Chapter 71

Pediatric Peripheral Nerve Block: Upper Limb

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Background

The brachial plexus (Fig. 71.1) is derived from the ventral rami of C5–T1 (with occasional contributions from C4 and T2). After leaving the intervertebral foramina, the roots travel between the anterior and middle scalene muscles, where they become three trunks (upper, middle, and lower). The trunks then emerge from the scalene muscles and lay cephaloposterior to the subclavian artery as they cross the base of the posterior triangle of neck. Each trunk forms anterior and posterior divisions as they pass over the lateral border of the first rib. At the apex of axilla, these divisions unite to form three cords, which are named according to their relative positions to the axillary artery (lateral, medial, and posterior). After leaving the axilla, the cords give rise to terminal branches which supply the muscles and skin of the upper limb.

In children, upper limb blocks are performed under general anesthesia or heavy sedation, although in cooperative and older children, it may be possible to perform these blocks awake or under light sedation. Since monitoring paresthesia is precluded by general anesthesia/heavy sedation or the child is too young to verbalize paresthesia, the use of nerve stimulation is essential for localization of nerve and avoiding intraneural injection. In addition, ultrasound allows direct visualization of the needle and neural structures and has further improved the success rate and safety of regional blocks in children.

Several approaches for brachial plexus block have been described, namely, interscalene, supraclavicular, infraclavicular, and axillary. Blockade of a single peripheral nerve is possible distal to the axilla. Different approaches should be used depending on the site of the surgery. For example, interscalene block provides the best coverage for shoulder surgery, while more distal techniques are indicated for surgery of the forearm and hand. General complications of brachial plexus block include infection at the needle insertion site, bleeding/hematoma formation, nerve injury, and local anesthetic toxicity. For more proximal blocks (e.g., interscalene), specific complications, such as phrenic nerve palsy, Horner's syndrome, recurrent laryngeal nerve palsy, epidural/intrathecal injection, and vertebral artery injection can occur. Pneumothorax is also a potential complication with supraclavicular and infraclavicular blocks; however, the increasing use of ultrasound has lowered the risk of these complications significantly.

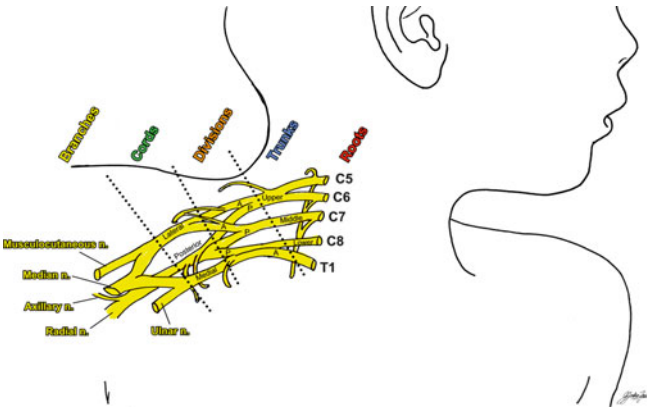


Fig. 71.1 Anatomy of the brachial plexus. *A* anterior divisions, *P* posterior divisions

Interscalene Block

Introduction, Indications, and Complications

The interscalene block targets the roots and proximal trunks of the brachial plexus between the anterior and middle scalene muscles at the level of the cricoid cartilage (C6) (Fig. 71.2). It is indicated for surgery of the shoulder and upper arm since it reliably anesthetizes the axillary and musculocutaneous nerves, although the hand and fingers are often spared. Phrenic nerve block is a major complication in infants and young children due to greater dependence on diaphragmatic function. Other risks include vertebral artery puncture and injection, epidural or intrathecal injection, Horner's syndrome, recurrent laryngeal nerve blockade, and hematoma formation in the neck due to arterial or venous puncture. A combined nerve stimulation and ultrasound-guided approach should be used to minimize complications.

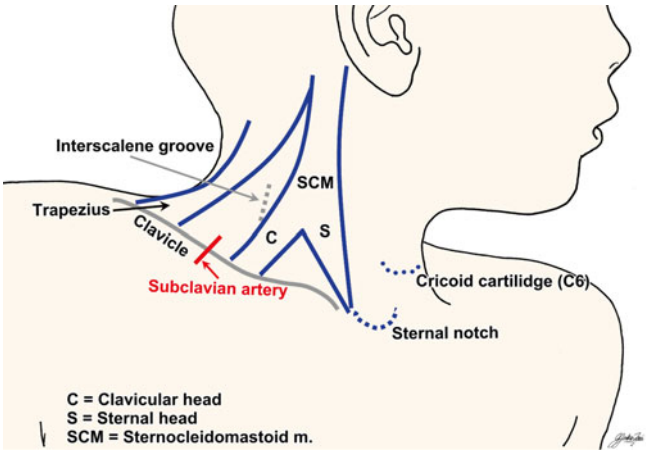


Fig. 71.2 Patient positioning and surface landmarks for interscalene brachial plexus block

Patient Positioning, Preparation, Equipment, and Dosage

The patient is placed with the head turned approximately 45° away from the side to be blocked. For parascalene block, a rolled towel is placed underneath the shoulders. The skin is cleaned with antiseptic solution. If ultrasound guidance is used, prepare the probe surface by applying a sterile adhesive dressing.

A 50-mm, 22-G insulated short-beveled needle is used. Recommended local anesthetics are 0.125–0.25 % bupivacaine or 0.1–0.2 % ropivacaine. Using 0.25 % bupivacaine at 0.2–0.3 mL/kg is a reasonable option for this block. The duration of sensory block averages 15 ± 4.5 h, independent of the type and concentration of the local anesthetic used. Epinephrine 1:200,000 may be added to detect intravascular injection.

Nerve Stimulation Technique

Different approaches have been described for this block. For interscalene approach, the point of needle insertion is at the level of cricoid cartilage (C6) within the interscalene groove (Fig. 71.2). The interscalene groove is located between the anterior and middle scalene muscles posterior to the lateral border of the sternocleidomastoid muscle (SCM), slightly above the point where the sternal and clavicular heads of the SCM separate. The line between the point of needle insertion and the cricoid cartilage should cross the Chassaignac's tubercle (anterior tubercle of the transverse process of the C6 vertebra), which can be felt easily. The needle is inserted at 60° to skin and directed medially, posteriorly, and caudally to prevent inadvertent puncture of the vertebral artery or epidural/intrathecal space. The initial current is set at 0.8–1.0 mA (2 Hz, 100–300 μs) and then gradually reduced to a threshold current of 0.2–0.4 mA (0.1–0.2 ms) after eliciting appropriate motor responses. Response at a current >0.4 mA indicates that the needle is too far away from the plexus; a current ≤0.2 mA signifies intraneural placement.

Another approach to this block is the parascalene approach [1]. A line is drawn between the midpoint of clavicle and the Chassaignac's tubercle. The needle is inserted two thirds of the way down this line and advanced posteriorly until twitches are seen. The risk of vascular puncture, Horner's syndrome, and phrenic nerve block is lower with this technique, but the external jugular vein may be penetrated.

Ultrasound-Guided Technique

A high-frequency (13-6 MHz) hockey stick or linear transducer probe is suitable for this block. The probe is placed on the neck in an axial oblique view at the level of the cricoid cartilage (C6) (Fig. 71.3). The anechoic great vessels (common carotid artery and internal jugular vein) and the overlying triangular-shaped sternocleidomastoid muscle are identified first. If necessary, color Doppler can be used to locate the vessels. Move the probe proximally and distally to identify the roots/trunks of the brachial plexus (which commonly seen as three round or oval-shaped hypoechoic structures) in the interscalene groove between the anterior and middle scalene muscles. Occasionally, the vertebral artery can be seen deep to the plexus and anterior to the C6 transverse process. Extra caution should be exercised not to confuse the artery with a nerve and inject into it. Visualization of the neural structures can be difficult in small children, so a "traceback" approach is recommended. In the traceback approach, the probe is placed in a coronal oblique plane at the upper border of the clavicle. The brachial plexus at this point appears as "a bunch of grapes," superolateral to the subclavian artery. The plexus is then traced back to the interscalene region by scanning in a cephalad direction (Fig. 71.4).

The needle is inserted either in-plane or out-of-plane, although the in-plane approach is preferred to ensure visualization of the needle, thereby minimizing the risk of complications. For the in-plane approach, the needle is inserted in a lateral-to-medial fashion into the interscalene groove. When using the out-of-plane approach, the plexus is centered in the middle of the screen, and the needle is inserted cranial to the probe at the midline. Direct the needle tip, which appears as bright dot on the screen, in a "walk-down" manner (see Ref. [1]) in proximity to the nerves. Nerve structures can be confirmed by nerve stimulation. A test dose with D5W is useful to visualize the spread and confirm nerve localization. After negative aspiration for blood or CSF, local anesthetic is deposited to achieve good spread surrounding the nerves within the interscalene groove. The depth should be less than 1–2 cm, even in teenage adolescents.

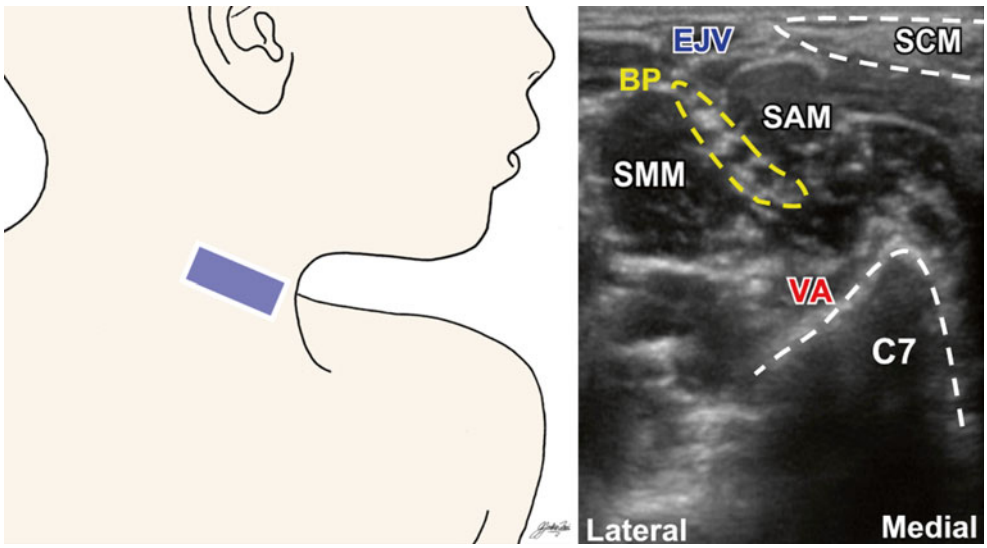
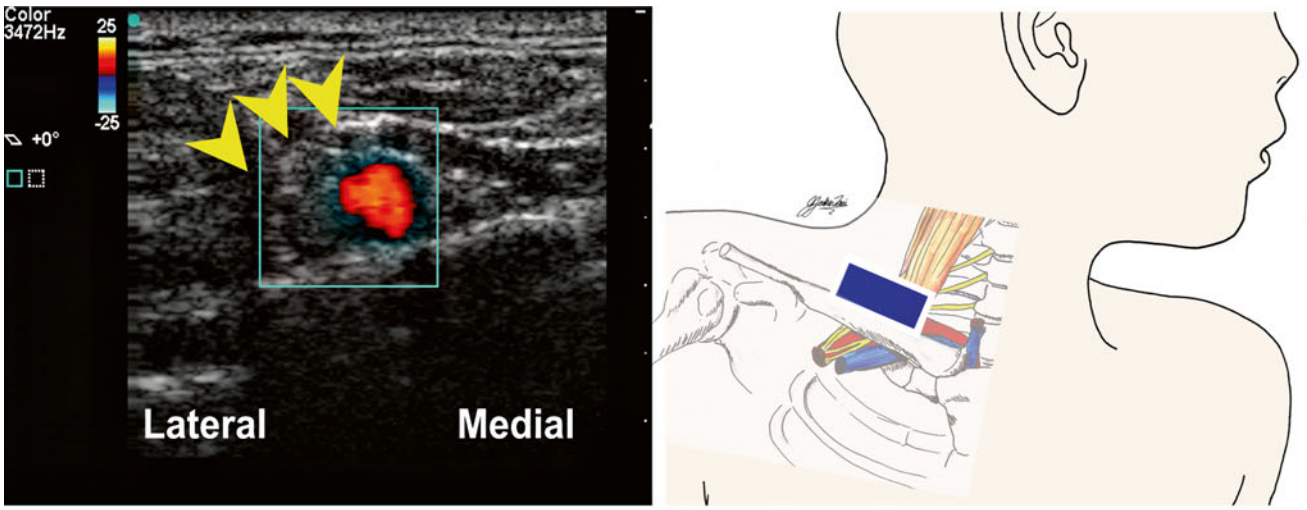
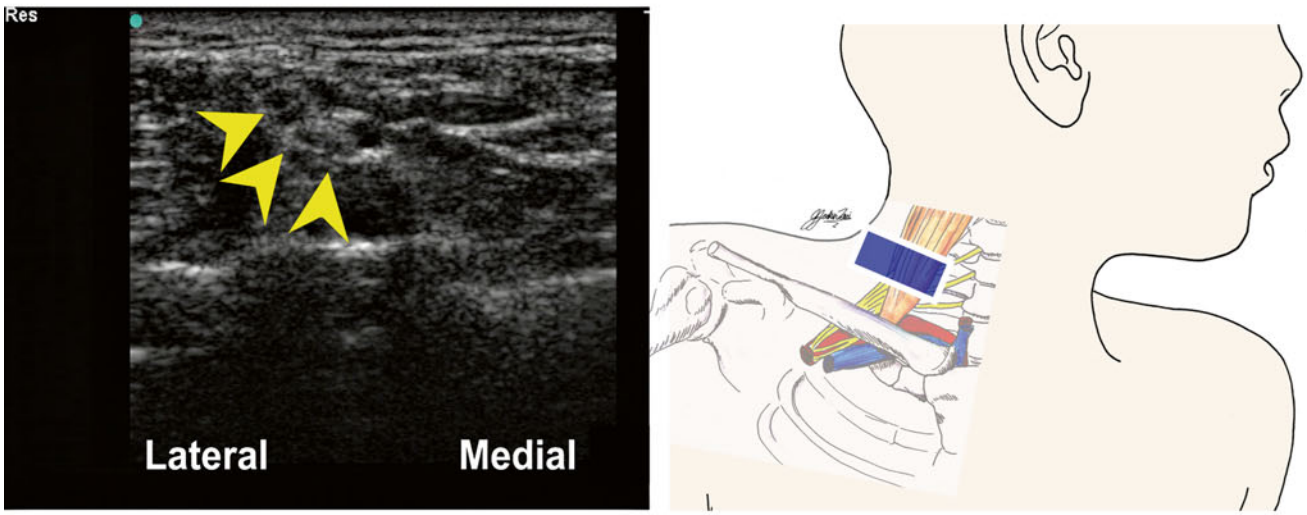


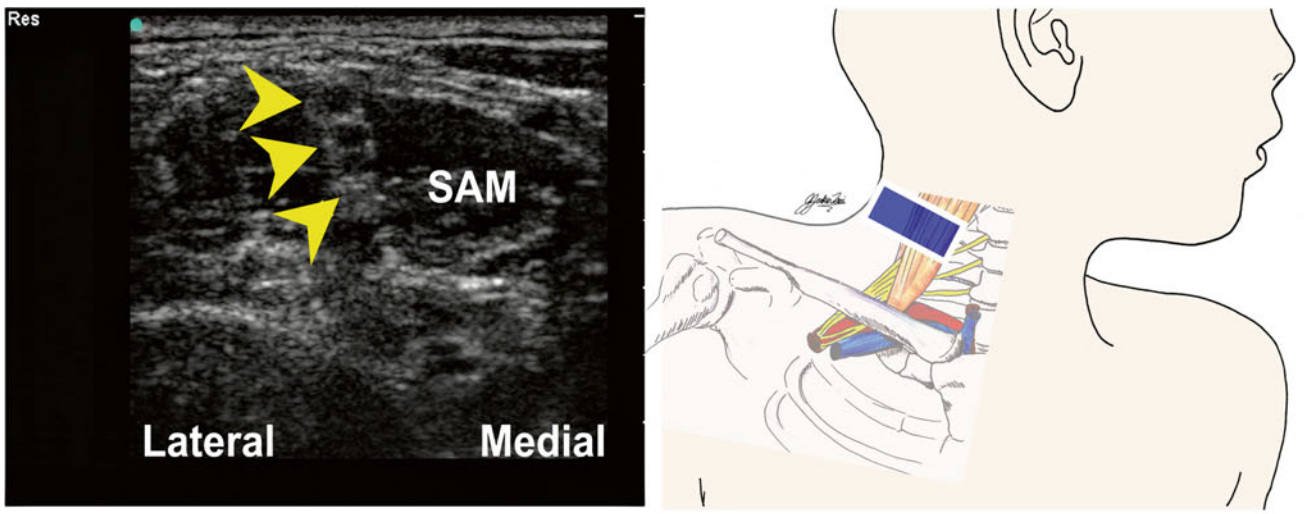
Fig. 71.3 Ultrasound image of the brachial plexus at the interscalene groove. *EJV* external jugular vein, *SCM* sternocleidomastoid muscle *SAM* scalenus anterior muscle *SMM* scalenus medius muscle, *VA* vertebral artery, *BP* brachial plexus, *C7* C7 vertebra



1. Locate the subclavian artery



2. Place the artery and plexus trunks/divisions centrally and track upward



3. Tilt the probe upward and downward to obtain the best view

Fig. 71.4 Ultrasound traceback approach for interscalene block. *SAM* scalenus anterior muscle; arrowheads show location of brachial plexus

Supraclavicular Block

Introduction, Indications, and Complications

This block targets the trunks and/or divisions of the brachial plexus where they are located cephaloposterior to the subclavian artery above the first rib (Fig. 71.5). The rapid onset of this block offers the most reliable blockade of the brachial plexus for anesthesia and analgesia of the entire upper extremity, especially the elbow, forearm, and hand. Because of the high risk of pneumothorax due to the proximity of the apex of the lung to the brachial plexus, an ultrasound-guided approach is strongly recommended.

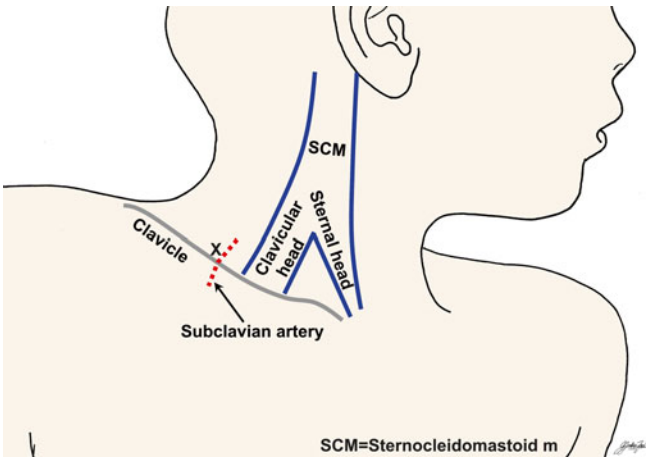


Fig. 71.5 Patient positioning and surface landmarks for supraclavicular brachial plexus block. *X* indicates the point of needle entry

Patient Positioning, Preparation, Equipment, and Dosage

The head of the patient is turned to the contralateral side. The arm is placed on the side, and the shoulder is pushed backward on to the mattress and down toward the feet (Fig. 71.5). The skin is cleaned with antiseptic solution. If the ultrasound approach is used, prepare the probe surface by applying a sterile adhesive dressing.

A 50-mm, 22-G insulated needle is used. Depth of insertion is related to the age and weight of the patient in a nonlinear manner. For a 10-kg child, the depth of insertion is about 10 mm. For every 10 kg increase in weight, the depth of insertion increases 3 mm until the child reaches 50 kg. After that, advance 1 mm for every 10 kg increase in weight. The maximum depth should not exceed 35 mm. The required depth of penetration is usually less than 1 cm for children and 1–2 cm for teenagers.

Recommended local anesthetics are 0.25–0.5 % bupivacaine, 0.2 % ropivacaine, and 2 % lidocaine. Blockade at this level can be achieved with volumes as low as 0.15–0.2 mL/ kg.

Nerve Stimulation Technique

The needle insertion point is located 1 cm above the midpoint of the clavicle posterolateral to the subclavian artery. The subclavian artery pulsation serves as the landmark for localization of the plexus. The current is initially set at 0.8 mA (2 Hz, 100–300 μs) and then gradually reduced to a threshold current of 0.2–0.4 mA (0.1–0.2 ms) after obtaining appropriate response. Motor response at a current $\leq$0.2 mA indicates intraneural placement, and the needle should be withdrawn. The spread of local anesthetic solution in children may be greater than for adults since, in children, the fascia adheres less to the nerve trunks. This increases the likelihood of a successful block with any motor response.

Ultrasound-Guided Technique

A high-frequency (13-6 MHz) hockey stick probe is ideal for small children. For older and/or obese children, a small footprint curved array probe (8-5 MHz) is a better option. The probe is first placed in a coronal oblique plane at the lateral end of the upper border of the clavicle. It is then moved medially until the subclavian artery is seen. The subclavian artery is anechoic, hypodense, pulsatile, and round; its identity can be confirmed by color Doppler. The plexus is located superior and lateral to the artery above the first rib and appears as a "bunch of grapes" outlined by a hyperechoic fascia sheath (Fig. 71.6). Below the artery, the first rib appears as a hyperechoic structure with a hypoechoic acoustic shadow, while the lung pleura is accompanied by a hyperechoic shadow due to air artifacts.

The needle is inserted immediately above the clavicle in a lateral-to-medial direction at a shallow angle. An in-plane approach is strongly recommended to ensure visualization of the needle tip at all times so as to minimize the risks of pneumothorax and vascular puncture. A test dose of D5W is used to visualize the spread and confirm nerve localization. Local anesthetic is first deposited into the "corner pocket" (the corner between the subclavian artery and the first rib). This way, the plexus is often lifted up and away from the pleura so as to reduce the chance of pleural puncture upon subsequent injection. The needle may then be repositioned to achieve good local anesthetic spread around the nerves within the fascia.

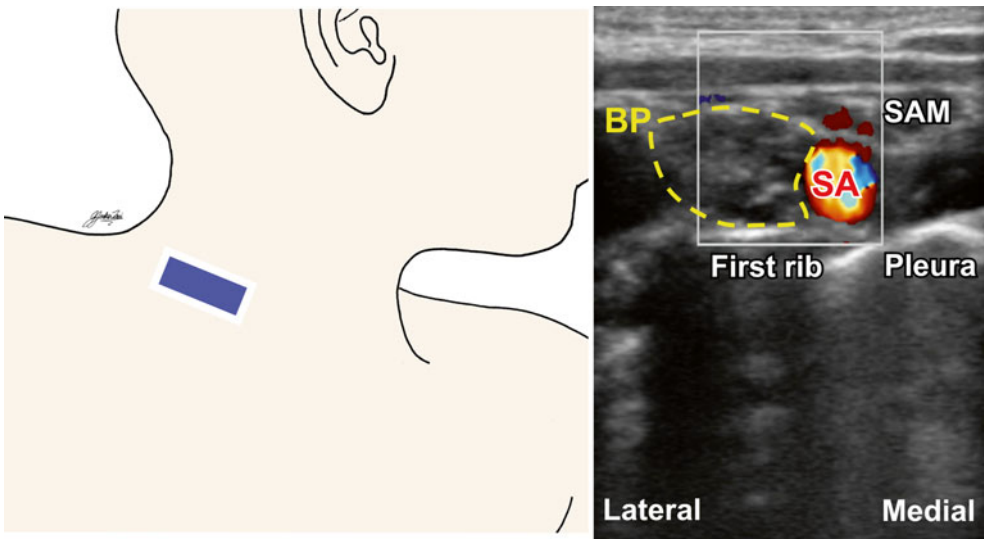


Fig. 71.6 Ultrasound image of the brachial plexus at the supraclavicular level. *BP* brachial plexus, *SAM* scalenus anterior muscle, *SA* subclavian artery

Infraclavicular Block

Introduction, Indications, and Complications

This block targets the cords of the brachial plexus where they surround the axillary artery. In this region, the three cords are arranged around the artery in the following manner: lateral cord cephalad, posterior cord posterior, and medial cord caudad. This block is indicated for surgery on the upper arm, elbow, forearm, and hand. Continuous infusion of local anesthetic via an infraclavicular catheter provides excellent postoperative analgesia for major upper limb surgery and is preferred over supraclavicular and axillary catheters because of ease of placement and securement.

Patient Positioning, Preparation, Equipment, and Dosage

A pillow is placed underneath the patient's shoulder. The elbow is flexed with the hand resting on the abdomen or with the arm resting at the side. Alternatively, the arm can be abducted and externally rotated with the elbow flexed. This maneuver has the advantage of stretching the cords and bringing them closer to the surface, enhancing the ultrasonographic appearance as well as facilitating local anesthetic spread. The skin is cleaned with antiseptic solution. If ultrasound guidance is used, prepare the probe surface by applying a sterile adhesive dressing.

A 50-mm, 22-G needle is commonly used for this block. An insulated needle should be chosen if nerve stimulation is used. The depth of penetration is usually within 2–3 cm at a lateral location inferior to the coracoid process. Recommended local anesthetic doses are 0.5 mL/kg of 0.2–0.5 % ropivacaine or 0.25–0.5 % bupivacaine. Concentrations may need to be reduced in very small children to obtain a volume of at least 5 mL for this block.

Nerve Stimulation Technique

A lateral approach is recommended where the point of needle insertion is approximately 0.5–1 cm inferior and slightly medial to the coracoid process (Fig. 71.7). At this point, the pleura is further away so the risk of pneumothorax is lower compared to a more medial injection site. The needle is advanced in a vertical direction until distal motor response (hand or wrist flexion) is obtained. The current is initially set at 0.8 mA (2 Hz, 100–300 μs) and then gradually reduced to a threshold current of 0.2–0.4 mA. Twitching of the pectoralis muscles indicates the needle is too shallow, while bone (rib) contact means it is too deep, and appropriate needle adjustment should be made. Careful aspiration is crucial to rule out pneumothorax or arterial/venous puncture.

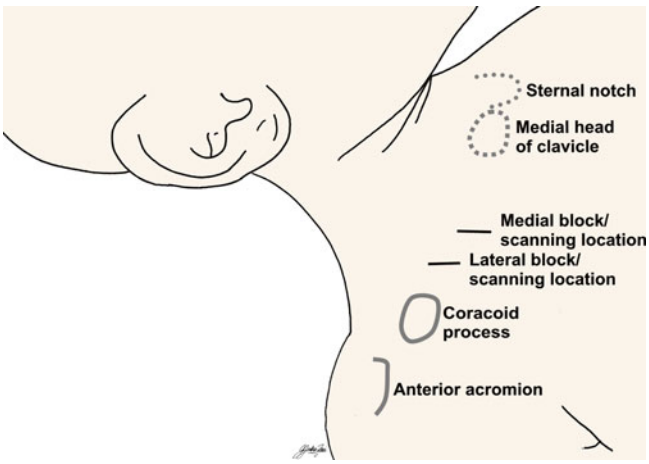


Fig. 71.7 Patient positioning and surface landmarks for infraclavicular brachial plexus block

Ultrasound-Guided Technique

A small footprint linear array transducer (13-6 MHz frequency) is ideal for young children. In older or larger children, a curved array transducer (8-5 MHz frequency) is desirable to allow greater depth of penetration.

A lateral block location is recommended. The probe is placed in a parasagittal plane below and slightly medial to the coracoid process. Scan medially and laterally to locate the axillary neurovascular bundle, which sits underneath the pectoralis major and minor muscles (Fig. 71.8). The axillary artery can be identified as a round or oval-shaped pulsatile structure. The axillary vein is almost always medial and caudad to the artery and is irregularly shaped. Color Doppler can be used to identify the vessel in cases of doubt. At this point, the cords, which are seen as hyperechoic oval structures, can be found posterolateral to the artery. The medial cord may be difficult to identify because it may be hidden between the axillary artery and vein and can be posterior or even slightly cephalad to the artery.

If a medial approach is to be used, the probe is positioned at the midpoint of the line between the anterior acromion and jugular notch. It is important to maintain the pleura and needle in view at all times during the time of needle insertion.

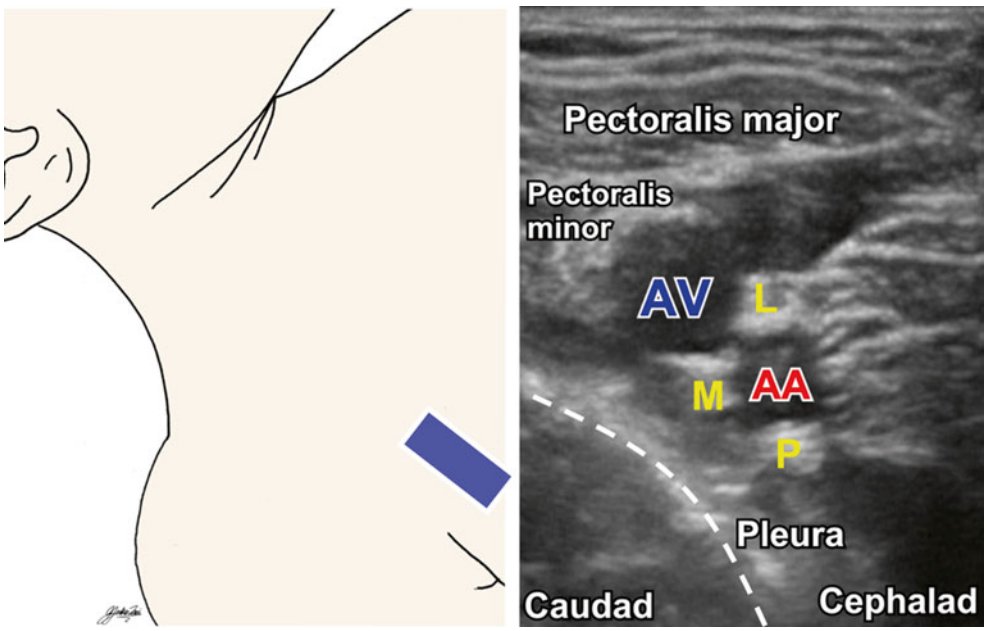


Fig. 71.8 Ultrasound image of the brachial plexus at the infraclavicular level at a lateral scanning location. *AV* axillary vein, *AA* axillary artery, *L* lateral cord, *M* medial cord, *P* posterior cord

The pleura usually appears as a hypoechoic cavity outlined by a hyperechoic line and is often located proximal to the vessels and plexus (Fig. 71.9).

Both in-plane and out-of-plane approaches can be used for this block. The in-plane approach is strongly recommended, especially when a more medial block location is chosen, because it allows visualization of the needle tip and shaft, thereby minimizing the risk of pleural puncture. The needle is inserted at the cephalad end of the probe at a 45–60° angle to the skin and advanced caudally. The needle is then directed to the posterior cord, and local anesthetic is deposited around it. This often results in a "U-shaped" spread around the artery and hence complete blockade of the plexus. If the spread is deemed inadequate, a further dose of local anesthetic is deposited as the needle is withdrawn to the lateral cord position. Another injection between the artery and the vein may be needed to ensure blockade of the medial cord. Nerve stimulation offers additional confirmation of the neural structure and is recommended. A test dose of D5W prior to injection of local anesthetic can visualize spread and confirm nerve localization.

Occasionally, the out-of-plane approach is required when there is not enough space for the in-plane needle insertion between the probe and the clavicle, especially in very small children. This approach also has the advantage of a reduced length of needle path for better patient comfort if the block is to be performed on a conscious child. A 45° angled needle insertion is used so that the distances between the needle insertion point, probe, and brachial plexus are equal (i.e., forming a right-angled triangle). The needle then "walks down" to reach the posterior cord while the needle tip is being tracked.

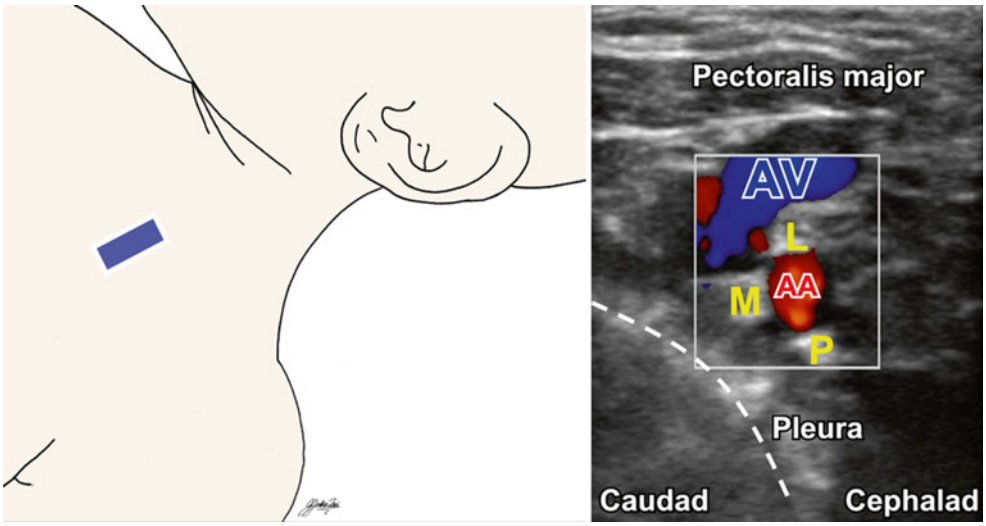


Fig. 71.9 Ultrasound image of the brachial plexus at the infraclavicular level at a medial scanning location. *AV* axillary vein, *AA* axillary artery, *L* lateral cord, *M* medial cord, *P* posterior cord

Axillary Block

Introduction, Indications, and Complications

This block targets the terminal branches of the brachial plexus (median, ulnar, radial, and musculocutaneous nerves) where they are in close relation to the axillary artery at the apex of axilla. The musculocutaneous nerve often leaves the plexus proximal to this point and travels between the biceps and coracobrachialis muscles; therefore, it must be blocked with a separate injection. Axillary block is indicated in surgery of the elbow, forearm, wrist, or hand. Traditionally, this block has been considered safer than blocks at more proximal locations because it is free from the pleura, vertebral artery, and phrenic nerve. However, hematoma formation causing nerve compression can occur occasionally in children. When performed blind, the success rate of this block is only 70–80 % [2], but the use of ultrasound, especially when combining with nerve stimulation, can improve nerve localization and hence the success rate significantly.

Patient Positioning, Preparation, Equipment, and Dosage

The arm of the patient is abducted 70–80° and externally rotated. The skin is cleaned with antiseptic solution. If ultrasound is used, prepare the probe surface by applying a sterile adhesive dressing.

A 50-mm, 22-G insulated needle is typically used. The recommended dose of local anesthetic for an ultrasound-guided technique is 0.2–0.3 mL/kg of 0.25–0.5 % bupivacaine, ropivacaine, or levobupivacaine and 0.5–1.0 mL for the musculocutaneous nerve. Higher volumes are needed if nerve stimulation is used.

Nerve Stimulation Technique

The axillary artery is first palpated at the apex of axilla. The needle is introduced at an approximately 45° angle to the skin at the upper edge of the axillary artery, pointing cephalad toward the midpoint of clavicle (Fig. 71.10). Advance the needle until a "pop" or "give" is felt as the needle enters the neurovascular sheath. Pulsations in the needle indicate that the needle tip is in immediate vicinity of the artery. An initial current is applied at 0.8 mA (2 Hz, 100 μs) and then gradually reduced to a threshold current of 0.4 mA (0.1 ms) after obtaining a distal motor response in the hand, wrist, or forearm. Local anesthetic is deposited after careful aspiration to rule out any intra-arterial/intravenous placement. A second injection can be made at the lower edge of the artery in a similar fashion ("two-puncture technique").

To block the musculocutaneous nerve, direct the needle (using the same needle insertion site) toward the belly of the coracobrachialis muscle and inject local anesthetic. Elbow flexion can be elicited if nerve simulation is used.

If a tourniquet is required for the surgery, the intercostobrachial nerve should be blocked; this can be done by subcutaneous injection of local anesthetic across the medial surface of the upper arm.

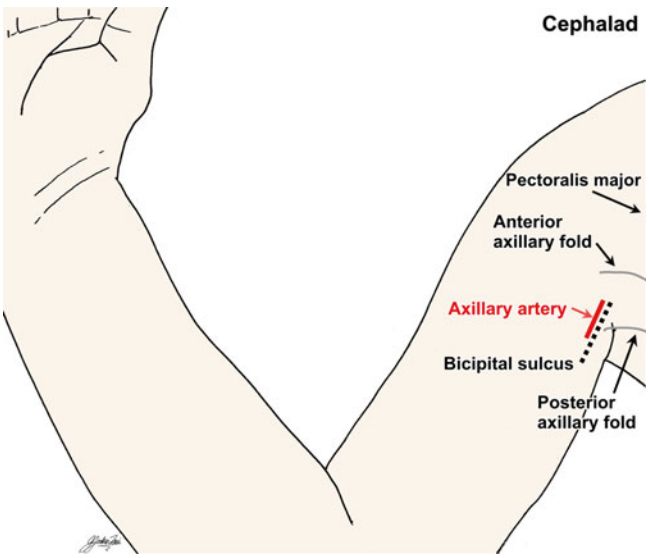


Fig. 71.10 Patient positioning and surface landmarks for axillary block of the brachial plexus

Ultrasound-Guided Technique

A high-frequency (13-6 MHz) linear probe is suitable for this block. In small children, a small footprint ("hockey stick") probe is desirable. The probe is placed in a transverse plane along the axillary crease and scanned as proximally as possible to obtain the best transverse view of the neurovascular bundle surrounded by the biceps brachii, coracobrachialis, and triceps muscles. The anechoic axillary artery can be identified as a pulsatile circular structure, while the anechoic axillary vein(s) is irregular in shape, compressible, and usually more superficial. The nerves, which appear as round- or oval-shaped structures with a honeycomb-like appearance, are situated around the artery (Fig. 71.11). The median nerve can be found between the artery and biceps brachii muscle and is located superficial to the artery. The ulnar nerve lies between the artery and the triceps muscle and is also superficial to the artery. The radial nerve is deep to the artery at the midline and can sometimes be difficult to locate. The musculocutaneous nerve, whose appearance can vary from round or oval to flat, can usually be found in the plane between the biceps and the coracobrachialis muscles. If necessary, each of these terminal branches can be traced distally for confirmation. The use of nerve stimulation can also help identify individual nerves according to the corresponding motor responses.

The needle is inserted either in-plane or out-of-plane in relation to the probe. Commonly, multiple injections and needle redirections are required to ensure circumferential spread of local anesthetic around each individual nerve. For the in-plane approach, the needle is inserted at an acute angle (20–30°) to the skin in a superior-to-inferior direction in parallel to the long axis of the probe. The needle is initially directed underneath the artery to reach the radial nerve. It is recommended to block the radial nerve first to minimize image distortion from the spread of local anesthetic. After that, the needle is withdrawn and redirected to deposit local anesthetic around the ulnar and the median nerves. A test dose with D5W is useful to visualize the spread and confirm nerve localization prior to injection of local anesthetic. If an out-of-plane approach is used, the needle is inserted approximately 1 cm away from the midpoint of the probe at a 30–45° angle from the skin to reach the nerves.

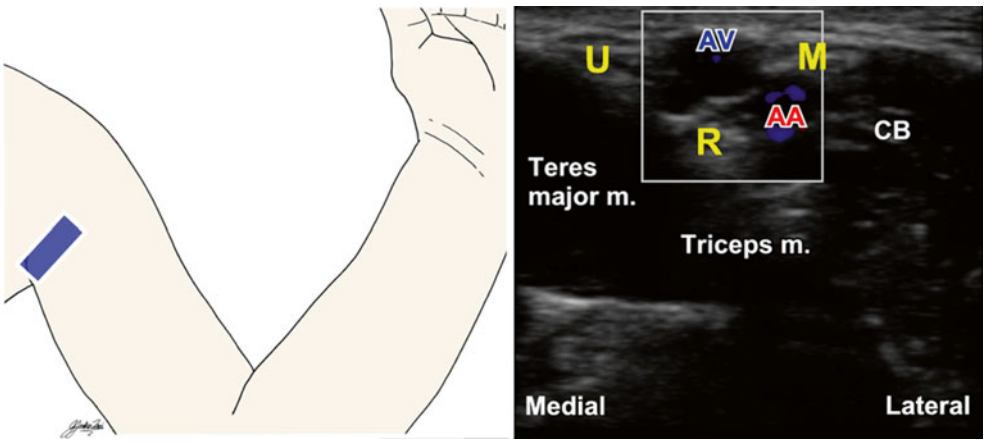


Fig. 71.11 Ultrasound image of the brachial plexus at the axilla. *AV* axillary vein, *AA* axillary artery, *CB* coracobrachialis, *U* ulnar nerve, *R* radial nerve, *M* median nerve

Distal Nerve Block of the Upper Extremity

Individual peripheral nerve blocks of the upper extremity can be used as rescue blocks to supplement incomplete brachial plexus blocks. Occasionally, they are performed to provide anesthesia for surgical procedures which involve a territory supplied by a single peripheral nerve or to prolong postoperative analgesia.

Median Nerve

Introduction, Indications, and Complications

The median nerve innervates muscles which produce flexion and opposition of the thumb, middle, and index fingers, as well as pronation and flexion of the wrist. The nerve is derived from the lateral and medial cords, carrying fibers from all roots (C5–T1). Distal to the axilla, it descends lateral to the brachial artery in the upper arm. It then crosses over to lie medial to the artery at the mid-humeral level. At the antecubital fossa, the nerve remains medial to the brachial artery (Fig. 71.12) and anterior to the brachialis muscle. After that, it pierces through bicipital aponeurosis to enter the forearm to supply all the muscles in the anterior compartment except the flexor carpi ulnaris and the medial half of the flexor digitorum profundus. At the wrist, it passes deep to the flexor retinaculum near the midline, lying between the flexor carpi radialis tendon and the palmaris longus tendon, before entering the hand to supply the thenar muscles and lateral two lumbricals. The cutaneous branches supply the palmar aspects of first three digits and the lateral half of the fourth digit.

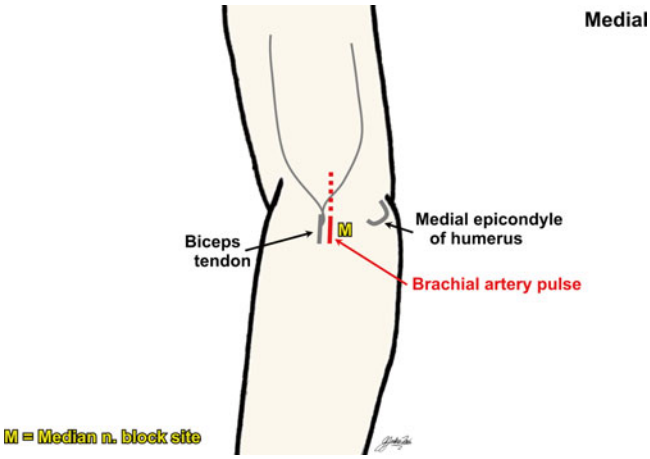


Fig. 71.12 Surface anatomy and landmarks for median nerve block

Patient Positioning, Preparation, Equipment, and Dosage

The arm is rested on an arm board with the elbow slightly flexed. Prepare the skin and, if ultrasound is used, the probe. A 50-mm short-beveled needle (insulated if using nerve stimulation) should be used. A volume of 1–3 mL of 0.25–0.5 % ropivacaine or bupivacaine is adequate for this block.

Nerve Stimulation Technique

The needle is inserted immediately medial to the brachial artery at the antecubital fossa (Fig. 71.12). Advance slowly until appropriate motor responses are observed (flexion in the lateral three digits, wrist flexion, or forearm pronation). The nerve should be superficial to the skin.

Ultrasound-Guided Technique

A high-frequency (13-6 MHz), small footprint ("hockey stick") probe should be used. The probe is placed in the axial plane medial to the biceps tendon at or near the antecubital fossa. The nerve, which appears as oval-peanut shaped and is often larger than the artery, should be seen lying medially to the brachial artery (Fig. 71.13). Both in-plane and out-of-plane approaches can be used. When using the in-plane approach, the needle is inserted medial to the probe to reduce the chance of puncturing the brachial artery. A test dose of D5W to observe the spread is recommended before local anesthetic is deposited around the nerve.

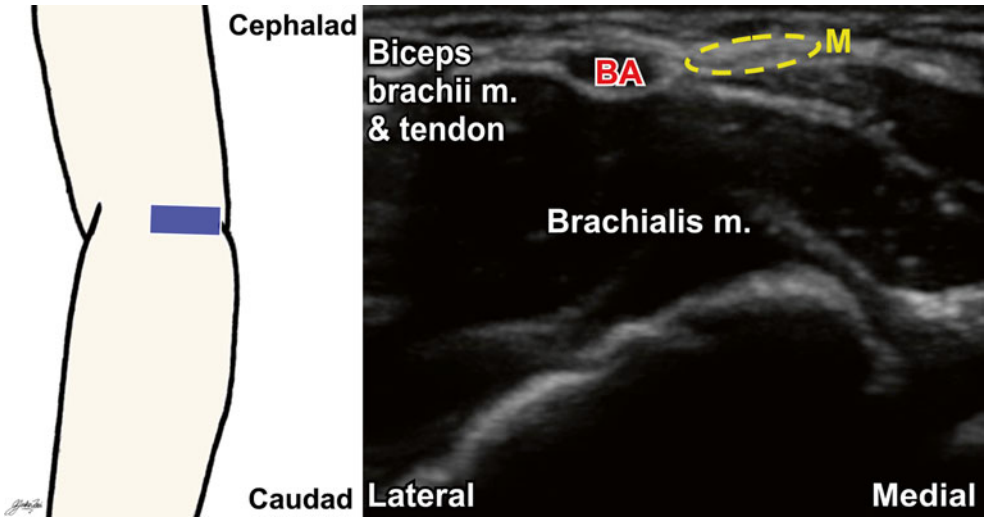


Fig. 71.13 Ultrasound image of the median nerve at the antecubital fossa. *BA* brachial artery, *M* median nerve

Ulnar Nerve

Introduction, Indications, and Complications

The ulnar nerve innervates muscles that produce flexion of the fourth and fifth fingers and ulnar deviation of wrist. It is derived from the medial cord, carrying fibers from roots C7 to T1. Distal to the axilla, the ulnar nerve descends medial to the brachial artery in the upper arm before passing posterior to the medial epicondyle in the condylar groove. The nerve then courses anteriorly in the forearm, lying on the surface of flexor digitorum profundus, deep to the flexor digitorum superficialis, and lateral to the flexor carpi ulnaris, to supply the flexor carpi ulnaris and medial half of the flexor digitorum profundus. The nerve runs medial to the ulnar artery, approaching the artery at the mid-forearm (Fig. 71.14). At the wrist, the nerve crosses superficial to the flexor retinaculum, between the ulnar artery (laterally) and the flexor carpi ulnaris tendon (medially), to supply all intrinsic muscles of hand except the thenar muscles and the lateral two lumbricals. The cutaneous branches supply the dorsal and palmar aspects of the fifth and the medial half the fourth finger.

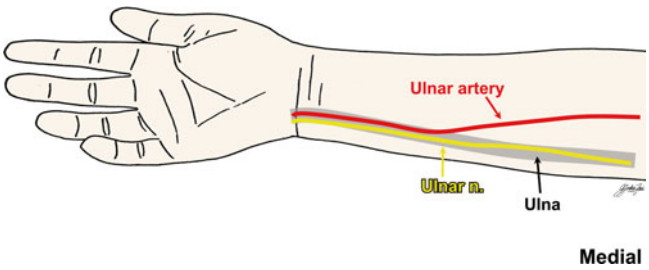


Fig. 71.14 Surface anatomy and landmarks for ulnar nerve block

Patient Positioning, Preparation, Equipment, and Dosage

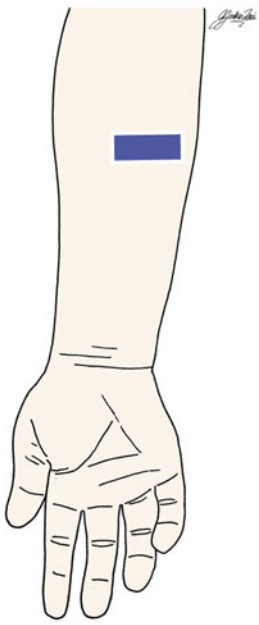
The elbow is flexed with the shoulder externally rotated and the forearm supinated. Prepare the skin and, if ultrasound is used, the probe. A 50-mm short-beveled needle (insulated if using nerve stimulation) should be used. A volume of 1–3 mL of 0.25–0.5 % ropivacaine or bupivacaine is adequate for this block.

Nerve Stimulation Technique

The needle is inserted 45° to the skin, 1–3 cm distal (or alternatively, 2–3 cm proximal) to the condylar groove between the medial epicondyle and olecranon process, pointing proximally in the direction of the groove. Advance slowly until appropriate motor responses are observed (flexion of the fourth and fifth fingers and/or ulnar deviation of the wrist). The nerve should be superficial at this point.

Ultrasound-Guided Technique

A high-frequency (13-6 MHz), small footprint ("hockey stick") probe should be used. The probe is placed in the axial plane across the flexor carpi ulnaris muscle on the forearm. The nerve, which appears as oval or round shape, should be seen lying medially to the ulnar artery (Fig. 71.15). Its location can be confirmed by scanning up and down the forearm to observe the nerve and the artery approaching each other at the mid-forearm. Both in-plane and out-of-plane approaches can be used. It is best to target the nerve when it separates from the artery to minimize the risk of arterial puncture during needle insertion. A test dose of D5W to observe the spread is recommended before local anesthetic is deposited around the nerve.



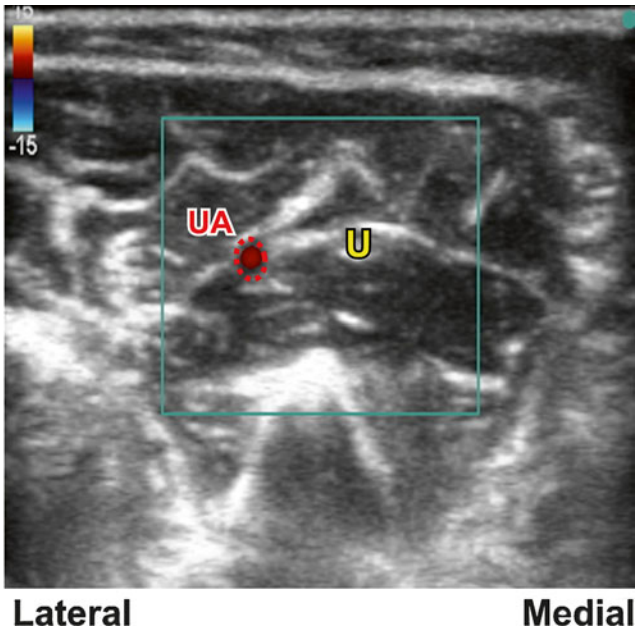


Fig. 71.15 Ultrasound image of the ulnar nerve in the forearm. *UA* ulnar artery, *U* ulnar nerve

Radial Nerve

Introduction, Indications, and Complications

The radial nerve innervates muscles that produce extension of the wrist and fingers. The nerve is derived from the posterior cord, carrying fibers from roots C5 to C8. After leaving the axilla, the nerve runs between two heads of the triceps muscle. It then travels in the radial groove of the humerus, posteromedial to the deep brachial artery. As it approaches the elbow, it crosses over the lateral epicondyle to enter the anterior compartment of the forearm, where it runs between the brachialis and brachioradialis muscles. The nerve divides into deep (motor) and superficial (sensory) branches as it passes in front of the lateral epicondyle. The motor branches supply the muscles of the posterior compartments of the arm and forearm, while the cutaneous branches supply the posterior arm and forearm as well as the dorsum of the hand except the medial and dorsal aspects of the lateral three and a half fingers up to the distal interphalangeal crease.

Patient Positioning, Preparation, Equipment, and Dosage

The arm is placed slightly abducted with the elbow flexed approximately 30°. Prepare the skin and, if ultrasound is used, the probe. A 50-mm short-beveled needle (insulated if using nerve stimulation) should be used. A volume of 1–3 mL of 0.25–0.5 % ropivacaine or bupivacaine is adequate for this block.

Nerve Stimulation Technique

The needle is inserted in the groove between the biceps brachii tendon and the brachioradialis muscle at the intercondylar line, pointing cephalad (Fig. 71.16). Advance the needle until appropriate motor response(s) (extension of the wrist and fingers) is observed. The nerve is usually superficial.

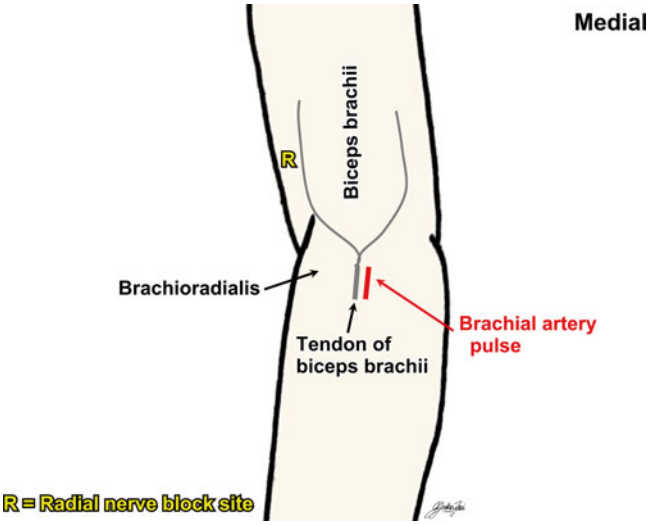


Fig. 71.16 Surface anatomy and landmarks for radial nerve block

Ultrasound-Guided Technique

A high-frequency (13-6 MHz), small footprint ("hockey stick") probe should be used. With the probe placed in the axial plane on the arm, the block can be performed at more proximal or distal locations. Proximally, the nerve can be located in the radial groove at the posterior humerus, where it travels with the deep brachial artery (Fig. 71.17). Distally, the nerve can be found in the groove between the biceps brachii tendon and the brachioradialis muscle at the lateral aspect of the distal upper arm (at the level of the supracondylar ridge). It can be confirmed by scanning further downward to look for where the nerve splits into two branches.

Both in-plane and out-of-plane approaches can be used. With an in-plane approach, the needle is inserted in an anterior-to-posterior direction to avoid puncturing the deep brachial artery. The out-of-plane approach causes less discomfort and is recommended in awake patients. The needle is inserted a small distance away from the midpoint of the probe, directing cephalad. A test dose of D5W to observe the spread is helpful before depositing local anesthetic around the nerve.

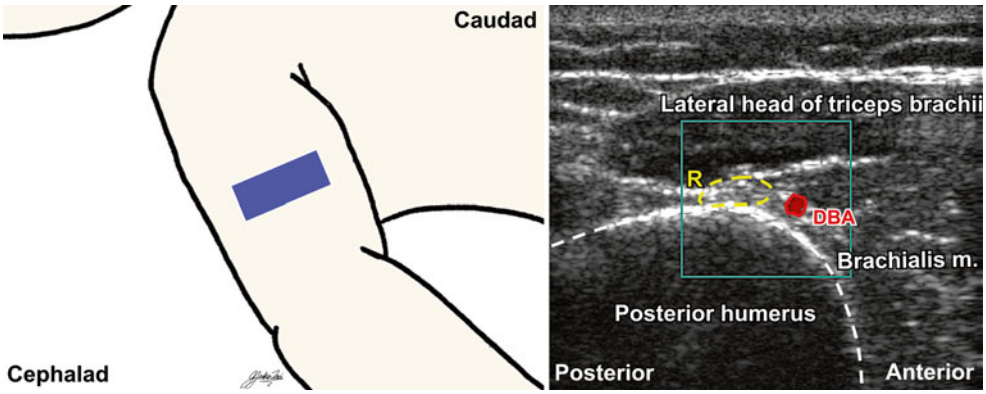


Fig. 71.17 Ultrasound image of the location of the radial nerve. *R* radial nerve, *DBA* deep brachial (profunda brachii) artery

Acknowledgments This chapter was written using Drs. Tsui and Suresh's textbook, *Pediatric Atlas of Ultrasound and Nerve Stimulation-Guided Regional Anesthesia* 1st edition (Springer) as a template. The authors thank Jenkin Tsui for providing the original artwork for the figures, Alex Kwan for the assistance with creating and organizing the figures, and Dr. Gareth Corry for the assistance with manuscript preparation and management.

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