Infraclavicular brachial plexus blocks

Alan Macfarlane BSc MBChB MRCP FRCA
Keith Anderson BSc MBChB FRCA

Anatomy and sites for blocks

Successful brachial plexus block requires a thorough knowledge of anatomy, both to decide on the appropriate approach and to locate the nerves. The plexus is traditionally found at specific anatomical points by using bony or vascular landmarks, whereas ultrasound allows block of the plexus at any point along its length. The course of the brachial plexus and its relationship to nearby structures is shown in Figure 1. Divisions are formed at the outer border of the first rib and then join to create cords. These can be blocked from below the clavicle as an infraclavicular block (ICB) or from the axilla as axillary block. As the plexus emerges below the clavicle approximately at its midpoint, it initially runs laterally between the clavicle (cephalad) and the artery (caudally) where it can be blocked by the vertical ICB. As it passes laterally, the plexus changes to sit cephalo-laterally to the artery and then wraps around the artery to assume its true anatomical position in the axilla with the cords lying lateral, posterior, and medial to the axillary artery. The boundaries of the infracavicular fossa are the pectoralis minor and major muscles anteriorly, ribs and intercostal muscles medially, clavicle and coracoid process superiorly, and the humerus laterally.

Infraclavicular approaches to the brachial plexus

The ICB was first described in the 1930s by Bazy and Labat. Interest was regenerated in 1973 when a new approach was described by Raj. The aim was to overcome the limitations of the traditional axillary block which had a poor success rate in blocking the musculocutaneous nerve and which could only be performed with the arm abducted. Numerous approaches and modifications of the ‘infraclavicular’ block now exist, which commonly leads to confusion. It is preferable that they are referred to by name and site of injection. The two most common approaches are described below.

Medial approaches around the middle of the clavicle

The most popular and simple to perform technique is the vertical ICB where the needle is inserted immediately below the midpoint of the clavicle, between the jugular notch and ventral acromion. It is recommended that, in smaller patients, the needle insertion point should be moved laterally (0.2 cm for every centimetre the clavicle measures <22 cm). The needle is directed ventral to dorsal, strictly in the sagittal plane (Fig. 1) with absolutely no medial angulation, as the pleura is very close on the inferomedial side. The plexus is encountered at an average depth of 2.3 cm (no deeper than 4 cm). If the plexus is not encountered, the needle should be angled gradually caudally from the clavicle. This is quite a simple block to perform with a nerve stimulator, but is not easy to perform with ultrasound primarily because the vertical angle of approach makes the needle difficult to visualize irrespective of the probe orientation (as it is outside the ultrasound beam).

The Raj ICB and a variation of the Raj technique by Borgeat and colleagues are techniques where the needle is inserted below the midpoint of the clavicle and directed laterally towards the axillary artery. They are often recommended by experts, but the needle must be inserted much deeper, where the anatomy is more difficult to visualize using ultrasound.

Lateral approaches around the coracoid process

The most popular are the pericoracoid ICB and the parasagittal ICB. Both techniques approach the plexus medial to the coracoid process and although the insertion point and needle directions differ, in reality they contact the plexus at a similar point. Indeed, this point is similar to the injection site of the traditional axillary block where the needle was directed towards the apex of the axilla from below.

Key points

The vertical infraclavicular block (ICB) has a high success rate from single injection using a nerve stimulator, but has potentially serious complications such as phrenic nerve palsy (25%) and pneumothorax (0.7%). Pericoracoid ICBs require multiple injections with a nerve stimulator or ultrasound guidance to verify adequate local anaesthetic spread posterior to the axillary artery to be successful.

ICBs may take 30 min before surgery can commence.

They are useful if the arm is immobile, often provide good anaesthesia of the upper arm (especially vertical infraclavicular), and provide an ideal site for catheter fixation for local anaesthetic infusions.

Alan Macfarlane BSc MBChB MRCP FRCA
Specialist Registrar
Glasgow Royal Infirmary
Glasgow
UK

Keith Anderson BSc MBChB FRCA
Consultant Anaesthetist
Glasgow Royal Infirmary
10 Alexandra Parade
Glasgow G31 2ER
UK
Tel: +44 141 211 4620
Fax: +44 141 211 1191
E-mail: keithanderson@doctors.net.uk (for correspondence)
The needle is inserted 2 cm medial and 2 cm inferior to the coracoid process and directed from ventral to dorsal (Fig. 1), the plexus is encountered at an average depth of 4.5 cm but may be as deep as 7.5 cm. Moving the needle medial from the coracoid process brings it closer to lung, so may increase the risk of pneumothorax; also, the proximity of the cords to the blood vessels at this level makes vascular puncture more likely with blind techniques. Furthermore, it is clear that success rates are low with single-shot injections but more acceptable with multiple injections. Unfortunately, multiple blind needle passes may make vascular puncture (and potentially pneumothorax) more likely. Therefore, we do not recommend the blind pericoracoid technique; instead, we suggest that an ultrasound-guided parasagittal approach is preferable.

**Parasagittal ICB**

The needle is inserted immediately below the clavicle in the groove between the coracoid process and the clavicle and passed from the cephalad to caudal (Fig. 2). The needle is gradually angled posteriorly from the anterior chest wall (ventral to dorsal), with the plexus encountered at a depth of around 5–6 cm (max. 7 cm).

**Drug dose/volume and plexus localization**

Most descriptions of ICB describe using 30–40 ml of the local anaesthetic agent of choice (using a concentration that ensures a safe dose). All approaches require a nerve stimulator or ultrasound to identify the nerves. With a nerve stimulator, one must use surface landmarks and anatomical knowledge to avoid unwanted structures (pleura and blood vessels).

**Nerve stimulation and the optimum response**

The musculocutaneous and axillary nerves leave the sheath before the coracoid process in 50% of patients. Stimulation of upper arm muscles, for example, biceps or deltoid, is therefore unlikely to result in a satisfactory block. There is some evidence that radial nerve (extension of wrist/fingers) or to a lesser extent median nerve (flexion of wrist or fingers) type stimulation distal to the elbow are the best predictors of successful block. Ideally, the needle position should be refined until stimulation is achieved at a current of ~0.5 mA (1 mA is unlikely to be successful and 0.2 mA may indicate intra-neural needle placement). Single injections reliably provide high success rates only for the vertical ICB.

**Ultrasound**

The development of high-resolution ultrasound has allowed the infraclavicular brachial plexus to be demonstrated under indirect vision. This allows observation of local anaesthetic spread and allows repositioning of the needle, which is required in 20–75% of patients, during the block to ensure anaesthesia of all the cords of the brachial plexus. This technique appears to increase the speed of block onset and the likelihood that the entire plexus will be anaesthetized. It is not surprising that ultrasound placed blocks are more successful than single-shot blocks when one considers the variation in local anaesthetic spread after even seemingly...
satisfactory neurostimulation endpoints. The type of stimulation response observed (and therefore the position of the needle) can influence the direction of local anaesthetic spread after single injection. Musculocutaneous stimulation pattern is associated with suboptimal spread of local anaesthetic observed by ultrasound, median pattern seems better, and radial pattern best for ICB around the coracoid process. This may be because the posterior cord is in the middle of the plexus at this level.

Local anaesthetic spread posterior to the artery is useful in predicting success of the block. If the needle is imaged by an in-plane approach (aligning the needle and ultrasound beam), vessels and pleura can be avoided. This is perhaps the most convincing argument for the use of ultrasound, because it is clear that any landmark approach to the infraclavicular plexus has the relatively frequent occurrence of vessel puncture (2–33%), and infrequent occurrence of pneumothorax (~0.7%). This may be particularly important in anti-coagulated patients, patients with significant pulmonary disease, and in the ambulatory surgical setting. This benefit almost certainly relies on good needle visualization, which can be challenging. Failure to visualize the needle tip gives a false sense of security and therefore damage to surrounding structures can still occur. For that reason, this is not an ultrasound block for the novice.

**Technique**

When using ultrasound localization in the infraclavicular region, the plexus can be scanned from anywhere between the middle of the clavicle and the coracoid process using a high-frequency (8–13 MHz) linear probe (though some prefer a small curved array probe). The plexus is easier to block laterally beside the coracoid process using ultrasound than medially at the vertical ICB site. Visualization is best with the probe in the parasagittal orientation, just caudal to the clavicle and just medial to the coracoid process. The artery is usually easily visualized deep to the pectoralis minor muscle. The hyperechoic nerve structures are usually found cephalad (lateral cord), posterior (posterior cord), and caudally (medial cord) to the artery (Fig. 2). The needle is introduced in the parasagittal plane and directed posterior to the artery. Local anaesthetic is best deposited in a horseshoe between 3 and 11 o’clock (Fig. 2). After injecting local anaesthetic, the plexus often becomes more easily visualized by creating an echogenic window.

**Choosing the best infraclavicular approach**

Although they share the name ‘infraclavicular’, the clinical characteristics of each approach vary considerably. Success and complication rates are in part operator-dependent and are shown in Table 1. Despite high overall success, block onset for surgery can
be slow.\textsuperscript{10} For nerve stimulator placed blocks, 50% are ready at 20 min and 60% at 30 min. Ultrasound placed blocks are quicker with 75% ready at 20 min and 86% at 30 min.

The vertical ICB is simple to perform with just a nerve stimulator and has a high success rate with just one injection. It anaesthetizes the upper arm and the forearm, with high levels of tourniquet tolerance (97%), probably because of reliable anaesthesia of the axillary (81%) and intercostobrachial (71%) nerves.\textsuperscript{14} It does, however, have a moderate incidence of phrenic nerve palsy, a small risk of vascular puncture, and is associated with pneumothorax (albeit rarely).

The parasagittal infraclavicular approach works best with ultrasound guidance which facilitates adequate spread of local anaesthetic. It is not a block for ultrasound beginners; however, in experienced hands, it is safe and reliable with a reasonable speed of onset. It is surprisingly good (but not perfect) at anaesthetizing the upper arm with quoted rates of axillary and intercostobrachial nerve block of 64% and 87%, respectively.\textsuperscript{14} It is not associated with phrenic nerve palsy and is the least likely approach to cause pneumothorax. Therefore, it is undoubtedly safer in patients with significant pulmonary disease. Blind techniques require multiple injections to achieve similar success rates, are associated with high vascular puncture rates, have an increased potential for pneumothorax, and are therefore not recommended.

**Clinical characteristics of supraclavicular and axillary blocks**

**Supraclavicular**

**Advantages**
- It reliably anaesthetizes the upper arm and the forearm. If any nerve is missed, it is usually the inferior trunk/ulnar nerve component.
- It can be performed without moving the arm.

**Disadvantages**
- It is associated with a small incidence of pneumothorax (0.5%) and fell into disrepute as a result. Although US guidance may reduce this, it can also create a false sense of security. Good needle visualization is necessary to avoid adding to emerging reports of pneumothorax with the US-guided technique.
- It is associated with relatively high rates of phrenic nerve palsy (up to 50%) and may not be the best choice for those with significant pulmonary disease.

**Axillary block**

**Advantages**
- Safe, reliable with multiple injections, rapid onset with ultrasound.
- Easy to learn.

**Disadvantages**
- Few.
- Technically difficult with limited shoulder abduction.

**Clinical niche for ICBs**

The infraclavicular brachial plexus blocks are an alternative to axillary block for anaesthetizing the elbow, forearm, and hand when positioning is compromised by limited abduction at the shoulder, for example, rheumatoid arthritis or an immobilized/traumatized arm. It is also an alternative to supraclavicular block for anaesthetizing the upper arm. The vertical infraclavicular is better than the lateral approaches in this respect and has similar rates of pneumothorax but less frequent phrenic nerve paresis. The lateral approach performed with ultrasound control has a minimal risk of phrenic nerve paresis or pneumothorax and so may be a better choice in those with respiratory compromise, but provides less reliable upper arm anaesthesia. Complications are rare and less frequent than supraclavicular approaches and vary depending on the specific infraclavicular technique used. Although the axillary block provides safe and straightforward regional anaesthesia of the arm, the infraclavicular approach does offer an alternative in some specific situations and can be considered a viable routine alternative in experienced hands. It has some advantages in providing upper arm anaesthesia, securing infusion catheters to the chest wall, and ease of patient positioning.

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**Table 1** Success and complication rates of the different infraclavicular approaches. NS, nerve stimulation; US, ultrasound

<table>
<thead>
<tr>
<th>Approach</th>
<th>Successful block (%)</th>
<th>Vascular puncture rate (%)</th>
<th>Pneumothorax rate (%)</th>
<th>Phrenic nerve palsy rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraclavicular</td>
<td>99</td>
<td>10</td>
<td>0.5–6</td>
<td>50</td>
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<tr>
<td>Vertical ICB</td>
<td>95</td>
<td>10–25</td>
<td>0.2–0.7</td>
<td>25</td>
</tr>
<tr>
<td>Pericoracoid ICB\textsuperscript{15}</td>
<td>91</td>
<td>0–17</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>Parasagittal ICB\textsuperscript{8, 11}</td>
<td>85–91 NS</td>
<td>33 NS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Axillary</td>
<td>75–95</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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References


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