How I Do It

Ultrasound-Guided Axillary Block

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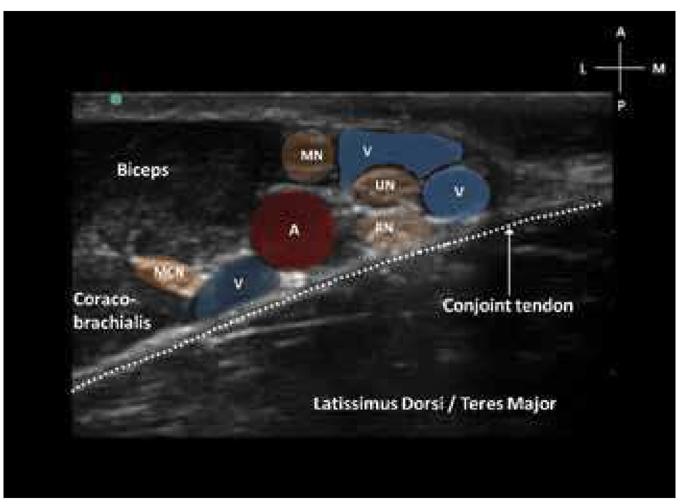
The ultrasound-guided axillary block is an excellent technique for providing surgical anesthesia at and below the elbow. It is at least as effective as the supraclavicular and infraclavicular blocks, if not more so because of the ability to individually target the four main terminal nerves of the arm.[1] It is also a safe approach, due in part to the shallow depth of the brachial plexus in this location, which allows excellent visualization of both nerves and needle. Inadvertent intraneural and intravascular injections are the only significant risks, and both are easily avoided. Finally, it is an easy block to learn and perform, as this article will illustrate.

Patient Positioning and Equipment Selection

The patient is placed supine with the arm abducted 90 degrees at the shoulder. Inability to abduct the arm represents one of the few absolute contraindications to this block. A high-frequency (>10 MHz) linear array transducer and 22-gauge 50 mm block needle are recommended. A peripheral nerve stimulator may be used to confirm the identity of the individual nerves, however as practitioners gain experience, they will find that it is by no means essential.

Figure 1



In the conjoint tendon zone view of the axillary brachial plexus, the entire neurovascular bundle is located anterior to the conjoint tendon. (A= artery, MCN = musculocutaneous nerve, MN = median nerve, RN = radial nerve, UN = ulnar nerve, V = vein). (Used with permission of www.usra.ca).

The Scanning Phase

1. Obtain the Conjoint Tendon Zone (CTZ) view:

The transducer is oriented perpendicular to the axis of the brachial plexus and axillary artery to image the neurovascular bundle in cross-section. It is essential that the transducer is placed as proximal in the axilla as possible. At this level, the conjoint tendon of the latissimus dorsi and teres major (and not the triceps) lies posterior to the neurovascular bundle. The conjoint tendon appears as a sloping hyperechoic line on ultrasound (Figure 1). The conjoint tendon is the key landmark in the axillary block as the entire neurovascular bundle lies superficial (anterior) to it.[2]

2. "Bounce" the transducer to identify the axillary veins:

The veins in the axillary neurovascular bundle are revealed by varying the downward pressure of the transducer in a "bouncing" motion to alternately expand and compress the veins. This serves two purposes.

1) **To identify the location of the veins and minimize the risk of inadvertent puncture**. There are usually at least two veins, one in the posterolateral quadrant of the neurovascular bundle, and one in the anteromedial quadrant (Figure 2b).
2) **To better delineate the nerves**. With compression, the median, ulnar and radial nerves come together and may appear as a single hyperechoic mass (Figure 2a). The expanded veins will separate the nerves into distinct structures (Figure 2b). The ability to compress and expand the veins also distinguishes them from nerves with large hypoechoic elements (see example in Figure 3), which instead of being compressed, will "roll" into different positions around the artery.

3. Use a "traceback" approach to locate and confirm the identity of the individual nerves:

The typical locations of the nerves with respect to the axillary artery, have been described by Retzl[3] and Christophe[4]. Their location and identity can be confirmed by scanning distally along the arm and observing the characteristic course that each nerve takes.

a. **Median and ulnar nerves.** The median and ulnar nerves both lie very close to the axillary artery in the axilla. More distally, the ulnar nerve diverges in a medial direction away from the artery, while the median nerve remains adjacent (usually lateral) to the artery (Figure 4). Because of its subcutaneous location, the ulnar nerve can be difficult to distinguish from pockets of adipose tissue on a

Figure 2a and 2b

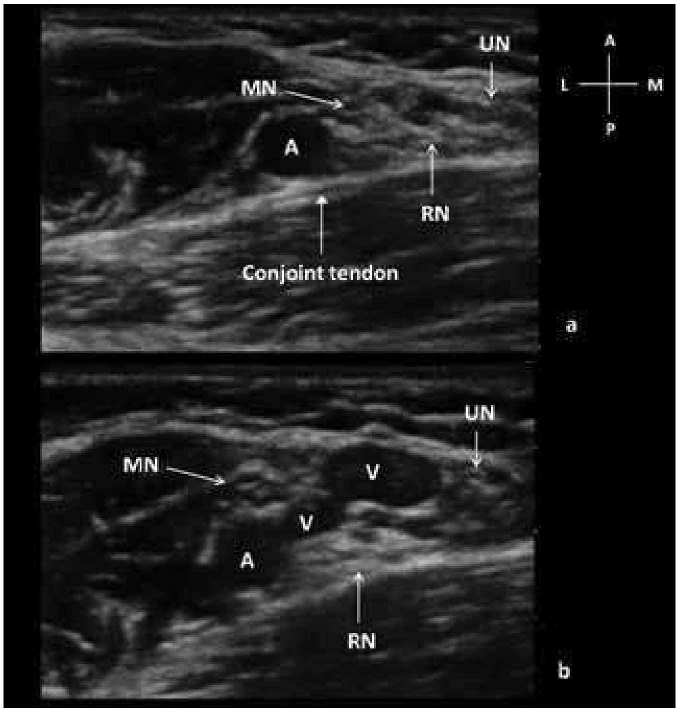
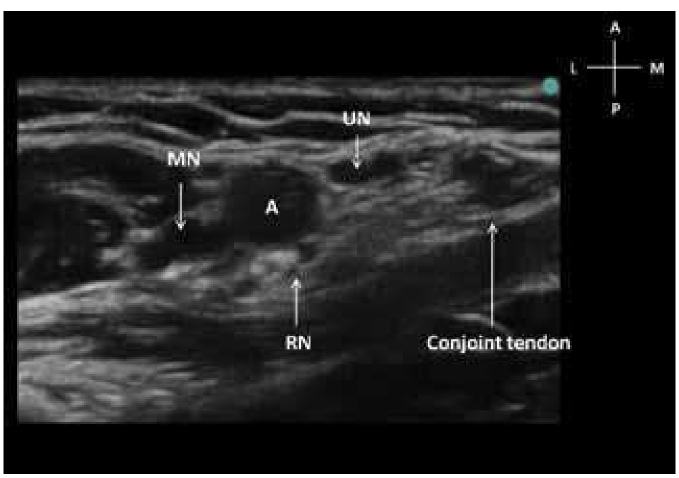


Figure 2a. With the veins compressed, the nerves appear as a single hyperechoic structure. Figure 2b. With the veins (V) expanded, the individual nerves are now apparent. (A= artery, MN = median nerve, RN = radial nerve, UN = ulnar nerve). (Used with permission of www.usra.ca).

Figure 3



An example of hypoechoic (dark) median and ulnar nerves, which may be mistaken for blood vessels. However, they do not pulsate (unlike arteries) and are non-compressible (unlike veins). The radial nerve, on the other hand, is almost always hyperechoic with indistinct margins. (A= artery, MN = median nerve, RN = radial nerve, UN = ulnar nerve). (Used with permission of www.usra.ca).

static image, but is easily recognizable on dynamic scanning.

b. **The radial nerve.** This has traditionally been regarded as the most difficult nerve to visualize.[5] However in the CTZ view it is almost always found sandwiched between the axillary artery and the conjoint tendon. Its appearance in this location, as a hyperechoic structure with indistinct margins, resembles that of a "cotton-wool ball" (Figures 2 and 3). Once again, its identity may be confirmed by scanning distally and observing the nerve descend in a fascial plane between the long and medial heads of the triceps muscle toward the posteromedial aspect of the humerus (Figure 5). The profunda brachii artery accompanies the radial nerve and can be identified as a hypoechoic pulsatile round structure.

c. **The musculocutaneous nerve.** The take-off of the musculocutaneous nerve from the lateral cord is highly variable. In general, the nerve lies lateral to the axillary artery, and by scanning in a proximal-distal direction can be observed to "slide" in a lateral-medial direction in the fascial plane between the biceps and coracobrachialis muscles. Its cross-sectional shape varies from triangular to elliptical (Figure 6).

The Needling Phase

Different methods of performing the axillary block have been described, including using out-of-plane (OOP) needle guidance[6] instead of an in-plane (IP) approach, and a perivascular technique[7,8] in which the aim is to deposit local anesthetic in a circumferential pattern around the artery rather than targeting individual nerves (perineural technique). It has been suggested that anesthesiologists who are familiar with the neurostimulation-guided axillary blockade may find the OOP technique easier to learn because of the similar approach to the nerves.[6] However, many people find that visualizing and tracking the needle tip is more difficult with an OOP approach compared to an IP approach, and this may increase the risk of inadvertent vascular or neural trauma. In the hands of trainees, the perivascular technique is associated with a shorter block performance time compared to the perineural technique; however, its efficacy has not been confirmed for local anesthetic (LA) volumes <40 mL.[7] My preferred method is to use an in-plane needle approach and a perineural technique, as I believe this affords more precision and thereby greater efficacy and safety.

1. The radial nerve:

The key to targeting the radial nerve is to use the conjoint tendon to direct the spread of LA between the tendon and the nerve, as described by Gray.[2] The needle

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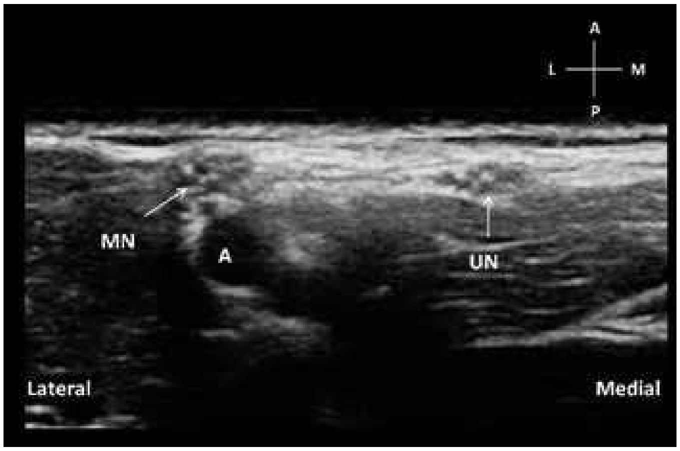
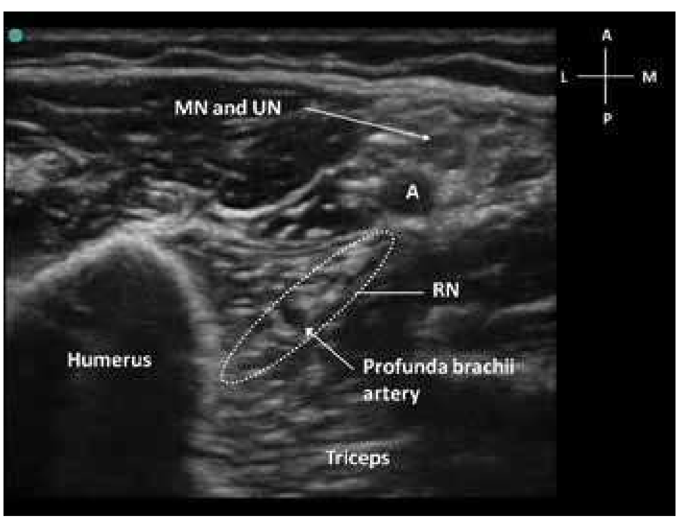
Figure 4



Mid-humeral view of the median nerve (MN), which lies immediately adjacent to the brachial artery (A); and the ulnar nerve (UN), which is subcutaneous and medial to the artery. (Used with permission of www.usra.ca).

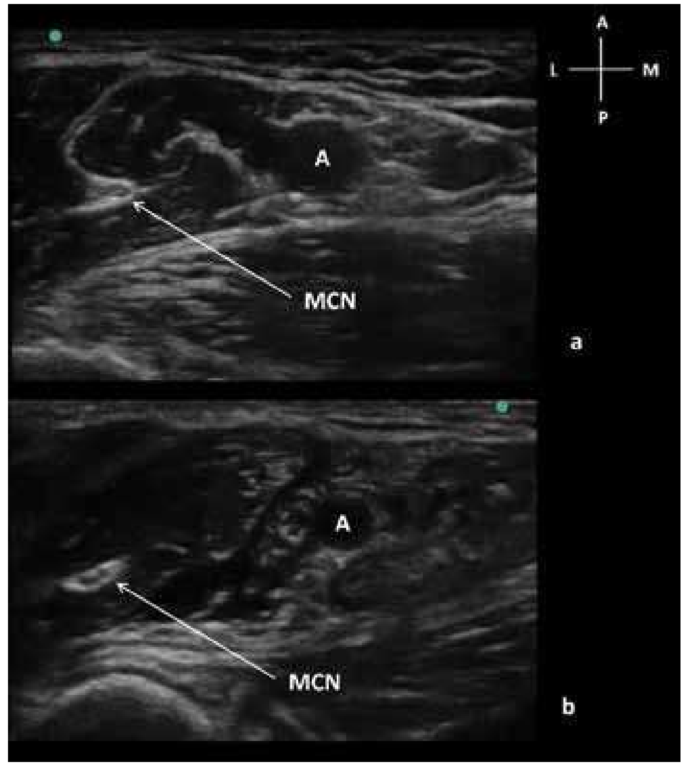
is inserted from the lateral side of the transducer onto the conjoint tendon, just where it meets the axillary artery (Figure 7a). If there is a vein in this location, it should be compressed and the junction between the vein and the tendon targeted instead. With the needle tip lying on the surface of the conjoint tendon, 0.5-1 mL boluses of LA are injected, and this will hydrodissect the plane between the tendon and the neurovascular bundle (Figure 7b). This also has the effect of lifting the whole plexus to lie more superficially. If necessary, the needle may be advanced

Figure 5



Distal to the conjoint tendon zone, the radial nerve runs postero-laterally in a fascial plane between the long and medial heads of the triceps toward the humerus. It is accompanied by the profunda brachii artery. (A= artery, MN = median nerve, RN = radial nerve, UN = ulnar nerve). (Used with permission of www.usra.ca).

Figure 6



The musculocutaneous nerve (MCN) is located lateral to the axillary artery (A) in a fascial plane between the biceps and coracobrachialis muscles. It has a cross-sectional appearance that varies from triangular (a) to elliptical (b). (Used with permission of www.usra.ca).

under the artery to promote LA spread under and around the radial nerve. A total of 5-8mL of LA is usually injected in this location. Bruhn et al.[9] have described an alternative medial-to-lateral needle approach to the radial nerve in order to avoid the vein commonly found in the posterolateral quadrant, but the principle of using the conjoint tendon to direct LA spread under the nerve remains the same.

2. The median nerve:

The needle is now withdrawn until the tip lies in the subcutaneous layer. It is then re-advanced in a shallow trajectory toward the median nerve, aiming to pierce its investing fascia at a tangent to the surface of the nerve so as to avoid accidental transfixion of the nerve (see section on "Clinical Pearls" on the next page). Penetration of the fascia is signalled by a tactile "pop," whereupon LA is injected in 0.5-1 mL boluses to surround the median nerve and to hydrodissect a safe passage toward the ulnar nerve (Figure 8). A total of 5-8 mL of LA is usually injected here, the endpoint being circumferential spread of LA around the nerve.

3. **The ulnar nerve:**

The needle is advanced further into the anteromedial quadrant of the neurovascular bundle and adjacent to the ulnar nerve (Figure 9). Injection of 0.5-1 mL boluses of LA, up to a total of 5-8 mL, in this area will surround the

Figure 7a and 7b

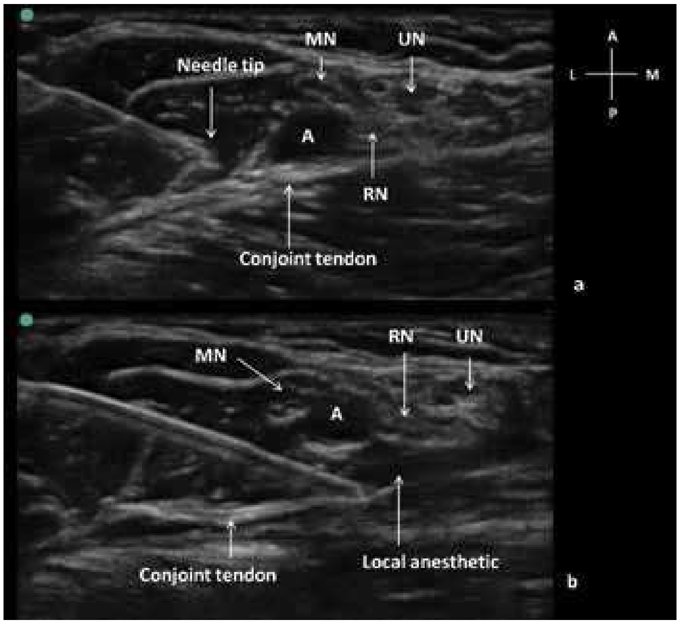


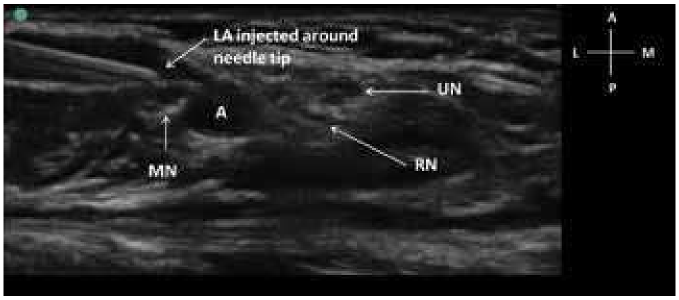
Figure 7a. The needle tip is advanced toward the posterolateral junction of the axillary artery (A) and the conjoint tendon. Figure 7b. Injection at this point causes local anesthetic to spread anterior to the conjoint tendon and under (posterior to) the radial nerve, lifting it up. (A= artery, MN = median nerve, RN = radial nerve, UN = ulnar nerve). (Used with permission of www.usra.ca).

ulnar nerve and usually delineate it clearly. Once again, the endpoint for injection is circumferential spread of LA around the nerve.

4. **The musculocutaneous nerve:**

Depending on how far lateral the musculocutaneous nerve lies from the axillary artery, the needle may need to be withdrawn and re-inserted through a second skin puncture. The nerve lies in the fascial plane between the biceps and coracobrachialis muscles. Once again, the needle should be advanced to contact the nerve at a tangent to its surface and pierce this fascial plane (Figure 10a, page 16). Three to five mL of LA injected in this plane should encircle the nerve (Figure 10b, page 16).

Figure 8



The needle is advanced at a tangent to the median nerve in order to pierce its enveloping fascia without transfixing the nerve. Local anesthetic (LA) is injected here to surround the nerve and to hydrodissect a safe passage toward the ulnar nerve. (A= artery, MN = median nerve, RN = radial nerve, UN = ulnar nerve). (Used with permission of www.usra.ca).

Clinical Pearls

Multiple fascial septae are present within the neurovascular bundle, such that each nerve is contained within its own fascial envelope. In order to pierce this investing fascia without also piercing the epineurium, the needle should always approach the nerve at a tangent to its surface. Safety is suggested by the nerve "rolling" away from the advancing needle tip as it tents the investing fascia. Entry into the fascial envelope is signalled by a tactile "pop."

A similar principle applies to avoiding vascular puncture. It is extremely difficult to inadvertently pierce a vein or artery with a B-bevelled block needle if the needle contacts the vessel wall at a tangent.

Intraneural injection and intravenous injection are the two most significant risks of this block. Both, however, can be recognized early and easily with ultrasound; intraneural injection by nerve expansion and intravascular injection by the lack of visible LA spread. The initial injection of LA should therefore only be made with the needle tip in view, and in boluses of less than 1 mL. Additional signs of possible intraneural injection include pain and resistance to injection; if these are elicited, injection should be stopped immediately and the needle tip repositioned. Intravascular injection may also be signalled by an increase in heart rate if epinephrine-containing LA solutions are used. Practitioners should continue to be vigilant for all these signs throughout the entire injection process.

Deliberate intraneural injection is not recommended. Instead, the aim is to deposit LA within the investing fascia surrounding each nerve but outside the epineurium. Block onset can be expected within 15 minutes of injection, if not sooner.

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Figure 9a and 9b

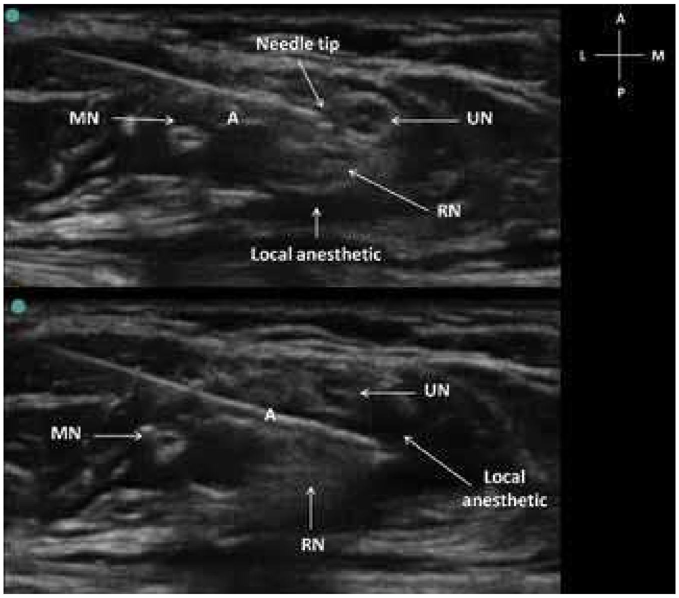

Figure 9a. The needle is advanced over the axillary artery (A) toward the ulnar nerve (UN) at a tangent to its surface. Figure 9b. Injection here surrounds the ulnar nerve (UN) and also often spreads superficial to the radial nerve (RN). (MN = median nerve). (Used with permission of www.usra.ca).

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How I Do It - **Ultrasound-Guided Axillary Block**

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Figure 10a and 10b

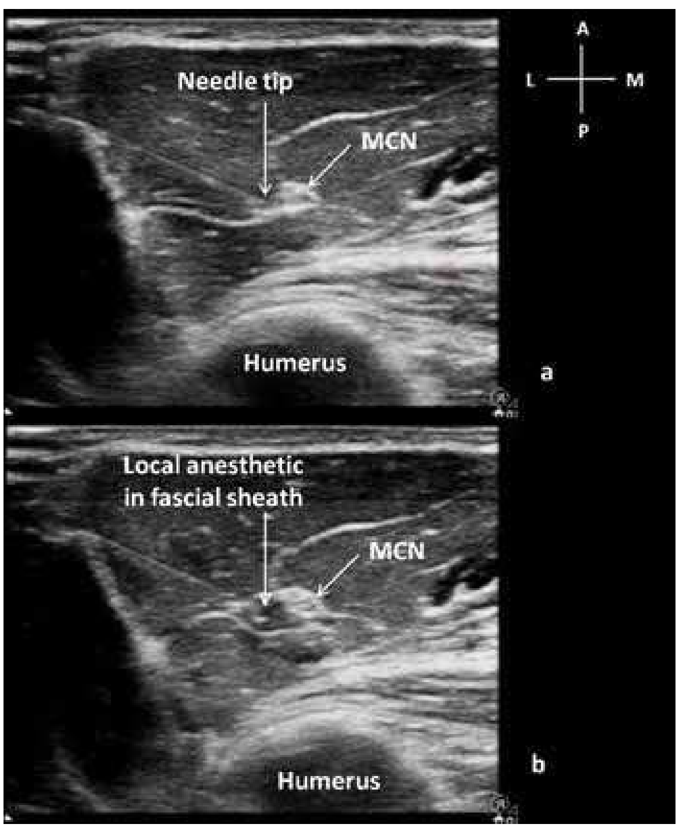

Figure 10a. The musculocutaneous nerve (MCN) is approached at a tangent, the aim being to enter the enveloping fascia without piercing the nerve. Figure 10b. Injection with the needle tip within the fascial sheath will surround the nerve with local anesthetic. (Used with permission of www.usra.ca).

A peripheral nerve stimulator can be used to confirm the identity of the nerves, but we do not recommend seeking a minimum current threshold (e.g. ≤0.5mA) as the endpoint of needle positioning since this has been shown to correlate poorly with needle-nerve contact.[10] Instead, one should seek an appropriate pattern of LA spread on injection. With experience, the individual nerves can be recognized by their sonoanatomy alone, and neurostimulation becomes unnecessary.

Summary

The axillary block is an extremely reliable and effective method of providing surgical anesthesia of the upper limb at and below the elbow. It is particularly suited for relatively inexperienced practitioners because of its low risk and the potential for safe practice of the in-plane needling technique.

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