Brachial plexus blockade

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The brachial plexus supplies the majority of sensation and function to the upper limb. It was first blocked with cocaine just over 100 years ago and, since then, many other approaches have been described.

Basic principles

Whilst appreciating the advances in technique in recent decades, it is important to remember that brachial block evolved as an alternative to general anaesthesia and should be primarily seen in that context. There will, of course, be procedures where supplementary general anaesthesia may be appropriate, *e.g.* prolonged surgery, or where other sites of pain and discomfort interfere with the comfortable positioning of the patient. A regional anaesthetic technique also allows us to avoid the rare, but significant, complications of general anaesthesia, *e.g.* failed airway, equipment failure or awareness. In high-risk patients (*e.g.* morbidly obese, severe cardiac or pulmonary disease), significant potential co-morbidity can be avoided. Although many patients are unaware of these potential complications, they certainly appreciate the absence of side-effects such as nausea, vomiting, 'hangover' and sore throat that are common following general anaesthesia.

Whilst induction of general anaesthesia can be considered a fairly predictable process, the success of a regional procedure cannot be taken for granted and all proponents of these techniques have to be able to cope with the occasional failure. Success rates of > 95% and low complication rates can be achieved if the following points are carefully considered:

- Adequate understanding of the anatomy
- Correct choice of block
- Correct choice of agent
- Use of the nerve stimulator
- Good teaching and adequate continuing experience
- Standard non-invasive monitoring

The detailed anatomy of the brachial plexus is well described in standard anatomy textbooks

Key points

Regional anaesthesia is a useful alternative to general anaesthesia

The majority of upper limb procedures can be performed under either an axillary or interscalene block

Using a nerve stimulator enhances safety and efficacy

Selection of the appropriate local anaesthetic agent and block, together with continued practice, are essential for success.

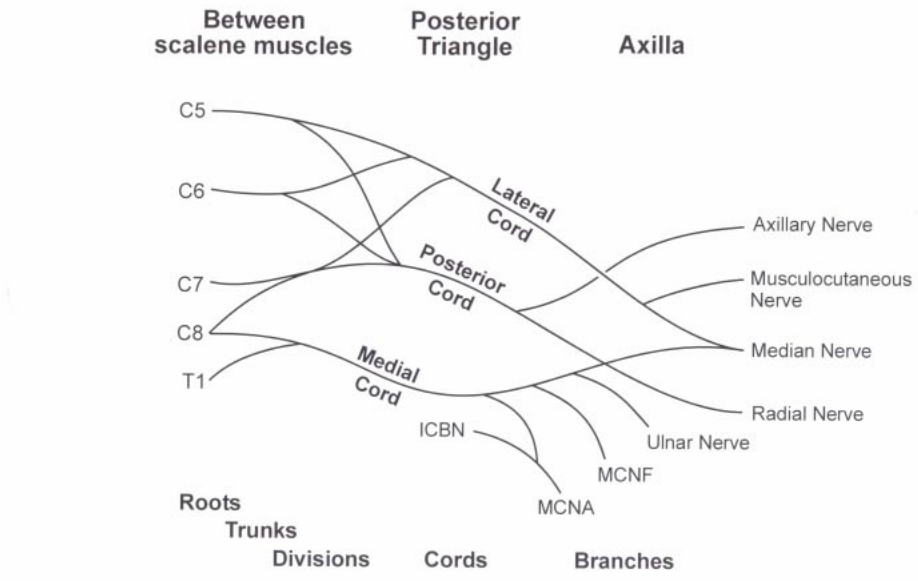

Fig. 1 The brachial plexus.

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and summarised in Figure 1. In our experience, the choice of block can be simplified by appreciating that the vast majority of procedures on the upper limb can be carried out using two techniques: (i) interscalene block for proximal humerus and shoulder surgery; and (ii) axillary block for procedures on the elbow, forearm and hand.

The axillary block offers a safer alternative to the supraclavicular block for a similar spectrum of procedures, whilst the infraclavicular block does not appear to offer any great advantage over the axillary approach. Therefore, it follows that, if the interscalene and axillary approaches are used exclusively, the anaesthetist will be able to gain and maintain more expertise and experience will not be diluted in an attempt to perfect three or four blocks.

When considering which local anaesthetic agent to use, the duration of the block clearly needs to extend beyond the duration of the operation, or longer, if postoperative analgesia is a significant consideration. When considering this aspect, one should bear in mind that the patient does not always appreciate the accompanying numbness and paralysis. Therefore, for many procedures, lidocaine remains the agent of choice followed by conventional simple analgesics in the early postoperative period. Prolonged blocks or a catheter technique can be useful for analgesia after major joint surgery such as total shoulder or elbow replacement, especially if the arm is either immobilised in a cast or, conversely, if active mobilisation is to be commenced soon after surgery. Inserting a catheter is particularly useful when ongoing sympathectomy is desirable or where excellent analgesia and relaxation is required to encourage co-operation during physiotherapy and mobilisation. Top-ups or an infusion of local anaesthetic can be used as appropriate. Table 1 summarises agents and duration of action.

The addition of epinephrine to lidocaine not only prolongs the duration of the block but also allows a larger dose to be given and facilitates the identification of an inadvertent i.v. injection before signs of CNS toxicity arise. It should be noted that the duration of block is generally shorter for interscalene block as systemic absorption is more rapid. Because of this and the type of surgery normally performed under this block, longer acting agents such as ropivacaine and levo-bupivacaine are more often appropriate.

Table 1 Choice of local anaesthetic and duration of action

Agent/technique	Analgesia duration	Anaesthesia duration
Lidocaine 15 mg ml^{-1} + 1:200,000 epinephrine	Up to 6 h	Around 3 h
Ropivacaine 5 mg ml^{-1} or levo-bupivacaine 5 mg ml^{-1}	9–16 h	6–8 h
Catheter techniques	Days	

The clinical characteristics of ropivacaine are very similar to those of bupivacaine, but the systemic toxicity and the likelihood of serious complications are reduced. Ropivacaine (5 mg ml^{-1}), although satisfactory for brachial plexus block, is not commercially available in the UK. However, mixing 20 ml of 7.5 mg ml^{-1} and 10 ml of 2 mg ml^{-1} will result in a concentration of 5.6 mg ml^{-1} in a total volume of 30 ml. Levo-bupivacaine (5 mg ml^{-1}) is a suitable alternative with similar clinical characteristics to ropivacaine. Although as yet not generally recommended, we believe the addition of epinephrine in a concentration of 5 μg ml^{-1} to either solution will allow easier identification of intravascular injection and, therefore, improve safety. The injection itself should be in 5 ml aliquots preceded by aspiration each time to detect intravascular placement of the needle.

Block technique

The peripheral nerve stimulator is an excellent tool to facilitate the performance of many regional blocks. Firstly, it helps identify nerves accurately if stimulation is achieved at currents of 0.3–0.5 mA without the need for patient co-operation or the eliciting of painful paraesthesia. Secondly, it is a useful tool for teaching trainees and demonstrating the functional anatomy during the block procedure. Finally, although not conclusively proven, using a short bevelled stimulator needle may make nerve penetration and intraneural injection less likely, reducing the potential for nerve damage compared with the eliciting of paraesthesia.

The importance of standard, non-invasive monitoring while performing the block and also intra-operatively cannot be overemphasised.

Interscalene block

For shoulder and upper arm procedures, this is the block of choice as it is the only approach that reliably blocks above the C5 root. Winnie's description of the technique from 1970 remains one of the best. The patient lies in the supine position with the head slightly turned to the opposite side. The posterior border of the sternomastoid is identified at the level of the cricoid cartilage (C6) and a finger rolled posteriorly to identify the groove between the scalenus anterior and medius muscles. Alternatively, the interscalene groove is sometimes easier to palpate just above the clavicle and can then be traced upwards to the level of the cricoid cartilage. The skin is infiltrated superficially with local anaesthetic before advancing the nerve stimulator needle in a plane slightly caudad but perpendicular to the skin giving the needle a mesiad, dorsad and

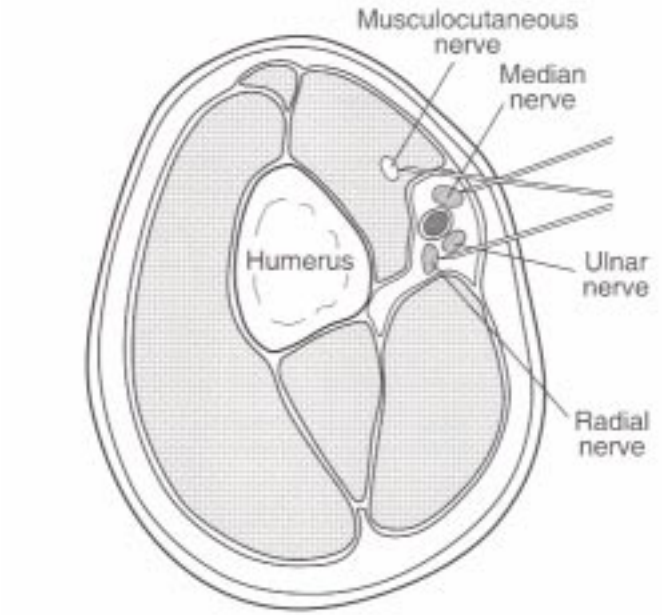

Fig. 2 Axillary block.

slightly caudad direction. The caudad direction is important as it reduces the chance of passing along a transverse process where inadvertent injection can be made into the epidural and intrathecal space or into the vertebral artery. The needle is advanced with the nerve stimulator at 2 mA. The plexus is often very superficial at this level, almost subcutaneous in thin individuals and, as soon as stimulation of biceps or triceps or more distal muscle contraction is achieved, the current is reduced to 0.5 mA. Fine-tuning of needle direction and depth may be needed to achieve this. When maximal muscle contractions are obtained at this current, 20–30 ml of local anaesthetic are injected in 5 ml aliquots. It is advisable to inject 2 ml of the solution first and wait for about 30 s before the rest of the local anaesthetic is injected as this allows detection of an inadvertent injection into the vertebral artery. An injection into the vertebral artery leads to the delivery of a high concentration of local anaesthetic to the brain and the likelihood of seizure. The incidence of this complication is low and difficult to ascertain, but has been reported to be around 0.3% in one series.

The incidence of phrenic nerve block is so high that it should be considered an integral part of the block. For this reason, bilateral interscalene blocks should not be performed simultaneously. It has been shown that FVC and FEV_1 are reduced by as much as 25% with additional minor changes in gas exchange and this should be taken into account when assessing patient suitability for this block balanced against the risks of general anaesthesia.

Axillary block

Although Winnie advocated a single injection of a large volume of local anaesthetic in the neurovascular sheath around the axillary artery, Thompson and colleagues subsequently clearly demonstrated septae between nerves of the brachial plexus using contrast CT studies. In some individuals, these structures will hinder the circumferential spread of local anaesthetic. This explains the considerable failure rate of complete block even when employing large volumes. With the use of a multiple injection technique and a nerve stimulator, success rates of up to 97% can be achieved. The improved level of success, together with an impressive safety record, has led to the increasing popularity of this particular block.

The patient lies supine with the head turned away from the side to be blocked. The arm is abducted to 90° and supported on a pillow. The elbow is flexed and the axillary artery palpated approximately 2–3 cm lateral to the border of the pectorals major muscle. Where access is more difficult due to trauma or arthritis in the shoulder, the block can still be performed up to around 10 cm distal to the axilla. After skin infiltration, 3 injections from one puncture site are made using the needle of a nerve stimulator as follows (Fig. 2).

The musculocutaneous nerve is sought first, above and deep to the axillary artery, using a stimulating current of 2 mA. Stimulating the biceps muscle and obtaining maximal contraction with a current of 0.3–0.5 mA confirm satisfactory position. Local anaesthetic (5 ml) is injected after aspiration (usually lidocaine 15 mg ml^{-1} + epinephrine 5 μg ml^{-1} – see above). The needle is then withdrawn subcutaneously and redirected downwards pointing just superior and anterior to the axillary artery. Nerve location is again achieved at 2 mA and median nerve stimulation is manifested by wrist and finger flexion. Solution (15 ml) is then injected once the needle position is optimised with currents of 0.3–0.5 mA. This is performed in 5 ml aliquots preceded by aspiration. Finally, withdrawing the needle subcutaneously and rolling the skin down about 5 mm so that the needle is pointing just inferior to the axillary artery blocks the radial nerve. The current is increased again to 2 mA and the needle advanced until extension of the fingers and thumb are observed (this normally gives a more consistent result than stimulating the triceps). Solution (10 ml) is then injected in 5 ml aliquots.

The index finger of the non-dominant hand should be used to identify the axillary artery at the beginning of the procedure and should be kept in position throughout, as subsequent arterial

palpation will become more difficult. At the end of the injection, the arm is adducted back to the patient's side. Appreciation of the 3D anatomy of the plexus, which comes with practice, is the key to performing this block successfully. With accurate localisations, at least 50% of these blocks are complete within 10 min and the vast majority within 20 min, unlike a single injection approach. This should help maintain list throughput, taking into account the resulting reduction in recovery time.

Supraclavicular block

The efficacy of the supraclavicular block, carried out properly, has traditionally been the standard to which all others are compared. This block's attraction is that, by using one single accurate injection, anaesthesia of the whole upper limb, including the proximal humerus, can be achieved. Unfortunately, the incidence of complications is significant, especially if an inexperienced anaesthetist or occasional practitioner performs the block. The more accurate landmarks of the subclavian perivascular approach have improved matters but complication rates of 2–5% for pneumothorax are not uncommon. Although some series with experienced practitioners report fewer clinically significant pneumothoraces, teaching institutions are likely to find the incidence even higher. The insertion of a chest drain is not only an unpleasant procedure but also carries its own significant additional morbidity. Approximately 67% of patients may also have phrenic nerve block and puncture of the subclavian vessels is also possible.

Avoiding all of these complications is especially important for patients with co-existing morbidity such as obesity, ischaemic heart disease or chronic pulmonary disease. It is these very patients who should have most to gain from a regional technique and who may end up more significantly compromised. In view of this and the availability of a safer and equally efficacious block, the routine use and the teaching of this block is becoming harder to justify. Its use in day-surgery patients should continue to be discouraged.

Infraclavicular block

This block has been gaining popularity as an alternative to supraclavicular or axillary approaches. Although there have been many descriptions of how to perform this block, the basic concept involves blocking the cords of the brachial plexus in the axillary fossa at a point 2 cm medial, 2 cm caudad and 2.25–7.75 cm deep to the coracoid process. The needle tip is, therefore, at approximately the same position as it would be if a high single injection axillary block was performed.

Pneumothorax has been reported, although the risk appears to be low, especially if the needle is not directed medially. Inadvertent vessel puncture is more common and, in one paper, had an incidence of 50%.

The only advantage of the infraclavicular block is that arm abduction, which might be painful in the injured upper limb, is not necessary. Otherwise, the multiple injection axillary block is safer, especially if performed by the occasional practitioner who may not be keen to insert a needle in the chest. The axillary block also appears to be more reliable in blocking the ulnar and medial cutaneous nerves of the arm and forearm.

Summary

Brachial plexus block is an excellent alternative to general anaesthesia for a wide variety of upper limb procedures and a useful analgesic component for some of the other more major elective and emergency procedures. The vast majority of orthopaedic, plastic and vascular operations can be carried out safely using one of 2 blocks, *i.e.* the axillary or interscalene, allowing skill and experience to be concentrated. These blocks provide efficacy with fewest significant adverse effects and their reliable performance can best be achieved using the peripheral nerve stimulator. By combining ease of performance with efficacy, it is hoped that many more practitioners will consider using these techniques in routine clinical practice.

Key references

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See multiple choice questions 21–24.