Horner’s syndrome and phrenic nerve palsy. The latter is often asymptomatic in healthy individuals but may present a problem in patients with respiratory compromise.

The key landmark for the interscalene block is the interscalene groove, between the anterior and middle scalenus muscle. It is palpated at the level of the cricoid cartilage (C6) and at the lateral border of the sternomastoid muscle. The external jugular vein often crosses this point, but this is not a reliable landmark. It is important to use a short regional block needle (maximum 50 mm) and maintain a caudad angle of direction. When a nerve stimulator is used, a motor response is most often observed in the C5–6 distribution of the superior trunk, but sometimes middle trunk (C7) stimulation is seen. Recently published articles suggest that a deltoid muscle motor response is a satisfactory endpoint for a successful block and once obtained there is no need to ‘hunt’ for a different motor response because there may be a risk of needle-induced nerve damage. Stimulation of the diaphragm via the phrenic nerve occurs when the needle position is too anterior. When the needle tip is too posterior, shoulder elevation (dorsal scapular nerve) is seen. Local anaesthetic solution, 20–30 ml, should be injected after careful aspiration. An ‘interscalene triangular swelling’ is an early sign of a successful block and is easily distinguished from an extra-fascial injection.

A posterior approach to the interscalene block was described in 1912, but was largely forgotten until it was re-introduced in 1990, using a loss of resistance technique and a peripheral nerve stimulator.
Supraclavicular approach

The supraclavicular approach to the brachial plexus provides the most reliable anaesthesia of the entire arm. The injection is made at the level of the trunks or the proximal divisions, where the fascial sheath is at its most compact. This could explain the reliability of the block and its relatively short onset of action. It is also the approach with the highest incidence of pneumothorax, though the incidence should be less than 5% when the landmarks are correctly identified and the needle is moved strictly in an antero-posterior direction. Phrenic nerve palsy may also occur after a supraclavicular brachial plexus block.

The most common supraclavicular technique is the subclavian perivascular approach, described by Winnie. The interscalene groove is palpated and followed distally until the pulsation of the subclavian artery is felt. This should be at the midpoint of the clavicle, about 1 cm posterior to it. It is important to note that the cupola of the lung is medial to the insertion point of the needle. Entry to the sheath can be identified by a ‘click’ as the needle pierces the tough fascia, by paraesthesia or by an appropriate motor response when a nerve stimulator is used. The subclavian artery runs within the fascia just anterior and inferior to the brachial plexus. If the needle punctures the artery, it should be withdrawn a few millimetres carefully until it lies outside the artery but still within the sheath.

The ‘plumb-bob’ technique is another supraclavicular approach. The needle entry site is immediately superior to the clavicle, just lateral to the point where the sternocleidomastoid is attached to the clavicle. The angle of needle entry is 90° to the table.

Infraclavicular approach

The classical infraclavicular approach is associated with a minimal risk of pneumothorax and good reliability, but has never been popular. The direction of the needle is towards the axilla, away from the lung and requires three-dimensional visualization of the pyramid-shaped anatomy of the axilla to be successful.

Recently, the vertical infraclavicular block has been described. It addresses the problems with an axillary brachial plexus block, namely the absence of a radial and musculocutaneous nerve block. The latter may be used to alleviate tourniquet pain. The needle entry point for the vertical infraclavicular block is immediately below the clavicle at a point midway between the sternal notch and the ventral apophysis of the acromion. The needle must be advanced in a vertical direction to a maximum depth of 4 cm. The most commonly made mistakes occur in the palpation of the lateral bony landmark. Often the coracoid or the humeral head are mistaken for the ventral apophysis. If the landmarks are identified correctly and the needle is advanced vertically, the needle should avoid the pleura.

Axillary approach

The axillary approach is most commonly used because it is relatively easy and has few side-effects. It is suitable for surgery to the forearm, wrist and hand, though the radial side of the forearm is sometimes missed. This can be addressed by blocking the musculocutaneous nerve separately by injecting local anaesthetic in the belly of the coracobrachialis muscle, just superior to the pulsation of the axillary artery and at 90° to the skin. Because the injection is made at the level of the terminal branches, the missed segment(s) show a nerve territory distribution and not a dermatomal pattern, as is the case when the injection is placed at the level of the roots. Although deliberate transarterial techniques have been described, the main complication from this block remains haematoma formation as a result of arterial puncture.

The entry point of the needle is classically just superior to the pulsation of the axillary artery at the lateral border of the pectoralis major muscle. The shoulder and the elbow should be in 90° abduction and flexion, respectively. When the needle tip is superior to the artery, a motor response is seen in the median nerve territory, mainly flexion of the fingers and wrist. Digital pressure is often applied just distal to the injection site to aid proximal spread of the local anaesthetic. A typical dose of anaesthetic is 30–40 ml. Researchers have compared multiple- and single-injection techniques. A multiple-injection technique involves identifying two, three or four separate terminal nerves in the plexus and injecting a small amount of local anaesthetic around each of them. It increases the success rate in blocking the musculocutaneous nerve but there is a slightly higher chance of neuropraxia after the block. An alternative is to use a single-injection technique and to block the musculocutaneous nerve separately if surgery is to take place in its distribution. There is no difference in success rate when paraesthesia in the appropriate distribution or motor response with a nerve stimulator are used to confirm correct needle position.
Catheter techniques
Catheter techniques were first described in 1946, but gained popularity only in the 1970s when suitable catheters and drugs became available. For continuous upper limb analgesia, the most commonly used routes are the interscalene, (vertical) infraclavicular and axillary. The main indications are continuation of postoperative analgesia and the treatment of certain chronic pain conditions. Contraindications include infection in or around the site of injection, patient refusal and systemic infection. The catheters are inserted with a Seldinger technique using a guide-wire. Various needle and catheter kits are available with normal, short-bevelled regional anaesthesia needles, or epidural-style Tuohy needles to aid the direction of the guide-wire and catheter. Migration of the catheter and infection are the most common complications.

Peripheral nerve blocks at the antecubital fossa and wrist
The six nerves that are easily blocked at the antecubital fossa (Figure 3) are the ulnar, median, radial, and the medial, lateral and posterior cutaneous nerves of the forearm. The ulnar, median and radial nerves can also be blocked at the wrist. Knowledge of the territory of each nerve is essential, so that the appropriate nerves can be blocked for the surgery proposed. These blocks are easy to learn and perform but their duration tends to be shorter than that of a plexus block. These nerve blocks can be used to supplement a ‘patchy’ brachial plexus block.

Ulnar nerve
The ulnar nerve runs in its sulcus behind the medial epicondyle of the humerus where it is often easy to palpate. It is important to block the nerve about 2 cm proximal to the epicondyle (Figure 3a) and the injection should be of low resistance. The movement of the nerve in the sulcus is restricted and it is more easily pierced with the needle, which could cause an intraneural injection. There is also a higher chance of ischaemia because there is little space in which the local anaesthetic can dissipate.

At the wrist, the nerve can be blocked by a ventral or medial approach. With the ventral approach, the nerve is blocked between the flexor carpi ulnaris tendon and the ulnar artery at the level of the skin crease. With the medial approach there is less chance of puncturing the artery. A short bevelled needle is inserted just deep to the flexor carpi ulnaris tendon from the medial side of the wrist.
Median nerve
The median nerve lies medial to the brachial artery just deep to the tough bicipital aponeurosis. It is easily blocked 1–2 cm proximal to the flexor skin crease of the antecubital fossa, just medial to the pulsation of the brachial artery (Figure 3b). Together with an ulnar nerve block it provides analgesia for the palm of the hand (except for the thenar), which is useful in hand surgery (e.g. Dupuytren’s fasciectomy).

Median nerve block at the wrist must be avoided in people with carpal tunnel syndrome because of the tight space beneath the retinaculum. The nerve is blocked just lateral to the palmaris longus tendon and deep to the retinaculum.

Radial nerve
The landmark for block of the radial nerve at the antecubital fossa is the groove between the brachioradialis muscle and the biceps tendon, just 2 cm proximal to the flexor crease. The needle is inserted at this point, in the direction of the lateral epicondyle of the humerus, which is palpated with a finger of the non-injecting hand (Figure 3c). The motor response when a peripheral nerve stimulator is used should be extension of the fingers and wrist.

At the wrist, the radial nerve is blocked by injecting a ‘sausage’ of local anaesthetic subcutaneously from the extensor pollicis brevis tendon to a point overlying the ulnar styloid. At the point of the injection the radial nerve has divided into its numerous terminal branches so this is not a discrete nerve block.

Medial cutaneous nerve of forearm
The medial cutaneous nerve of the forearm supplies the cutaneous innervation of the medial side of the forearm and is easily blocked immediately after a median nerve block at the elbow. The needle is withdrawn and redirected proximally and local anaesthetic injected subcutaneously between the head of the pronator teres muscle and the medial border of the biceps tendon.

Lateral cutaneous nerve of forearm
The lateral cutaneous nerve of the forearm is the continuation of the musculocutaneous nerve and supplies the cutaneous innervation of the lateral side of the forearm. It is blocked in an analogous fashion to the medial cutaneous nerve of forearm, usually after a radial nerve block at the elbow using the same landmarks. A ‘sausage’ of solution is injected between the brachioradialis muscle and the lateral side of the biceps tendon.

Posterior cutaneous nerve of forearm
The posterior cutaneous nerve of the forearm is a proximal branch of the radial nerve and supplies the skin on the posteroradial aspect of the forearm. It is blocked by injecting local anaesthetic solution subcutaneously from the lateral epicondyle of the humerus to the olecranon.

FURTHER READING

www.nysora.com
www.nerveblocks.net

Copyright © 2004 The Medicine Publishing Company Ltd