REVIEW

Standard approaches for upper extremity nerve blocks with an emphasis on outpatient surgery

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Purpose of review

Currently, no standards exist with regard to the techniques and administration of ultrasound-guided peripheral nerve blocks. Consequently, the techniques and teaching substantially vary among practitioners and institutions. The purpose of this review is to propose a set of standard US-guided techniques for upper extremity nerve blocks.

Recent findings

On the basis of the synthesis of information in available literature and the consensus of an internationally recognized collaborative panel of regional anaesthesia experts, the review recommends a standardized approach to common upper extremity nerve blocks using ultrasound guidance.

Summary

A set of structured recommendations and approaches are suggested to help standardize clinical practice and teaching of ultrasound-guided upper extremity nerve blocks. Additional emphasis is placed on the discussion of nerve blocks in outpatient surgery.

Keywords

peripheral nerve blocks, regional anesthesia, standards, ultrasound, upper extremity

INTRODUCTION

Ultrasound guidance is rapidly becoming quintessential in the practice of peripheral nerve blockade (PNB). However, techniques of PNB have substantially evolved with ultrasound guidance and differ markedly in methodology, pharmacology, recommended number of injections, needle insertion sites and monitoring when compared with traditional, nonultrasound-based techniques. At this time, there are no standard methods of application and teaching upon which trainees can easily adopt ultrasound guided techniques for PNB.

Therefore, the purpose of this review is to propose a set of standard ultrasound-guided techniques for upper extremity nerve blocks, based on the available literature and the consensus of an international collaborative panel of internationally recognized regional anaesthesia experts. The most common techniques to PNB of the upper extremity are described by a standard approach that represents methods agreed-upon by NYSORA led international expert-panelists. Common indications, patient positioning, initial transducer position, elements of the optimal ultrasound view, a systematic approach to obtain this view, suggested needle trajectory, recommended placement of the needle and the required number of injections to accomplish the block are discussed for each technique. Block-specific procedures and suggested monitoring are also discussed. The scope of this review is limited to the single-injection upper extremity PNB because discussion of continuous injection techniques warrants its own review. Wherever appropriate, special consideration is given to the practice of PNB in the outpatient population. Finally, the recommended volumes of local anaesthetics are for surgical anaesthesia in average sized patients (50–90 kg).

Monitoring during peripheral nerve blocks

In addition to the standard American Society of Anesthesiologists (ASA) monitoring, specific

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KEY POINTS

- Ultrasound-guided peripheral nerve blocks are rapidly becoming the preferred method of practice.
- Standards of practice of ultrasound-guided peripheral nerve blocks have not been established.
- Establishing a set of practice standards and indications should facilitate clinical practice, communication amongst clinicians and training of peripheral nerve blocks.
- An international panel of experts suggested a set of standardized approaches to upper extremity nerve blocks on the basis of the current literature.

multimodal monitoring of needle placement and local anaesthetic administration may decrease the risk for needle misadventures, inadvertent intravascular injection of local anaesthetic, and mechanical and injection-related nerve injury [1,2].

A multimodal algorithm that combines ultrasound guidance with nerve stimulation and injection pressure monitoring was recommended by the panelists Appendix Algorithm A1, http://links.lww.com/COAN/A25. Ultrasound is used to visualize the relevant anatomy in order to guide the needle tip to the desired location while avoiding needle–nerve contact and/or intrafascicular injection. Risk for local anaesthetic systemic toxicity (LAST) may be reduced by ultrasound monitoring, as an intravascular injection can be suspected by the absence of local anaesthetic spread in the expected space [3,4▪,5]. Although ultrasound may detect an intraneural injection by an increase in the diameter of the nerve and proximal-distal distribution [6], the perineurium can rupture with a miniscule amount of injectate, making ultrasound alone inadequately sensitive to reliably prevent an intrafascicular injection [7▪,8–11]. The primary role of nerve stimulation in combination with ultrasound guidance is to help detect an inadvertent needle–nerve contact, intraneural or intrafascicular needle placement. The panel concurred that the presence of a motor response at a current of 0.3 mA or less (0.1 ms) indicates a needle–nerve contact or an intraneural needle placement [12]. More practically, a nerve stimulation can be set at 0.5 mA (0.1 ms). Therefore, when a motor response is present at 0.5, the panel suggests that the needle be repositioned until the motor response disappears (Algorithm A1). Adequacy of the needle position is then confirmed by observing the spread of local anaesthetic in the desired tissue plane on ultrasound. This strategy largely obviates the need to manipulate current intensity during the procedure. Adhering to a cut-off motor response at 0.5 mA also increases the sensitivity of nerve stimulation in detecting needle–nerve contact or intraneural needle placement.

The panel suggested that when the ultrasound imaging of the needle and anatomy are adequate, it is not necessary to elicit an evoked motor response before injection. However, an evoked motor response can be sought intentionally to confirm nerve location or when imaging quality is suboptimal.

High opening pressure during injection pressure monitoring can detect needle placement into non-compliant tissues (such as the nerve fascicle) or needle–nerve contact [8,13–16]. Therefore, when high opening pressure ($\geq$15 psi) is obtained before the injection commences, the needle should be repositioned before proceeding with the injection.

Of note, the ability of these proposed Appendix Algorithm A1, http://links.lww.com/COAN/A25 and monitoring techniques to decrease the risk for complications of PNB has not been tested in randomized controlled trials in humans. However, on the basis of the cumulative evidence, the panel suggested that these technologies, when incorporated into a multimodal approach, should decrease the risk for neurologic complications [2,17].

In summary, for all the techniques described, triple monitoring (ultrasound, nerve stimulation, injection pressure) is suggested [2,18]. Injection is commenced if no motor response is present at a current less than 0.5 mA, opening pressure less than 15 psi and after negative aspiration test for blood to rule out an intravascular needle placement. Of note, aspiration test and injection are performed while releasing the pressure on the transducer to increase the sensitivity of the suggested monitoring.

INTERSCALENE BRACHIAL PLEXUS BLOCK

The interscalene block is a block of the brachial plexus at the level of the roots or trunks. The interscalene block provides reliable anaesthesia for surgery of the shoulder, distal clavicle, proximal humerus and lateral aspect of the elbow [19]. The medial aspect of the elbow (lower trunk distribution) may be spared with this technique; consequently, a more distal brachial plexus block such as a division-level (supraclavicular) or a cord-level block (infraclavicular) should be considered for distal upper extremity surgery necessitating anaesthesia in the ulnar nerve distribution.

The patient is in a supine or semi-sitting position with the head facing away from the side to be blocked. Alternatively, the patient can be

FIGURE 1. Ultrasound transducer position and needle insertion for interscalene brachial plexus block.

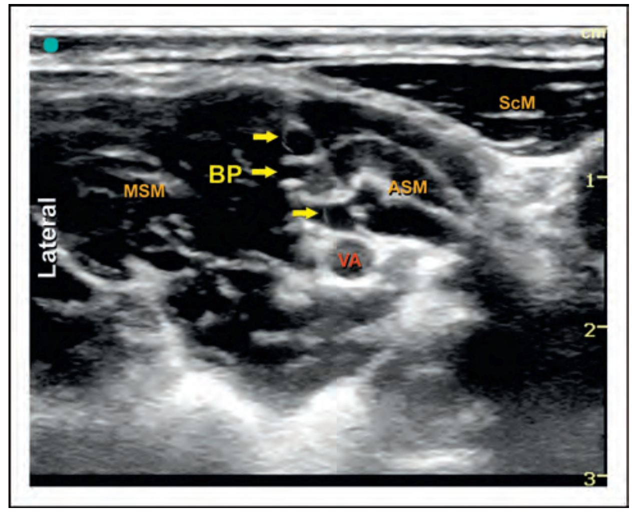

FIGURE 2. Ultrasound anatomy for interscalene brachial plexus block. ASM, anterior scalene muscle; BP, brachial plexus; MSM, middle scalene muscle; SCM, sternocleidomastoid muscle; VA, vertebral artery.

positioned in a semi-lateral position. This facilitates an in-plane needle insertion (postero-lateral to antero-medial) (Fig. 1). During the procedure, the head faces the contralateral side.

The interscalene space and the elements of the brachial plexus are readily identified by one of the following initial transducer positions and scanning sequences.

(1) A linear transducer is placed in an oblique sagittal plane cephalad to the midpoint of the clavicle within the supraclavicular fossa. The subclavian artery is identified. Care should be taken to distinguish the subclavian vein from the artery. Lateral and superior to the artery are the trunks and/or divisions of the brachial plexus that appear as anechoic nodules. The brachial plexus is then traced proximally (cephalad) to a desired location in the interscalene space between the anterior and middle scalene muscles. The brachial plexus is visualized as an elongated series of anechoic circles (Fig. 2). The panel concurs that this view represents the ideal location for an injection.

(2) The brachial plexus trunks and roots can be traced proximally to their respective vertebral foramina. The transverse processes at C5 and C6 have both an anterior and posterior tubercle, whereas the transverse processes of C7 does not have an anterior tubercle, which can be helpful in identifying the vertebral levels and corresponding roots. Separate injections to block individual roots are not recommended, as an intrafascicular injection and proximal spread of local anaesthetic to the spinal cord may occur at this location [8]. Although some clinicians routinely identify individual roots for teaching purposes, the panel concurred that this is not necessary for a successful block.

(3) The linear ultrasound transducer is placed in the transverse orientation at approximately 2–3 cm above the clavicle. The carotid artery and internal jugular vein are identified medially. The transducer is moved laterally to identify the anterior and middle scalene muscles, the interscalene space and the brachial plexus in-between.

(4) The external jugular vein is identified about 2–3 cm above the clavicle. The transducer is placed in a transverse view at this position to identify the scalene muscles and brachial plexus in-between.

The panel suggested that the optimal critical view should include at least the upper two elements of the brachial plexus (the upper and middle trunks, or C5-C6) aligned between the anterior and middle scalene muscles (Fig. 2). Colour or power Doppler is highly recommended to exclude the presence of vascular structures (vertebral artery, branches of the thyrocervcal trunck) in the vicinity of the needle path [20].

The panel recommended an in-plane needle approach from lateral to medial direction. The needle course is usually shallow and makes imaging of the needle and anatomy relatively straightforward. In contrast, a medial to lateral approach may risk injury to the phrenic nerve or perforation of vascular structures and thus, it is not recommended as a routine by the panel.

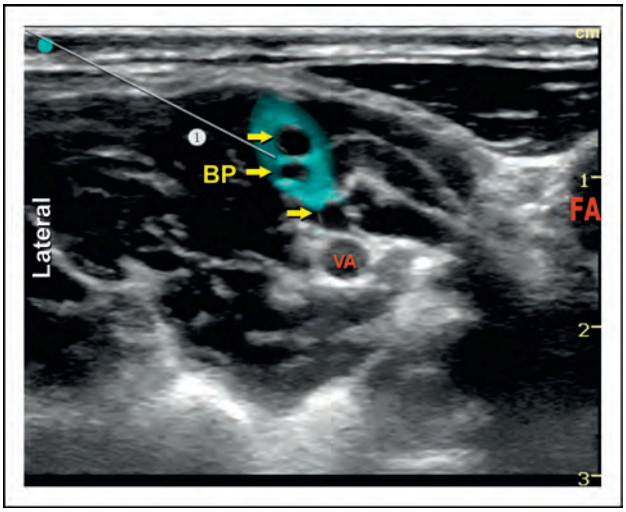

FIGURE 3. Needle insertion path and distribution of local anaesthetic (blue shaded area) to anaesthetize interscalene brachial plexus. BP, brachial plexus; VA, vertebral artery.

After guiding the needle through the prevertebral fascia, the local anaesthetic is deposited underneath the prevertebral fascia between the middle and anterior scalene muscles. For upper arm and/or shoulder surgery, injection is typically targeted towards the upper aspects of the brachial plexus (C5–C6/upper–middle trunk), as targeting lower might bring the needle tip unnecessarily close to the vertebral and/or subclavian artery. Inadvertent injection of even very small volumes of local anaesthetic into the vertebral artery can rapidly lead to the neurological symptoms of LAST. For a successful block, the needle must traverse the medial fascia of the middle scalene muscle in order to enter the interscalene groove; however, injection into the stroma of the brachial plexus is not required [21]. A twitch of the shoulder, arm or forearm can occur during needle advancement but it is not intentionally sought.

Local anaesthetic should spread around the upper and middle trunks of the brachial plexus (Fig. 3). Adequate spread of local anaesthetic can usually be accomplished with a single injection. Although as little as 5 ml has been reported to be sufficient for analgesia, the panel recommended 15–20 ml of local anaesthetic as a clinically more relevant volume for a consistent successful surgical block [4▪,22].

The precise level of the injection is not critical for efficacy of the block despite of a wide array of anatomical variations. A common variation is when the C5 nerve root courses across the anterior border or even through the belly of the anterior scalene muscle [18,23]. However, even in such cases, no literature suggests that additional injections of local anaesthetic are necessary.

FIGURE 4. Ultrasound transducer position and needle insertion for supraclavicular brachial plexus block.

SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK

The supraclavicular block provides surgical anaesthesia and analgesia to the divisions of the brachial plexus, and is indicated for surgery on the humerus, elbow, forearm and hand [1,24,25].

The patient is positioned supine or in semi-sitting, with the head turned away from the side being blocked (Fig. 4). Slight downward traction on the arm downward, if possible, might create more space in the supraclavicular fossa. This may be particularly useful in obese patients, but is not typically necessary. Initially, a high-frequency linear transducer is placed at the mid-clavicular level, above and parallel to the clavicle, slightly tilted caudally.

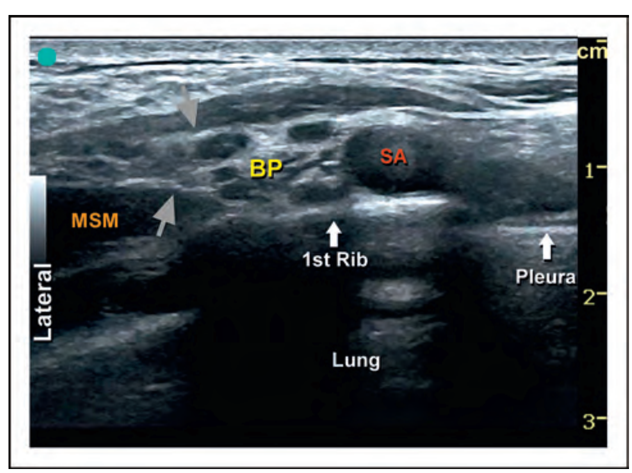

FIGURE 5. Essential ultrasound anatomy for supraclavicular brachial plexus block. BP, brachial plexus; MSM, middle scalene muscle.

The ultrasound view should include the brachial plexus and the subclavian artery, above the first rib and the pleura. The plexus is imaged lateral to the subclavian artery (Fig. 5). If this view is not obtained with the transducer in the suggested position, tilting and moving the transducer anteriorly or posteriorly is useful to facilitate the optimal view. Colour or power Doppler is used to rule out the presence of vascular structures along the needle path (e.g. dorsal scapular artery, branches of the thyrocervical trunk) [26]. The panel suggests that the transducer position should allow visualization of both the subclavian artery and the brachial plexus just above the first rib.

Once the suggested ultrasound view is obtained, the panel suggests that the needle be inserted in-plane for greater control and for decreasing the risk of pleural puncture. Although either medial or a lateral approach may be equally efficacious, the panel recommends a lateral to medial approach, as this allows more direct access to the brachial plexus at the lateral junction between the subclavian artery and the first rib [27,28]. A motor response of the forearm or hand is often obtained but not routinely sought as the needle enters the brachial plexus sheath. The panel suggests two or three separate injections: one at the inferior aspect of the plexus above the first rib, and one at the superolateral aspect of the plexus (Fig. 6). Additional injection(s) are performed only if the described injections do not result in adequate spread within the plexus (uncommon).

The panel recommends hydro-dissection during needle advancement for greater control of the needle tip location until the needle enters the brachial plexus sheath. After injection, the plexus sheath should be filled with local anaesthetic. For successful supraclavicular block, a higher volume of local anaesthetic is required than for the interscalene block. The reported effective volume for 95% of patients (ED 95) is up to 42 ml [29,30]. The panel however, recommends 20–25 ml of local anaesthetic.

INFRACLAVICULAR BRACHIAL PLEXUS BLOCK

The infraclavicular block at the level of the cords of the brachial plexus is used for anaesthesia and analgesia of the arm, elbow, forearm and hand [31].

The panel suggested that the patient is positioned supine with the arm abducted 90° and flexed at the elbow (Fig. 7). The recommended transducer is a high-frequency linear transducer. The transducer is placed in a sagittal plane, caudal to the distal third of clavicle and medial to the coracoid process. The required elements in the optimal view include the axillary (subclavian) artery and vein(s), below the fascia of the pectoralis minor muscle (Fig. 8). The lateral, medial and posterior cords lie lateral, medial and posterior to the artery, respectively. Individual cords of the brachial plexus may not be well imaged in the perivascular space; however, this is not necessary to accomplish a successful block.

Needle insertion is in the cephalad to caudad direction via an in-plane approach (Fig. 9). After passing the fascia of the pectoralis minor muscle (PMiM), the needle tip is directed towards the lateroposterior aspect of the artery. A motor response of the forearm or hand can be obtained but it is not routinely sought. Local anaesthetic spread should be observed underneath the PMiM

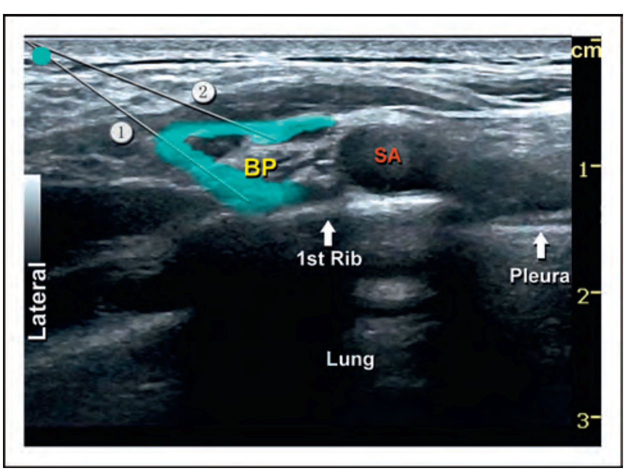

FIGURE 6. Needle insertion path and distribution of local anaesthetic (blue shaded area) to anaesthetize brachial plexus at the supraclavicular location. BP, brachial plexus.

FIGURE 7. Ultrasound transducer position and needle insertion for infraclavicular brachial plexus block.

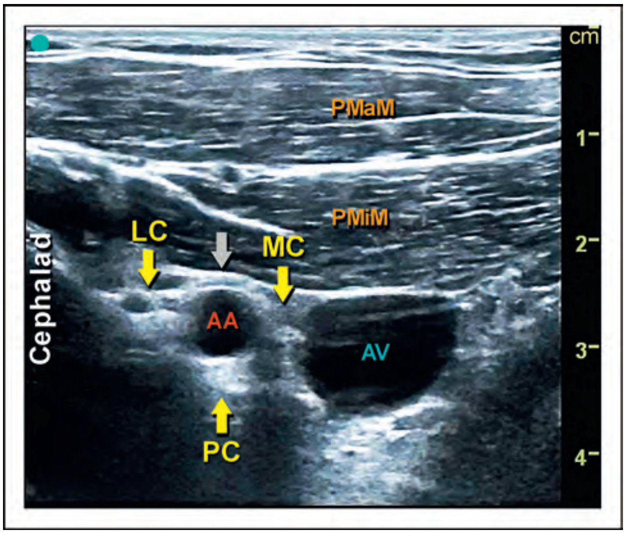

FIGURE 8. Essential ultrasound anatomy for infraclavicular brachial plexus block. AA, axillary artery; AV, axillary vein; LC, lateral cord; MC, medial cord; PC, posterior cord; PMaM, pectoralis major muscle; PMiM, pectoralis minor muscle.

fascia, in a 'U' or 'C' shape around the artery. Two injections, deep and lateral to the artery, are typically sufficient to block all three cords. However, if there is inadequate spread after 10–15 ml of local anaesthetic has been injected, the needle can be redirected to the area of interest, for an additional injection. The infraclavicular block requires a larger volume of local anaesthetic for success; an estimated MEV (90) of 35 ml has been reported [32]. However, the panel recommended that a total of 20–30 ml of local anaesthetic is sufficient to accomplish a successful block.

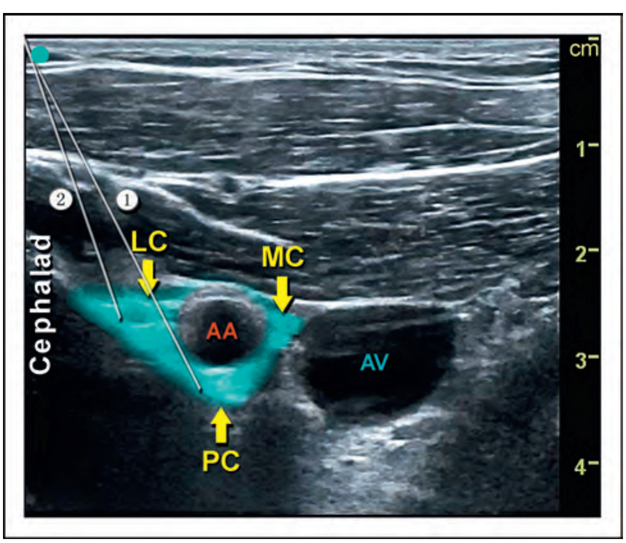

FIGURE 9. Needle insertion path and distribution of local anaesthetic (blue shaded area) to anaesthetize brachial plexus at the infraclavicular location. AA, axillary artery; AV, axillary vein; LC, lateral cord; MC, medial cord; PC, posterior cord.

Needle tip localization can be challenging in the infraclavicular block because of the steep angle of the needle. This may be particularly difficult in patients with large pectoralis muscles or obesity.

AXILLARY BRACHIAL PLEXUS BLOCK

The axillary block is performed at the level of the terminal nerves of the brachial plexus (ulnar, median, radial and musculocutaneous nerves) and it is commonly used for surgical anaesthesia or analgesia of the elbow, forearm and hand [33].

The panel recommended positioning the patient supine with the arm abducted and flexed at the elbow (Fig. 10). A high-frequency linear transducer is preferable. The transducer is positioned perpendicular to the humerus in the axillary fossa, at the level of the intersection of the deltoid and biceps muscles.

The optimal view should include the axillary artery and veins in short axis, and an outline of the neurovascular sheath. A separate view is occasionally required to visualize the musculocutaneous nerve more laterally. It is not always possible to visualize the median, ulnar and radial nerves in anterior, medial and posterior position to the artery, respectively, in a single plane. Slight tilting of the transducer and proximal-distal scanning are often required to identify the specific nerves of the brachial plexus. More proximally in the axillary fossa, the latissimus dorsi muscle and overlaying fascia may also be visualized posterior to the axillary artery; however, the implications of the of injection into fascial sheaths are the same (Fig. 11).

FIGURE 10. Ultrasound transducer position and needle insertion for axillary brachial plexus block.

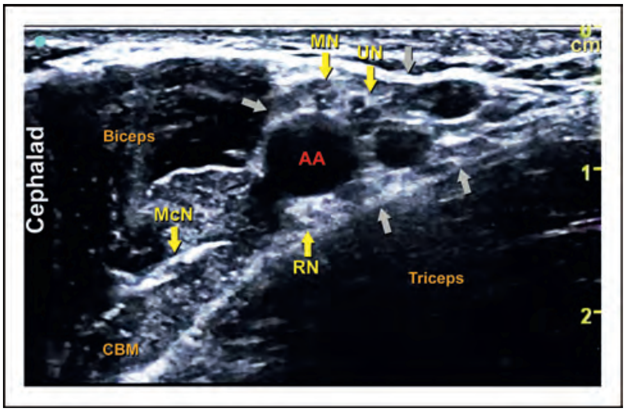

FIGURE 11. Essential ultrasound anatomy for axillary brachial plexus block. AA, axillary artery; CBM, coracobrachialis muscle; MCN, musculocutaneous nerve; MN, median nerve; RN, radial nerve; UN, ulnar nerve.

At this position, the musculocutaneous nerve has already exited from the perivascular sheath and can be identified by scanning caudad and cephalad from the initial position described above, as it courses towards the axillary artery between the biceps brachii and the coracobrachialis muscles.

The panel suggests that with the exception of the musculocutaneous nerve, visualization of the individual nerves and their separate blockade is not necessary once an adequate view is achieved (Fig. 12). The panel suggests that the needle be inserted in-plane (or out of plane) to make two separate injections superior and posterior to the axillary artery within the neuro-vascular sheath. A motor response is not routinely sought, but when obtained, it should be assured that it is not present at a low current intensity, suggesting needle–nerve contact or intraneural needle placement. Specific injections targeting each nerve (median, radial, ulnar) typically are not needed [34▪]. Instead, two injections of local anaesthetic periarterially – 10 ml posterior to the artery at 6 : 00H and 10 ml anterior to the artery at 1 : 00H – should result in an adequate spread of local anaesthetic around the median, ulnar and radial nerves (Fig. 12). If needed, an additional injection can be made to accomplish an adequate periarterial spread. A separate injection of 5 ml of local anaesthetic is required to block the musculocutaneous nerve. Therefore, the suggested volume of local anaesthetic for a successful axillary brachial plexus block is 20–30 ml [35]. Multiple superficial venous structures are present around the axillary artery. To reduce the risk for intravascular injection, the panel suggests that minimal pressure should be applied to the transducer during injection of local anaesthetic, as veins can be compressed and accidentally punctured.

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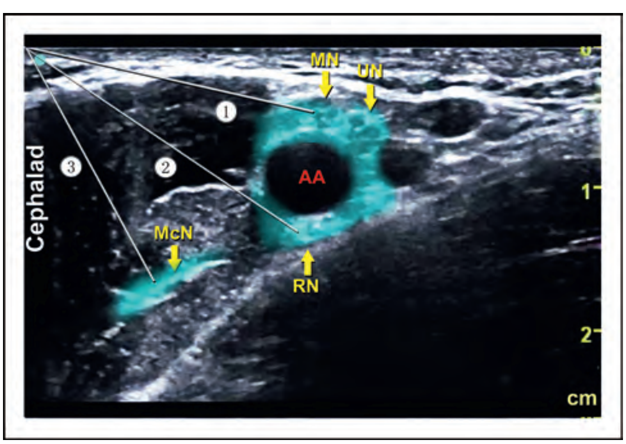

FIGURE 12. Needle insertion path and distribution of local anaesthetic (blue shaded area) to anaesthetize brachial plexus at the axillary location. AA, axillary artery; MCN, musculocutaneous nerve; MN, median nerve; RN, radial nerve; UN, ulnar nerve.

CONCLUSION

In summary, currently, no standards exist with regard to the techniques and administration of ultrasound-guided peripheral nerve blocks. On the basis of the synthesis of the published evidence and collective clinical experience, an international expert panel has recommended what could constitute standard, common ultrasound-guided techniques for upper extremity nerve blocks. The recommended approaches and recommendations may be beneficial to foster standardizing clinical practice and teaching of ultrasound-guided upper extremity nerve blocks.

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Conflicts of interest

Other authors have no conflicts of interest. No grants or support were provided for this article.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:
■ of special interest
■■ of outstanding interest
Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 514–515).

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