CHAPTER 6: UPPER EXTREMITY BLOCKS

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UPPER EXTREMITY BLOCKS

Anatomy of the brachial plexus

Roots

The brachial plexus is most frequently formed by five roots originating from the ventral divisions of spinal nerves C5 through T1. After exiting through the corresponding intervertebral foramen, the roots of the plexus are found in the cervical paravertebral space, between the anterior and middle scalene muscles. In the cervical region the spinal roots emerge above the corresponding cervical vertebrae, as seen in figure 6-1. Because there are 8 cervical nerves but only 7 cervical vertebrae, starting with T1 the spinal roots emerge below the corresponding vertebra (e.g., T1 exits between T1 and T2).

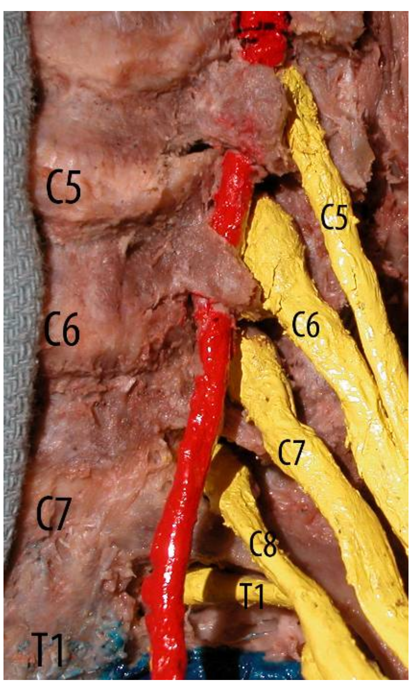

Fig 6-1. Left supraclavicular area. The sternocleidomastoid, scalene muscles, great vessels, soft tissue and fascias have been removed. The vertebral artery is shown in red. The roots of the plexus are seen exiting in between two vertebrae. The dome of the pleura is shown in blue at the bottom of the image. (Dissection by Dr. Franco. Copyrighted image).

The distance from C5 to T1 roots is large and irreducible, and equal to the height of four vertebrae. This fact in itself could help explain the frequent lack of dense anesthesia in the C8-T1 dermatomes after an injection performed at the level of the C5-C6 roots (interscalene block). Another important and frequently ignored reason is the expansive wave created by the pulse of the subclavian artery and felt mostly by the distal roots of the plexus (C8-T1), the lower trunk and its divisions. Because the local anesthetic diffuses to points of least resistance, this expanding pulsatile force may keep the local anesthetic from reaching the most distal elements of the plexus.

In addition to knowing the formation of the plexus and its architecture throughout its trajectory, it is also important from my perspective to understand the plexus in terms of its relative surface area at different locations. The five roots occupy an area that is elongated in the frontal plane, but very narrow in the sagittal plane (anteroposterior). When the five roots combine together to form three trunks, not only there is a 40% reduction in the number of nerve structures (from 5 to 3), but also the trunks become physically contiguous, as shown in figure 6-2, helping reduce their combined surface area. In fact this is the point at which the brachial plexus is reduced to its smallest surface area. This striking convergence of innervation is unique to the brachial plexus and has no parallel in the lower extremity and helps explain the rapid onset and high success rate of the supraclavicular approach. The surface area of the plexus increases again when the trunks originate six divisions although they stay together so the small increase in surface area is compensated by a larger surface of absorption. The surface area increases the most at the level of the axilla where the plexus gives off the terminal branches.

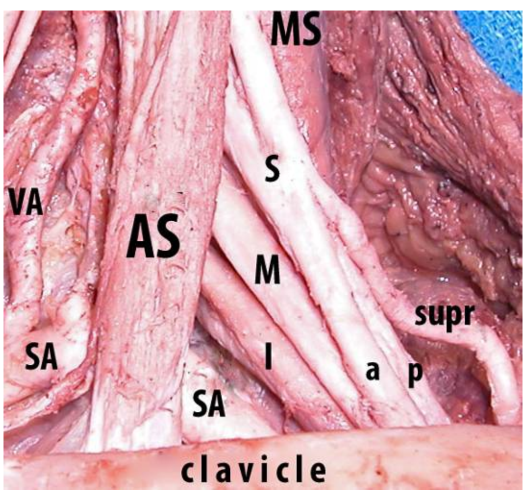

Fig. 6-2. Left supraclavicular area. The SCM, great vessels and fascias have been removed. The trunks (S, M, I) of the plexus are seen emerging in between the anterior scalene (AS) and medial scalene (MS). Also shown are the anterior (a) and posterior (p) divisions of the upper trunk and its supraescapular branch (supr), the subclavian artery (SA) and vertebral artery (VA). (Dissection by Dr. Franco. Copyrighted image).

The scalene muscles

The anterior scalene muscle originates in the anterior tubercles of the transverse processes of C3 to C6 and inserts on the scalene tubercle of the superior aspect of the first rib. The middle scalene muscle originates in the posterior tubercles of the transverse processes of C2 to C7 and inserts on a large area of superior aspect of the first rib, behind the subclavian groove.

Brachial plexus structure: Trunks to terminal branches

The five roots converge toward each other to form three trunks -upper, middle and lower- stacked one on top of the other, as they traverse the triangular interscalene space formed between the anterior and middle scalene muscles. This space becomes wider in the anteroposterior plane as the muscles approach their insertion on the first rib.

While the roots of the plexus are long, the trunks are almost as short (app 1cm) as they are wide, soon giving rise to a total of six divisions (three anterior and three posterior), as they reach the clavicle. The area of the trunks corresponds to the point where the brachial plexus is confined to its smallest surface area, three nerve structures, closely related to one another, carrying the entire sensory, motor and sympathetic innervation of the upper extremity, with the exception of a small area in the axilla and upper middle arm, which is innervated by the intercostobrachial nerve, a branch of the second intercostal nerve. This great reduction in surface area allows the plexus to negotiate the narrow passage between the clavicle and the first rib at the apex of the axilla.

The brachial plexus, represented by its divisions, enters the apex of the axilla lateral to the axillary artery, the latter being the continuation of the subclavian artery. In order to offer a short profile the neurovascular bundle "spread" from medial to lateral with the axillary vein the most medial structure, followed by the axillary artery in the center and the divisions of the plexus most lateral, as shown in figure 6-3 and 6-4.

Fig 6-3. Neurovascular bundle under the clavicle, left side. The soft tissue and fascias have been removed for clarity. The neurovascular bundle crosses under the clavicle with the vein most medial, the axillary artery in the center and then the divisions most laterally. (Dissection by Dr. Franco. Copyrighted image).

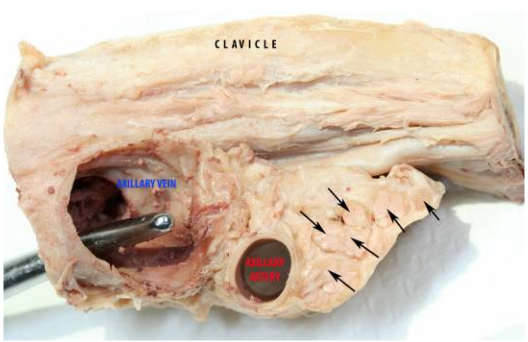

Fig 6-4. Neurovascular bundle under the clavicle in cross section, left side. The alignment of the neurovascular bundle under the clavicle is shown in cross section with some of the connective tissue intact. The arrows point to the 6 divisions located lateral to the axillary artery. (Dissection by Dr. Franco. Copyrighted image).

It is important to realize that immediately below the clavicle and before arriving at the coracoid process, the six divisions of the plexus and the origin of the three cords are located lateral to the artery and not around it (see figures 6-3 and 6-4). This is an important anatomical detail while considering different infraclavicular approaches.

As the cords approach the level of the coracoid process the lateral cord remains on the lateral side while the posterior and medial cords migrate behind the artery adopting all of them the characteristic position around it from which they take their name. At this level the cords are covered superficially by pectoralis minor and pectoralis major muscles. It seems to me important to mention that the rotation of the cords behind the artery from their original lateral position is usually arrested before the medial cord reaches a true medial position with respect to the artery and before the posterior cord get to be truly posterior to it. So, a cross section of the neurovascular bundle at the level of the coracoid process reveals that the cords are not exactly located at the 3, 6 and 9 o'clock position Instead, on the right side, the lateral cord is usually in position 10 (anterolateral), the posterior cord is in position 7 (posterolateral) and the medial cord is in position 4 (posteromedial). On the left side, the lateral cord is in position 2 (anterolateral), the posterior cord in position 5 (posterolateral) and the medial cord in position 8 (posteromedial). This means that usually there are two cords on the lateral side of the artery (lateral and posterior cords) and only one on its medial side (medial cord), making the approach from the lateral side more rational, especially during blind techniques.

At about the level of the lateral border of the pectoralis minor muscle the three cords give off their terminal branches. The posterior cord originates the axillary and radial nerves; the medial cord originates part of the median nerve, plus the ulnar, medial brachial and medial antebrachial cutaneous nerves. The lateral cord originates the rest of median nerve and musculocutaneous nerve. Sometimes the musculocutaneous nerve remains attached to the median nerve until reaching the proximal arm.

Brachial plexus sheath

For some authors the uneven spread of local anesthetic frequently observed after a single injection in the axilla is enough evidence that the brachial plexus sheath does not exist. This is not necessarily so. On the one hand, it is clear both in the surgical suite and the anatomy laboratory, that connective tissue is ubiquitous around neurovascular structures in the body, especially in more exposed areas like the axilla, the neck, the groin, etc. It is clear that nerves and vessels are immersed in a connective tissue matrix and are not simply "cables" lying between two muscular planes. Our own published cadaver studies have provided macroscopic photographic evidence of its existence. Part of that is shown in figures 6-5 A, B and C.

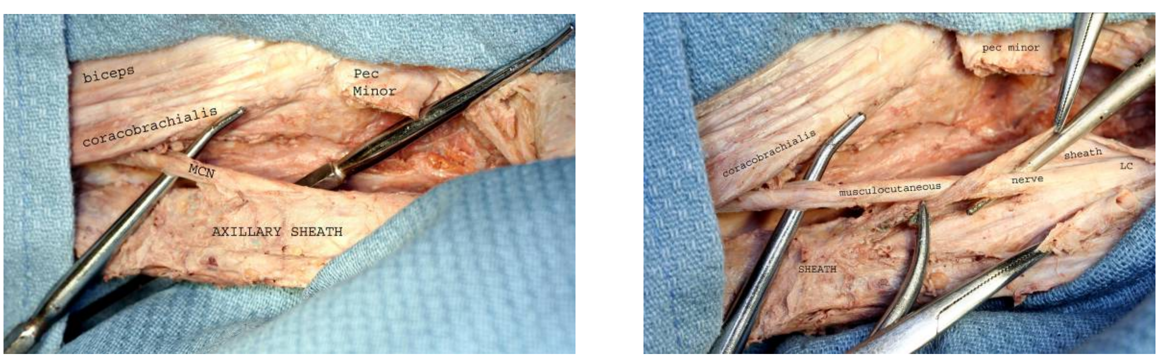

Fig 6-5 A and B. Axillary sheath. Left axillary region dissection showing A: the axillary sheath intact from which the musculocutaneous nerve (MCN) is seen exiting. B: shows the same specimen after the sheath has been open. The intra sheath portion of the MCN can be seen taking off from the lateral cord (LC). Cadaver dissection by Dr Franco. Images are copyrighted.

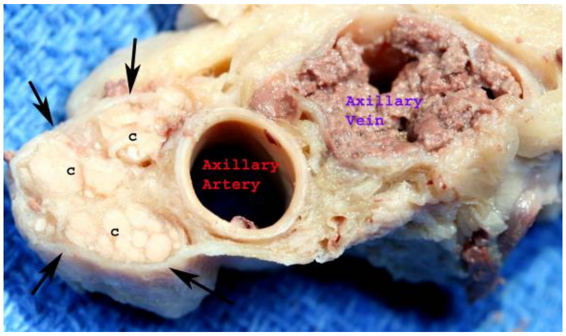

Fig 6-5 C. Axillary sheath in cross section. The axillary sheath just below the clavicle (apex) is shown with arrows as a well defined sturdy fascia surrounding the neurovascular bundle. The interior is otherwise filled with loose connective tissue. The three cords of the plexus (c) are shown lateral to the artery. Cadaver dissection by Dr Franco. Image is copyrighted.

Ultrasound, on the other hand, has confirmed that nerves and vessels in all regions of the body, but especially in exposed places like the axilla, are embedded in a matrix of soft connective tissue contained within a fascial sheath. This loose connective tissue within the sheath absorbs the local anesthetic solution like a sponge, limiting to some degree its free diffusion. In addition to this internal (within the sheath) factor, there are other factors outside the sheath that may also play a role on the spread of local anesthesia within it. An example is the pulsatile effect of the subclavian artery affecting the spread to C8-T1 levels in interscalene and supraclavicular blocks.

Distribution of the branches of the brachial plexus

Axillary nerve (C5-C6): gives an articular branch to the shoulder joint, motor innervation to the deltoid and teres minor muscles and sensory innervation to part of deltoid and scapular regions.
Radial nerve (C5-C6-C7-C8): supplies the skin of the posterior and lateral arm down to the elbow, the posterior forearm down to the wrist, lateral part of the dorsum of the hand and the dorsal surface of the first three and one-half fingers proximal to the nail beds. It also provides motor innervation to the triceps, anconeus, part of the brachialis, brachioradialis, extensor carpi radialis and all the extensor muscles of the posterior compartment of the forearm. Its injury produces a characteristic "wrist drop".
Median nerve (C5-C6-C7-C8-T1): gives off no cutaneous or motor branches in the axilla or the arm. In the forearm it provides motor innervation to the anterior compartment except the flexor carpi ulnaris and the medial half of the flexor digitorum profundus (ulnar nerve). In the hand provides motor innervation to the thenar eminence and the first two lumbricals. It provides the sensory innervation of the lateral half of the palm of the hand and dorsum of first three and one-half fingers including the nail beds.
Ulnar nerve (C8-T1): like the median nerve, the ulnar nerve does not give off branches in the axilla or the arm. Its motor component supplies the flexor carpi ulnaris and the medial half of the flexor digitorum profundus. In the hand it provides the motor supply to all the small muscles of the hand except the thenar eminence and first two lumbricals (median). Its sensory branches supply the medial third of the dorsum and palmar sides of the hand and dorsum of the 5th finger and dorsum of the medial side of 4th finger.
Medial brachial cutaneous nerve (T1): it is solely a sensory nerve. It supplies the skin of the medial side of the arm. It is joined here by the intercostobrachial nerve, branch of the second intercostal.

Medial antebrachial cutaneous nerve (C8-T1): It is also a sensory nerve. It supplies the medial side of the anterior forearm.
Musculocutaneous nerve (C5-C6-C7): gives motor innervation to the choracobrachialis, biceps and brachialis muscles. At the elbow it becomes purely sensory innervating the lateral anterior aspect of the forearm to the wrist.

Pearls

- With the shoulder down the three trunks of the brachial plexus and the origin of the divisions are located above the clavicle, therefore during a supraclavicular block the needle does not need to reach below the clavicle.
- During procedures using a needle in the supraclavicular area, the needle should never cross medial to the parasagittal plane dictated by the insertion of the anterior scalene muscle on the first rib, because of risk of pneumothorax.
- The pulsatile effect of the subclavian artery exerted mainly against C8-T1 roots and the lower trunk explains why the C8-T1 dermatome can be spared during interscalene and supraclavicular blocks. To avoid this problem during a supraclavicular block the injection needs to be performed in the vicinity of the lower trunk or its divisions, evidenced by fingers twitch with a nerve stimulator or by injecting between the subclavian artery and the first rib when using ultrasound. In the case of interscalene block this is usually not a problem since its main indication is anesthesia/analgesia of the shoulder that does not require anesthesia of C8-T1 dermatomes.
- The SCM muscle inserts on the medial third of the clavicle, the trapezius muscle on the lateral third of it, leaving the middle third for the neurovascular bundle. These proportions are maintained regardless of patient's size. Bigger muscle bulk through exercise does not influence the size of the muscle insertion area.

INTERSCALENE BLOCK
NERVE STIMULATOR TECHNIQUE

Indications

Its main indication is anesthesia or analgesia of the shoulder, including the clavicle and proximal part of the humerus.

Point of contact of the needle with the brachial plexus

The needle approaches the plexus at the level of the roots, high in the interscalene space, approximately at the level of C5-C6 roots (most likely C5).

Main characteristics

This block is superficial and usually easy to perform. Characteristically it misses the C8-T1 dermatomes, which include the sensory territories of ulnar, medial antebrachial cutaneous, and medial brachial cutaneous nerves (medial side of the upper extremity).

Patient position and landmarks

The patient is lightly sedated. Older, obese and recent trauma patients can be expected to be extremely sensitive to the depressant effects of benzodiazepines and/or narcotics. Titrate to effect.

The patient is placed in a semi sitting position and the space between the cricoid and thyroid cartilages (cricothyroid membrane) is located and marked as shown in figure 6-6. The patient is asked to lower his shoulders and to slightly rotate the head to the opposite side. It is important to emphasize here that the patient should rotate and not incline the head away so as to keep the midline neutral. With the midline in neutral position the intervertebral foramen looks caudal, lateral and slightly posterior. Tilting the head away from the operator, on the other hand, could align the intervertebral foramen with the needle trajectory.

Fig 6-6. Cricoid thyroid membrane. The level of the cricothyroid membrane is located by palpation and marked on the skin.
(On a model with permission).

A horizontal plane that starts at the cricothyroid membrane medially and intercepts the posterior border of the SCM laterally is established, as shown in figure 6-7.

Fig 6-7. Cricoid-SCM plane. The level of the cricothyroid membrane is projected laterally to intercept the posterior border of the SCM.
(On a model with permission).

The index and middle fingers of the palpating hand are placed behind the SCM at this level pushing it slightly forward (medially), as shown in figure 6-8. This maneuver brings the palpating fingers under the SCM and on top (anterior) to the anterior scalene muscle. The fingers are then rolled back until they fall into the interscalene groove, which at this proximal point in the neck is a real structure and easy to identify. This is the point of needle insertion.

Fig 6-8. Point of needle insertion. The interscalene groove is found at the intersection of the cricoid plane with the posterior border of the SCM.
(On a model with permission).

Type of needle

A 2.5 cm or 5cm, 22-G, insulated needle can be used.

Nerve stimulator settings

The nerve stimulator is set to deliver a current of 0.8-0.9 mA, at a pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec). A small skin wheal is raised with 1% lidocaine or 1% mepivacaine using a small needle (ideally 27-G).

Needle insertion

The needle is introduced between the two palpating fingers in a medial and slightly caudal direction, but most importantly with a 20 to 30-degree posterior direction, as shown in figure 6-9.

Fig 6-9. Needle insertion. The needle is advanced medial, caudal and posterior.
(On a model with permission).

It is important to realize that this is a superficial block that should take place within the confines of the tips of the palpating fingers and not beyond them. In no circumstance the needle should be introduced further than the projection of the clavicular head of the SCM.

Any distal motor twitch as well as biceps, triceps or deltoid muscles are adequate. There is some controversy in the literature as to whether a shoulder twitch is acceptable for an interscalene block. Besides the usual arm twitches, anatomical and clinical evidence support accepting deltoid twitches. Motor twitches from trapezius (spinal accessory nerve) and levator scapulae (dorsal scapular nerve) are not acceptable. For further reading on this issue please see: Silverstein W et al. Interscalene block with a nerve stimulator: A deltoid motor response is a satisfactory endpoint for successful block. Reg Anesth Pain Med 2000; 25:356-359 and accompanying editorial by William Urmey, same journal page 340-342.

A twitch of the abdomen signals phrenic nerve stimulation and it is evidence that the needle is anterior to the anterior scalene. In this case the needle should be withdrawn and redirected slightly posteriorly. A motor twitch of the scapulae or trapezius muscle indicates that the position of the needle is too posterior and needs to be repositioned anteriorly.

Local anesthetic and volume

For single shot techniques in adults, 30 mL of 1.5% mepivacaine plain provides 2-3 h of anesthesia. The addition of 1:400,000 of epinephrine prolongs the anesthesia to about 3-4 h. The residual analgesia post anesthesia is variable in duration, although rarely persists for more than 2 h after block resolution. The addition of lyophilized tetracaine (20 mg per 10 mL of solution) to 1.5% mepivacaine, for a final concentration of 0.2% tetracaine, provides around 6 h of surgical anesthesia.

Ropivacaine or bupivacaine 0.5% plus epinephrine 1:400,000 can be used in the same volume to provide 12 h plus of anesthesia. For more rapid onset and long duration we use 10 mL of 1.5% mepivacaine followed by 20 mL of 0.5% ropivacaine or bupivacaine plus 1:400,000 epinephrine.

For postoperative analgesia 20 mL of 0.2% ropivacaine can be used.

Side effects and complications

Systemic local anesthetic reaction can occur as with any block. More specific (and frequent) side effects related to interscalene block are: **Horner's syndrome** (ptosis, miosis and anhydrosis) due to stellate ganglion block and **hoarseness** due to recurrent laryngeal nerve involvement. Characteristically this block produces also 100% of phrenic nerve block with diaphragmatic paralysis (Urmey et al, Anesth Analg, 1991). This can produce dyspnea and reductions in respiratory volumes of up to 30%. Pneumothorax is possible, but rare with this block.

Clinical pearls

- Because of the position of the shoulder, so close to the head of the patient, the anesthesiologist must carefully evaluate the patient and surgeon before deciding to perform an interscalene block as the only anesthesia for the case. A nervous patient and a rough surgeon could be indications for interscalene analgesia combined with general anesthesia.
- It must be remembered that some of these procedures are performed in positions other than supine (e.g., beach chair, lateral), which can make the management of the airway, if needed, a bit more challenging.
- A language barrier between patient and anesthesiologist is also a relative contraindication for interscalene block as the sole anesthetic.
- This is a very superficial block that can be performed at 1-2 cm from the skin in most patients.

INTERSCALENE BLOCK
ULTRASOUND TECHNIQUE

Indications

Shoulder anesthesia and/or analgesia, including clavicle and proximal humerus.

Patient position

The patient is placed semi seated, with the shoulder down and the head slightly turned the opposite way, as shown in figure 6-10.

Fig 6-10. Position. The patient is semi seated, with shoulder down and head slightly rotated to the opposite side. The ultrasound machine is placed on the opposite side.
(On a model with permission).

Type of needle

A 2.5 cm or 5 cm, 22-G, insulated needle is what we frequently use.

Type of transducer

This is a superficial block for which a high frequency (8-15 MHz) linear probe is well suited.

Scanning

Two are the most frequent ways to scan the neck to visualize the roots of the plexus. One is to start a transverse scan over the sternocleidomastoid muscle (SCM) just lateral to the cricoid cartilage, or start more distally parallel to the clavicle and then trace the plexus proximally to the roots. In either case the probe ends in a semi transverse position (cephalad rotation) overlapping the SCM with a slight distal orientation as shown in figure 6-11.

Fig 6-11. Probe position. To get a good perpendicular cut of the roots, the probe is slightly rotated as shown. (On a model with permission)

The image obtained at this level is shown in figure 6-12.

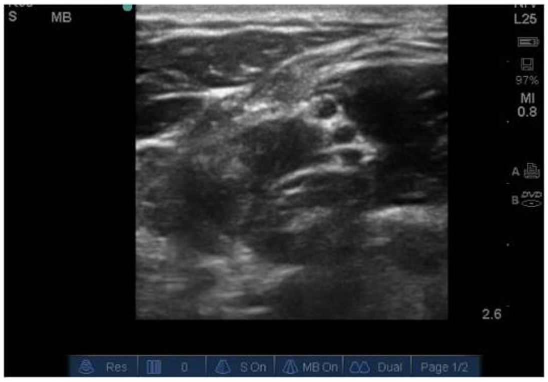

Fig 6-12. Interscalene image. With the probe in the position shown in fig 6-11 it is possible to visualize part of the SCM, ant and middle scalene muscles and the proximal roots of the plexus. (Author's archive)

Needle insertion

The needle can be advanced in plane from medial to lateral, or lateral to medial, or out of plane usually from cephalad to caudal. It is our preference to insert the needle in plane from lateral to medial as shown in figures 6-13 and 6-14.

Fig 6-13. Needle insertion. The needle is introduced in plane from lateral to medial. (On a model with permission)

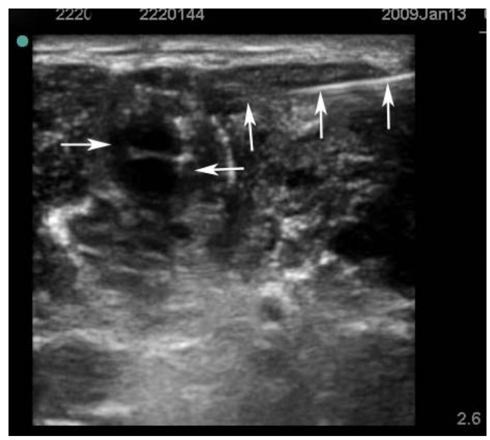

Fig 6-14. US image. Vertical arrows show the needle while the two horizontal arrows show part of the hypoechoic spread of local anesthetic around the plexus roots. (Author's archive)

This technique resembles Winnie's classical interscalene approach. With the needle under direct visualization the injection is performed in the proximity of C6 root. The spread of local anesthetic should expand the interscalene space and bathe C5-C6 and C7 roots, as shown in figure 6-14. If the spread is insufficient around a particular root the needle is repositioned accordingly for a new injection.

Local anesthetic and volume

We use between 20-30 mL of local anesthetic of the same kind used for nerve stimulation techniques.

Side effects and complications

The side effects and complications are essentially the same described for nerve stimulation techniques. It is possible that ultrasound techniques, with a more targeted injection and potentially smaller volumes, may theoretically decrease the incidence of side effects, but this remains to be proven.

SUPRACLAVICULAR BLOCK
NERVE STIMULATOR TECHNIQUE

Indications

This block is indicated for any surgery on the upper extremity distal to the shoulder or for analgesia of the entire upper extremity.

Point of contact of the needle with the brachial plexus

The needle approaches the plexus at the level of the trunks, and ideally the injection should take place in the vicinity of the lower trunk.

Main characteristics

This block is considered by some as more difficult to learn than other upper extremity blocks and historically it has been associated with a higher risk of pneumothorax. The literature cites pneumothorax rates between 0.5-6.1 percent. However with good anatomy and meticulous technique we have been able to practically eliminate this risk.

A supraclavicular block is usually associated with a short onset, dense anesthesia and high success rate. As we discussed it in the anatomy section, this is due to the compact arrangement of the plexus at the level of trunks and divisions. Because of these favorable characteristics, the supraclavicular block has been called the "spinal of the upper extremity".

We perform our own variation of the supraclavicular block, a very anatomical approach that starts by determining the pleura boundaries as the first step. This allows us to take advantage of such extraordinary block while limiting its potential drawbacks. Our experience to late 2009 includes more than 5,000 supraclavicular blocks without ever having demonstrated a single pneumothorax. A common question posed to us is whether we perform routine chest X-rays after a supraclavicular block. The answer is no. In fact we only do an X-ray when the clinical situation merits it (e.g., an unusually difficult technique and or symptomatic patient). Traditionally our anesthesiology textbooks have left the impression that a pneumothorax following a supraclavicular block has a late onset, making the technique a bad choice for outpatients. Our review of the literature fails to demonstrate this. In fact most of the cases of pneumothorax associated with supraclavicular block published in the literature, have been diagnosed within a few hours after the block and most of them have been investigated because of the patients' early symptoms. We perform this technique with great success in all kinds of patients, including same day surgery and trauma patients.

Some history of the supraclavicular approach

The supraclavicular block was introduced into clinical practice in Germany by Kulenkampff in 1911. A publication of his technique appeared later in the English literature in 1928. Kulenkampff accurately described the plexus as being more compacted in the neighborhood of the subclavian artery, where he rightly believed that a single injection could provide adequate anesthesia of the entire upper extremity. Kulenkampff's technique was simple and in many ways sound. Unfortunately his recommendation to introduce the needle toward the first rib, in the direction of the spinous process of T2 or T3, carried an inherited risk for pneumothorax that would be responsible for the technique falling into disfavor.

Albeit with several modifications, the supraclavicular approach remained a popular choice until the early 1960's. Eventually, the combined effect of pneumothorax fear and the introduction of the axillary approach by Accardo and Adriani in 1949, and especially by Burnham in 1958, marked the beginning of the decline for one of the best approaches in regional anesthesia.

The axillary approach introduced a good technique with its share of shortcomings (e.g., smaller area of anesthesia than supraclavicular, tendency to produce "patchy" blocks and lower overall success rate), but definitely devoid of pneumothorax risk. The axillary block received a big push when in 1961 De Jong published an article in Anesthesiology praising it. His paper was based on cadaver dissections and included the now famous calculation of 42 mL as the volume needed to fill a cylinder 6 cm long that, according to De Jong, "should be sufficient to completely bathe all branches of the brachial plexus". Coincidentally (or not) the same journal issue carried a paper by Brand and Papper out of New York, comparing axillary and supraclavicular techniques in their hands. This article is the source of the 6.1% pneumothorax rate frequently quoted for supraclavicular block. The authors were determined to prove that the axillary block was safer and better than the supraclavicular block. They succeeded by not only producing the highest percentage of pneumothorax (6.1%), but the highest number (14 cases) for an individual study. This study should be considered an aberration.

In retrospect these two articles could be considered the turning point at which the axillary route became the preferred approach here in the United States and the rest of the world. With some exceptions this is still true to day. Fortunately ultrasound in regional anesthesia has caused a renewed interest in this approach and we could not be happier.

The supraclavicular technique with its rapid onset, density, high success rate along with large area of anesthesia are highly desirable. These good characteristics are, according to David Brown and colleagues, "unrivaled" by other techniques. In our practice the supraclavicular approach is the cornerstone of upper extremity regional anesthesia.

Patient position and landmarks

The patient lies in the semi sitting position, the ipsilateral shoulder down and the head turned to the opposite side, as shown in figure 6-15. The arm to be blocked is flexed at the elbow and, if possible, the wrist is supinated to easily detect a twitch of the fingers.

Fig 6-15. Patient position. The patient is semi seated with the head of the bed elevated 30 degrees. The head of the patient is turned away, the shoulder is down and the arm is flexed at the elbow and supinated at the wrist. (On a model with permission).

The point at which the clavicular head of the SCM muscle inserts in the clavicle is then identified, as shown in fig 6-16. A parasagittal (parallel to the midline) plane at this level determines an "unsafe" zone medial to it, where the risk of pneumothorax is high and a lateral zone that is safer.

Fig 6-16. Lateral head of SCM. The most lateral insertion of the SCM on the clavicle is found and marked with an arrow. Crossing this plane medially increases the risk of pneumothorax. (On a model with permission).

Because the trunks are short and run in a very steep direction caudally towards the clavicle, there is a narrow "window of opportunity" to perform the block above the clavicle. It must be performed at enough distance from the insertion of the SCM on the clavicle to be safely away from the pleural dome, but not too far to miss the trunks and the plexus completely. We call this distance "the safety margin". In adults we calculate this distance to be about 1 inch (2.5 cm), which corresponds to the width of the author's thumb. This distance is marked on the skin over the clavicle for orientation, as shown in figure 6-17.

Fig 6-17. Safety margin. A safety margin of 1" (2.5 cm) lateral to the insertion of the SCM on the clavicle is marked on the skin. (On a model with permission).

This is only an **orientation** point that **usually** will coincide with the midpoint of the clavicle in an adult patient. At this level the brachial plexus is usually easily palpable, either as a groove or as some type of bump(s). This is usually called "interscalene groove", but the interscalene groove only exists high in the C5-C6 level. The groove is lost more distally as the scalene muscles diverge from each other in the frontal and sagittal planes. <u>The palpation of the plexus</u> is what determines the actual point of needle entrance **and not a fixed distance**. The plexus can be palpated a few mm medial or lateral to the orientation point, but never too far from it.

The palpating finger is placed parallel to the clavicle and the point of needle entrance is located immediately cephalad to it, as shown in figure 6-18.

Fig 6-18. Orientation arrows. The medial arrow pointing up shows the lateral insertion of SCM (pleura's lateral boundary). The lateral arrow pointing caudally shows the needle entrance point. The two lateral arrows pointing at each other show the needle trajectory (parallel to the patient's midline). (On a model with permission).

Type of needle

A 5cm, 22-G, insulated needle is used for this technique.

Nerve stimulator settings

The nerve stimulator is set to deliver a current of 0.8-0.9 mA, at a pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec). A small skin wheal is raised with 1% lidocaine or 1% mepivacaine using a small needle (ideally 27-G).

Needle insertion

The needle is inserted first anteroposterior (toward the bed) with a 30 degree caudal orientation, as shown in figure 6-19, for a distance of a few mm and up to 1.5 cm, depending on the amount of subcutaneous tissue. After a short distance, a twitch of the upper trunk (shoulder) is usually found as evidence that the needle is approaching the frontal plane of the plexus.

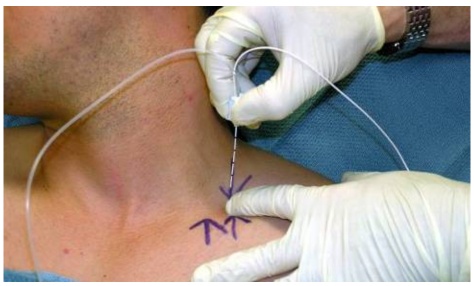

Fig 6-19. Needle insertion. The needle is first introduced in a posterior direction (toward the bed) with a 30 degree caudal orientation. (On a model with permission).

The direction of the needle is then changed from anteroposterior to caudal, advancing it parallel to the midline (and parallel to the most lateral pleural boundary), with a slight (10 degrees) posterior orientation, as shown in figure 6-20.

Fig 6-20. Direction of the needle. The needle is then advanced caudad, parallel to the midline, with a slight posterior orientation. (On a model with permission).

The reference to the midline is easy to ascertain and avoids confusion. The use of other landmarks (e.g., nipple) provides lesser accuracy because of variability among patients.

The needle is advanced caudally with a slight posterior angle to match the slight posterior rotation of the plexus (the upper trunk is the most anterior and the inferior trunk the most posterior). Because the trunks are physically contiguous, as the needle is advanced, a twitch of the upper trunk (shoulder) should be followed by one from the middle trunk (pectoralis, triceps, supination, pronation) and finally a twitch from the lower trunk (wrist and fingers). The goal of the technique is to produce an isolated muscle twitch of the fingers. Wrist flexion and extension are also acceptable responses, but supination or pronation or any other more proximal motor twitches are not.

If after advancing the needle the motor twitch of the shoulder disappears and no twitch is elicited from the middle trunk, it usually means that the angle of insertion of the needle is not matching the orientation of the trunks, and that the tip of the needle is wandering away from the trunks (usually anteriorly). The needle should be slowly withdrawn until the original twitch is elicited once again, and then redirected either posteriorly (most of the times) or anteriorly, but always parallel to the midline.

It is very important not to advance the needle more than 2 cm in the caudal direction if no twitch is visible. In this case the situation should be reassessed starting with the nerve stimulator and its connections and determination of landmarks. On the other hand, when a twitch from the brachial plexus is being elicited the depth of needle insertion is less important as such motor twitch reveals that the needle is still in close proximity to the plexus.

Local anesthetic and volume

For single shot techniques in adults, 30 mL of 1.5% mepivacaine plain provides 2-3 h of anesthesia. The addition of 1:400,000 of epinephrine prolongs the anesthesia to about 3-4 h. The residual analgesia post anesthesia is variable in duration, although rarely persists for more than 2 h after block resolution. The addition of lyophilized tetracaine (20 mg per 10 mL of solution) to 1.5% mepivacaine, for a final concentration of 0.2% tetracaine, provides around 6 h of surgical anesthesia.

Ropivacaine or bupivacaine 0.5% plus epinephrine 1:400,000 can be used in the same volume to provide 12 h plus of anesthesia. For more rapid onset and long duration we use 10 mL of 1.5% mepivacaine followed by 20 mL of 0.5% ropivacaine or bupivacaine plus 1:400,000 epinephrine.

For postoperative analgesia 20 mL of 0.2% ropivacaine can be used.

Side effects and complications

Besides the common complications accompanying any block, the supraclavicular technique can also be followed by Horner's syndrome, hoarseness and phrenic nerve palsy, but less frequently than after interscalene block. Neal et al in 1998 studied diaphragmatic paralysis in 8 volunteers after supraclavicular block using ultrasound (replicating what Urmey et al did in 1991 to demonstrate 100% of diaphragmatic paralysis after interscalene block). They found an incidence of 50% of diaphragmatic paralysis. No subject experienced changes in pulmonary function tests (PFTs) or subjective symptoms of respiratory difficulty. This is our experience too.

In the issue of pneumothorax, I already mentioned that the literature cites a risk of 0.5% to 6.1%, the latter being an aberration. A careful and meticulous technique should carry a minimal risk of pneumothorax. In our long experience including thousands of cases in all sorts of patients we have never demonstrated a case of pneumothorax.

Clinical pearls

- This is not a block for a practitioner that rarely performs peripheral nerve blocks. The person interested in learning to perform it should first become familiar with the anatomy of the supraclavicular area including the location of the dome of the pleura. Using ultrasound makes the visualization of the pleura easier, but still requires the operator to be familiar with the anatomy of the area.

- When using a nerve stimulator technique, the block should not be attempted unless the insertion of the sternocleidomastoid in the clavicle is clearly established. In fact this is a must especially for a person not experienced with the technique. With time it becomes easier to ascertain the boundaries of the SCM.
- It helps to know that the neurovascular bundle crosses the clavicle under the midpoint of it, so this should be kept in mind as a reliable reference.
- Due to the steep direction of the plexus from the neck to the axilla, the higher in the neck (the further away from the clavicle) the more medial the plexus is. By the same token, the further below the clavicle the more lateral to its midpoint the plexus is.
- The needle should never be inserted more than 2 cm caudal if no twitch is elicited. This warning applies to every patient regardless of weight.
- The injection should always be slow, alternated with frequent and gentle aspirations. This technique provides time to recognize accidental intravascular injection in those cases where blood is not aspirated. I also believe it helps to keep the needle from moving backwards as a result of high speed flow at the tip of the needle.

SUPRACLAVICULAR BLOCK

ULTRASOUND TECHNIQUE

Indications

Anesthesia and/or analgesia for any procedure on the uppe r extremity distal to the shoulder.

Patient position

The patient is placed in the semi seated position as shown in figure 6-21.

Fig 6-21. Position. The patient is placed semi seated with the shoulder down and the head turned the opposite way. (On a m odel with permission).

Type of needle

A 5cm, 22-G, insulated needle is used.

Type of transducer

This is also a superficial block for which a high frequency (8-15 MHz) is used.

Scanning

We usually start scanning medially, over the sternocleidomastoid muscle, right above the clavicle, as shown in figure 6-22.

Fig 6-22. Probe position, first stage. The probe is place over t he SCM and above and parallel to the clavicle. (On a model with permission).

At this level we get to see the dome of the pleura and above it, the subclavian vein at that point where it is joining the internal jugular vein to form the brachiocephalic vein, as shown in figure 6-23.

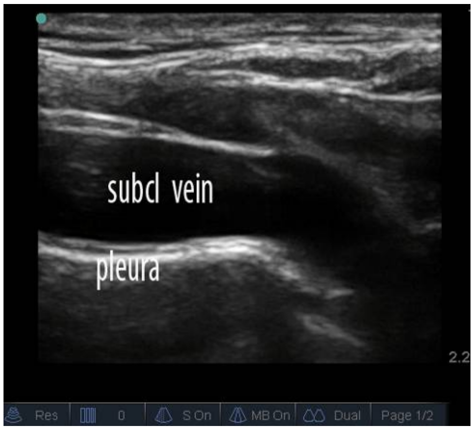

Fig 6-23. Scanning, first image. With the probe over the SCM the subclavian vein and pleural dome can be visualized. (Author's archive).

The probe is then slid laterally towards the midpoint of the clavicle, as shown in figure 6-24,

Fig 6-24. Probe position, second stage. The probe is moved laterally to visualize the plexus as it passes over the 1st rib. (On a model with permission).

At this level a cross section of the subclavian artery, the first rib and plexus can be visualized, as shown in figure 6-25.

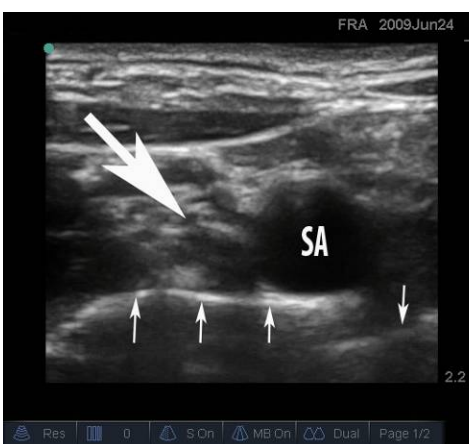

Fig 6-25. Scanning the plexus above the clavicle. The subclavian artery (SA) is seen above the first rib, which is shown with three arrows pointing up. A small arrow pointing down shows the pleura while the larger single arrow shows the position of the divisions of the plexus. (Author's archive).

Needle insertion

The needle is advanced in plane, from lateral to medial, as shown in figure 6-26. The entrance point is located at about 1 cm away from the probe to decrease the angle of insertion and improve needle visualization.

Fig 6-26. Needle insertion. The needle is advanced in plane, from lateral to medial. (On a model with permission).

The needle is then slowly advanced under direct visualization, towards the angle formed by the first rib and the subclavian artery, as shown in figures 6-27 A and B.

Fig 6-27, A and B. Needle insertion. The needle is slowly brought behind the subclavian artery (AA) and above the first rib. (Author's archive).

Intermittent injections of small amounts of local anesthetic solution confirm the location of the tip of the needle as it is being advanced. The injected volume also gently expands the connective tissue surrounding the nerves, producing what has been called "hydro dissection". This contributes to "clear a path" for the needle decreasing the chances of inadvertent neural puncture.

The goal of the supraclavicular technique is to see the spread of local anesthetic reaching the angle between the first rib and the subclavian artery, as shown in figure 6-28.

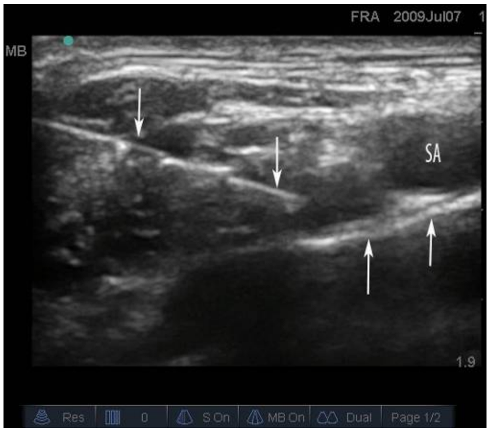

Fig 6-28. Injection. The local anesthetic spread should be seen reaching the angle formed by the 1st rib (vertical arrows pointing up) and the subclavian artery (SA). The local anesthetic is seen as a hypoechoic (dark) shadow projecting from the tip of the needle. (Author's archive).

Local anesthetic and volume

For single shot techniques in adults, 30 mL of 1.5% mepivacaine plain will provide 2-3 h of anesthesia. The addition of 1:400,000 epinephrine prolongs the anesthesia to about 3-4 h. The residual analgesia post anesthesia is variable in duration, although it rarely persists for more than 2 h after block resolution. The addition of 2 mg/mL of lyophilized tetracaine to 1.5% mepivacaine, for a final concentration of 0.2% tetracaine, prolongs the duration of surgical anesthesia to 4-6 hours.

For longer anesthesia/analgesia 30 mL of 0.5% ropivacaine or bupivacaine can provide more than 12 h of anesthesia, although the onset is delayed to 20-30 min. If a more rapid onset is needed we use 5-10 mL of 1.5% mepivacaine followed by 20 ml of 0.5% ropivacaine or bupivacaine. We always add epinephrine 1:400,000 as intravascular marker.

Also 20-30 mL of 0.2% ropivacaine can be used to provide postoperative analgesia for surgery performed under general anesthesia.

INFRACLAVICULAR BLOCK
NERVE STIMULATOR TECHNIQUE

Indications

This block can provide anesthesia/analgesia of a large area of the upper extremity including the elbow, especially if performed proximally near the apex of the axilla. It is considered a good approach for continuous techniques because it offers more stability than other more mobile locations.

Point of contact of the needle with the brachial plexus

The needle approaches the plexus at the level of the cords, or even divisions if the block is performed proximally, closed to the clavicle.

Main characteristics

The infraclavicular block could be considered an axillary block in which the needle enters the axilla through its anterior wall (pectoralis muscles), instead of through its base. The infraclavicular space of the anesthesiologists corresponds to part of the axillary pyramid of the anatomists. With the arm in adduction it is represented on the skin by a triangular area whose base is superior (clavicle), a medial wall formed by the projection on the skin of the thoracic cage and a lateral wall formed by the medial side of the upper arm. Depending on the patient's amount of subcutaneous tissue and/or muscle this block can be deep. Patients should be adequately sedated.

It is widely recommended when using a nerve stimulator to obtain a distal twitch in the hand or wrist and to avoid either a biceps twitch (musculocutaneous nerve or lateral cord) or pronation of the forearm (lateral cord). This recommendation is based on clinical experience. A biceps twitch could be the result of musculocutaneous nerve stimulation, outside the sheath, or from lateral cord stimulation inside the sheath. Because the operator can not accurately distinguish one from the other, this response is unreliable.

It is likely that a twitch from the posterior cord (elbow, wrist and or finger extension) could be best, because the posterior cord is located at about the same distance from the other two, and the spread of local anesthetic from this central location might be more even. There could be another good reason to inject behind the artery, although it may be more difficult to get there. Because the posterior structures (including the posterior cord) are more closely packed, the spread of local anesthetic from anterior to posterior may be more difficult than from posterior to anterior. Ultrasound, with visualization of the axillary artery and the cords around it, makes this injection easier to accomplish.

Different infraclavicular techniques have been described. A simple technique is the coracoid approach first described by Whiffler in the British Journal of Anaesthesia in 1981 and later redefined by MRI studies performed in 40 volunteers by Wilson, Brown et al, and published in Regional Anesthesia in 1998. This is the technique we most frequently perform when using nerve stimulation.

Patient position and landmarks

The patient is placed semi seated with the ipsilateral shoulder down. The arm is slightly abducted 30-45 degrees, as shown in figure 6-29, to bring the neurovascular bundle away from the thoracic cage and decrease the chance of pneumothorax.

Fig 6-29. Patient position. The patient lays semi seated with shoulders down and the arm to be blocked in slight abduction. (On a model with permission).

As the neurovascular bundle follows the arm its relationship to the coracoid process is pretty much maintained. The coracoid process is found by palpation at the level of the deltopectoral groove (junction between the middle third with the lateral third of the clavicle), about 2 cm below the clavicle, and marked on the skin, as shown in figures 6-30 and 6-31.

Fig 6-30. Coracoid palpation. The coracoid is found below the clavicle in the deltopectoral groove. (On a model with permission).

Fig 6-31. Coracoid marking. The position of the coracoid is marked on the skin. (On a model with permission).

Needle insertion point

The point of needle entrance is marked 2 cm caudal and 2 cm medial to the coracoid process as shown in fig 6-32.

Fig 6-32. Needle entrance point. Two cm caudal and two cm medial from the coracoid process. (On a model with permission).

Type of needle

It is possible to use sometimes a 5cm, 22-G insulated needle, but a 10cm, 21-G insulated needle is usually necessary.

Nerve stimulator settings

The nerve stimulator is set to deliver a current of 0.8-0.9 mA, pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec).

Needle insertion

The needle attached to the nerve stimulator is advanced in the anteroposterior direction, towards the bed, as shown in figure 6-33.

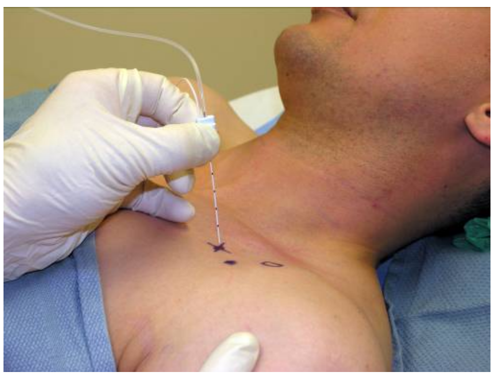

Fig 6-33. Needle insertion. The needle is introduced from anterior to posterior. (On a model with permission).

Before entering in contact with the plexus the needle passes through pectoralis major and pectoralis minor muscles producing a visible local twitch. The brachial plexus is found deep to them. If not response from the plexus is obtained, the needle is redirected caudal (most of the times) or cephalad, but maintaining the same parasagital plane without medial or lateral deviation.

Local anesthetic and volume

The nerve stimulator-guided infraclavicular technique usually requires a relatively high volume of local anesthetic for better results. Usually 40 mL of 1.5% mepivacaine plain will provide 2-3 h of anesthesia. The addition of 1:400,000 epinephrine prolongs the anesthesia to about 3-4 h. The residual analgesia post anesthesia is variable in duration, although it rarely persists for more than 2 h after block resolution. The addition of 2 mg/mL of lyophilized tetracaine to 1.5% mepivacaine, for a final concentration of 0.2% tetracaine, prolongs the duration of surgical anesthesia to 4-6 hours.

For longer anesthesia/analgesia 30 mL of 0.5% ropivacaine or bupivacaine can provide more than 12 h of anesthesia, although the onset is delayed to 20-30 min. If a more rapid onset is needed we use 5-10 mL of 1.5% mepivacaine followed by 20 ml of 0.5% ropivacaine or bupivacaine. We always add epinephrine 1:400,000 as intravascular marker.

Ropivacaine 0.5% can be used in the same volume for more than 12 h of anesthesia. Also 20-30 mL of 0.2% ropivacaine can be used to provide postoperative analgesia for surgery performed under general anesthesia.

Side effects and complications

Muscle pain and hematomas, which can be large in size, can happen. Pneumothorax can occur due to injury of the pleura through an intercostal space.

Clinical pearls

- This is a good place to put a catheter because it is easier to fix it.
- Use adequate sedation, as this block is more uncomfortable for patients than other more superficial blocks.
- The junction between lateral and middle third of the clavicle can be used to locate the deltopectoral groove and the coracoid process.
- Placing the arm in slight abduction (30-40 degrees) brings the neurovascular bundle away from the thoracic cage (it follows the arm) and decreases the chance of pneumothorax.

INFRACLAVICULAR BLOCK

ULTRASOUND TECHNIQUE

Indications

The same indications mentioned for nerve stimulation techniques, basically anesthesia/analgesia of elbow, forearm wrist and hand.

Two main infraclavicular techniques

Ultrasound introduces a degree of flexibility to our techniques of regional anesthesia that we did not have before. It certainly gives the operator the chance to choose the best needle path based on the anatomy and the ultrasound image obtained, without necessarily having to conform strictly to any particular technique already described.

When using ultrasound in the infraclavicular area I distinguish two main approaches, a proximal one just under the clavicle and a more distal one at the level of the coracoid process. As I mentioned in the anatomy section, the brachial plexus crosses under the clavicle as divisions before forming three cords. The divisions and the proximal trajectory of the cords below the clavicle are located lateral to the axillary artery. When the cords approach the coracoid process they rotate and surround the artery to take the position from which they get their names.

Based on these two different dispositions of the plexus with respect to the axillary artery I will describe two techniques.

Patient position

We perform both techniques with the patient in the semi seated position with the shoulder on the side to be blocked down and the arm in abduction of about 45 degrees, as shown in figure 6-34. Abducting the arm improves the ultrasound image of the neurovascular bundle, perhaps by stretching it and bringing it closer to the anterior wall.

Fig 6-34. Patient position. The patient is semi seated, shoulder down, arm abducted. (On a model with permission).

Type of needle

A 5cm, 22-G, insulated needle can be used in some patients, but it is usually necessary to use a 10cm, 21-G, insulated needle due to the depth of the neurovascular bundle at this location. Because the needle crosses through muscle, good sedation is important as well as injection of local anesthetic in the intended needle path to keep the patient comfortable.

PROXIMAL INFRACLAVICULAR TECHNIQUE

Type of transducer

Depending on the thickness of the patient's chest wall the operator can use a linear high frequency (8-15 MHz) probe or a curved low frequency (3-7 MHz) one.

Scanning

For this more proximal approach we place the transducer parallel and immediately below to the midpoint of the clavicle, as shown in figure 6-35.

Fig 6-35. Proximal scanning, left side. The transducer is placed parallel to the midpoint of the clavicle and immediately below it. (On a model with permission).

The image obtained at this proximal level is a cross section of the neurovascular bundle as it aligns under the clavicle in a formation that has the axillary vein as the most medial structure, followed by the axillary artery in the center and the divisions of the plexus most laterally, as shown in figure 6-36.

Fig 6-36. Proximal scanning, left side. At this proximal level pectoralis major (Pec major) is the main muscle seen superficial to the neurovascular bundle. Pectoralis minor is located distally to this US section. Among the neurovascular bundle structures the axillary vein (AV) is the most medial, followed by the axillary artery (AA) and then the divisions of the plexus most laterally. (Author's archive).

Needle insertion

The needle can be advanced out of plane from caudal to cephalad, but we usually prefer an in plane technique from lateral to medial, as shown in figure 6-37.

Fig 6-37. Needle insertion, left side. The needle is introduced in plane from lateral to medial. (On a model with permission).

Figures 6-38 A, B and C, show a sequence of ultrasound images showing needle insertion and injection.

Figure 6-38; A, B and C. Needle insertion/injection, left side. A (left): the divisions of the plexus are shown surrounded by a fascial sheath lateral to the axillary artery (AA); B (center): the shadow of the needle path (pointed by arrows) is barely seen as the needle comes in at a 45 degree angle. The two smaller arrow heads point to the indentation of the fascia produced by the piercing needle; C: the spread of local anesthetic is seen as a hypoechoic shadow pointed by a large arrow and the resulting expanded sheath is shown with the smaller arrows. (Author's archive)

CORACOID INFRACLAVICULAR TECHNIQUE

This technique is performed around the coracoid, but as opposed to the nerve stimulation technique the level is not dictated by a fixed measurement with respect to the coracoid, but instead by an optimal ultrasound image of the axillary artery and the surrounding cords.

Type of transducer

A linear high frequency (8-15 MHz) or a curved low frequency (3-7 MHz) probe is used depending on the thickness of the patient's thoracic wall.

Scanning

For this more distal approach we place the transducer in an oblique fashion in the mid pectoral region, as shown in figure 6-39. This probe rotation is needed to get a better cross section of the neurovascular bundle, which is traveling diagonally in the infraclavicular region.

Fig 6-39. Coracoid level scanning, right side. The transducer is placed in an oblique fashion to get a perpendicular cut of the neurovascular bundle at the level of the coracoid process. (On a model with

The ultrasound image obtained at this level is shown in figure 6-40. At this level the cords of the plexus have already rotated behind the axillary artery and adopted their arrangement around it from which they take their names, medial, posterior and lateral.

Fig 6-40. Coracoid level scanning, right side. With the probe at the level of the coracoid process the neurovascular bundle appears under both pectoralis muscles. The axillary vein (V) is more medial, close to the chest wall, while the axillary artery (A) is more lateral, surrounded by the three cords, lateral (L), posterior (P) and medial (M). (Author's archive).

Needle insertion

As it is the case with the more proximal approach, the needle can be inserted out of plane, from caudal to cephalad, but we usually prefer to advance it in plane, from lateral to medial (superior to inferior), as shown in figure 6-41.

Fig 6-41. Needle insertion, right side. The needle is introduced in plane, from lateral (superior) to medial (inferior). (On a model with permission).

Clinical pearls

- The proximal infraclavicular approach is a block of the divisions of the plexus and as such it can resemble a supraclavicular block in onset and density of anesthesia.

AXILLARY BLOCK
NERVE STIMULATOR TECHNIQUE

Indications

It is best suited for anesthesia/analgesia of the upper extremity distal to the elbow.

Point of contact of the needle with the brachial plexus

The needle approaches the plexus at the level of its terminal branches.

Main characteristics

The axillary block is not properly a brachial plexus block, but rather a block of its terminal branches. The larger surface area that the branches as a whole occupy and the tendency for the local anesthetic to follow the paths of low resistance along individual nerves affect the circumferential spread of the local anesthetic within the sheath (please see discussion on axillary brachial plexus sheath in the anatomy section). A single injection technique is an option, but multiple injections have shown to increase the success rate at this level. If a single injection is to be attempted, the operator needs to specifically target the nerve feeding the surgical area. If the surgical area involves more than one terminal nerve, the single injection technique should be performed in the proximity of the radial nerve because, as mentioned in the anatomy discussion, the local anesthetic solution tends to spread inside the sheath more easily from back to front that vice versa. In addition, my observations in the anatomy lab show that better circumferential spread of local anesthetic may be obtained with a slight elevation of the elbow, because this maneuver releases some of the stretching of the neurovascular bundle.

Some authors advice to perform the block high in the axilla to improve its overall success. This can be uncomfortable to the patient and challenging to the anesthesiologist. The only perceived advantage would be to increase the chances of blocking the musculocutaneous nerve before it leaves the sheath, but since its take off is variable the operator could never be certain. I believe that a better strategy is to start the axillary block by first blocking the musculocutaneous nerve in the proximal arm and then complete the block according to what is needed.

Although some variability exists, usually the median nerve is superficial (anterior) to the axillary artery, following its same direction; the ulnar nerve (and medial brachial/antebrachial cutaneous nerves) are medial and somewhat posterior to the artery; the musculocutaneous nerve is lateral to the artery (and eventually under the biceps muscle); and the radial nerve is posterior to the artery.

I believe that in the 21st century, with the variety of tools at our disposal, there is no good reason to perform a trans axillary technique.

Patient position and landmarks

The patient is supine, the arm is abducted to about 80-90 degrees and the elbow is slightly elevated 20-30 degrees by using a small pillow or folded blanket.

The biceps muscle is identified by visualization and/or palpation. The coracobrachialis muscle is found immediately under it (posterior). While biceps is highly mobile the coracobrachialis is palpated as a thick poorly movable mass. The pulsation of the axillary artery is found immediately under the coracobrachialis. Sometimes it helps to displace the latter slightly anterior to feel the pulsation of the artery. Figure 6-42 shows the arm position in abduction with a small pillow under the elbow and the trajectory of the axillary artery marked in blue.

Fig 6-42. Patient position and axillary artery marking. The arm is abducted about 80° to 90°, the elbow is elevated slightly with a small p illow and the axillary artery is marked. (On a model with permission).

Type of needle

This is usually a superficial block, even in obese patients. A 5cm, 22-G, insulated needle usually suffices.

Single injection axillary block

As I mentioned before, evidence shows that success rate in the ax illary region increases with 2 and 3 injection techniques as opposed to a single injection. If a si ngle injection technique is employed the "epicenter" of the injection should occur at the nerve that is more relevant to the surgical site. If more than one nerve is involved in the innervation of the surgical site, the single injection technique should be pe rformed preferably in front of the radial nerve. The volume of local anesthetic needed for a single injection technique is 40 to 50 mL. If more than one injection is performed the volume should be divided accordi ngly. If only one nerve is needed 5 mL o f local anesthetic solution is enough for anesthesia. A so lution of 1.5% m epivacaine plus 1:400,000 epinephrine provides 3-4 hr of anesthes ia. If longer anesthesia is desired 0.5% ropivacaine or bupivacaine with epinephrine provi des 12 hr plus of anesthesia. For analgesia 0.2% ropivacaine is adequate.

In order to perform a targeted injection of a specific nerv e in the axilla it is neces sary to know how to block each individual nerve. The following is a description of each technique.

MUSCULOCUTANEOUS NERVE BLOCK

The musculocutaneous nerve originates from the lateral co rd (it can take off from the median nerve already in the arm) and because of its uncertain take off level we lik e to block it first.

Nerve stimulator setting

The nerve stimulator is set to deliver a current of 0.8-09 mA, pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec). A small skin wheal is raised with 1% lidocaine or 1% mepivacaine using a small needle, ideally 27-G.

Needle insertion

The operator identifies and holds the patient's biceps m uscle with one hand and directs the needle with the oth er in a direction perp endicular to the main axis of the arm, advancing it between biceps and coracobrachialis, as shown in figure 6-43.

Fig 6-43. Blocking the musculo cutaneous nerve. The needle is introduced under the biceps perpendicular to the main axis of the arm. (On a model with permission).

Type of response

As the needle approaches the musculocutaneous nerve a motor twitch of biceps with flexion of the elbow is obtained. The current is reduced to 0.5 mA and, if a response is still visible at this level, the injection is started.

MEDIAN NERVE BLOCK

The median nerve is most frequently located anterior (superficial) to the axillary artery running in the same direction, making it a very superficial block.

Nerve stimulator settings

The nerve stimulator is set to deliver a current of 0.8-09 mA, pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec). A small skin wheal is raised with 1% lidocaine or 1% mepivacaine using a small needle, ideally 27-G.

Needle insertion

Using the mark of the axillary artery on the skin as a reference, the needle is introduced very tangential to the skin (shallow angle), in the same direction of the artery, as shown in figure 6-44.

Fig 6-44. Median nerve block. The needle is introduced in reference to the axillary artery with a very shallow angle and in the same direction than the artery. (On a model with permission).

It is better to mark the course of the artery on the skin than to keep the fingers on the pulse to avoid bringing the artery even closer to the skin and increasing the chances for accidental artery puncture.

ULNAR NERVE BLOCK

The ulnar nerve is located immediately medial to the artery, slightly deeper than the median nerve. It gives sensory innervation to the medial side of the hand. Because the medial brachial and the medial antebrachial cutaneous nerves run along with the ulnar nerve on the medial side of the axillary artery, the ulnar nerve technique is performed for anesthesia of the medial arm and medial forearm.

Nerve stimulator settings

The nerve stimulator is set to deliver a current of 0.8-09 mA, pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec).

Needle insertion

Using the mark of the axillary artery on the skin as a reference, the needle is directed slightly medial to the artery, as shown in figure 6-45.

Fig 6-45. Ulnar nerve block. The needle is introduced slightly medial to the line representing the axillary artery. Notice the small difference in the angle of insertion compared to the median nerve block. (On a model with permission).

RADIAL NERVE BLOCK

The radial nerve is most frequently located posterior (deeper) to the axillary artery. It is the largest of the terminal branches of the plexus.

Nerve stimulator setting

The nerve stimulator is set to deliver a current of 0.8-09 mA, pulse frequency of 1 Hz and pulse duration of 0.1 msec (100 microsec).

Needle insertion

The operator uses two fingers of one hand as “hooks” to slightly displace the artery out of the way in order to reach the radial nerve located posterior to it. The needle is inserted posterior with a 30 degree cephalad orientation, as shown in figure 6-46.

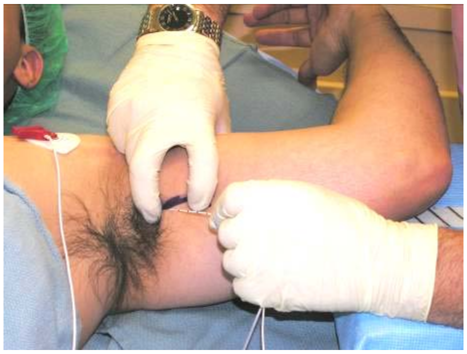

Fig 6-46. Radial nerve block. The axillary artery is displaced towards the biceps to gain entrance to its posterior aspect. The needle is then introduced in reference to the mark on the skin with a 30 degree cephalad orientation. (On a model with permission).

Complications

Pneumothorax is virtually impossible to get from this location. Hematomas from vascular puncture are more common and can be associated with nerve damage.

Pearls

- This is a block mainly indicated for surgery on the distal forearm, wrist and hand.
- It is not a good choice for elbow surgery.
- Tourniquet pain is an issue and not necessarily due to intercostobrachial nerve, but mainly due to insufficient proximal anesthesia of the deeper planes of the arm.
- Two and three injection techniques have proven more successful, but if a single injection is preferred this injection should be in front of the nerve most responsible for the sensory innervation of the surgical site. If more than one nerve is involved the injection should be performed in front of the radial nerve.

AXILLARY BLOCK
ULTRASOUND TECHNIQUE

Indications

The same indications mentioned for the nerve stimulation technique.

Patient position

The patient is semi seated with the arm in abduction and the elbow flexed, as shown in figure 6-47.

Fig 6-47. Patient position. The patient is semi seated, with the arm abducted and the elbow flexed. (On a model with permission).

Type of needle

This is a superficial block for which a 5cm, 22-G, insulated needle suffices.

Type of transducer

We use a high frequency (8-15 MHz) linear probe.

Scanning

The probe is placed across the neurovascular bundle in the proximal part of the arm, as shown in figure 6-48.

Fig 6-48. Scanning. The probe is place perpendicular to the main axis of the neurovascular bundle. (On a model with permission).

At this level the neurovascular bundle of the axilla is usually very superficial and the terminal nerves can be seen surrounding the axillary artery. The median nerve is usually superficial (anterior) to the artery, the ulnar nerve is medial and somewhat posterior, and the radial nerve is posterior, as shown in figure 6-49.

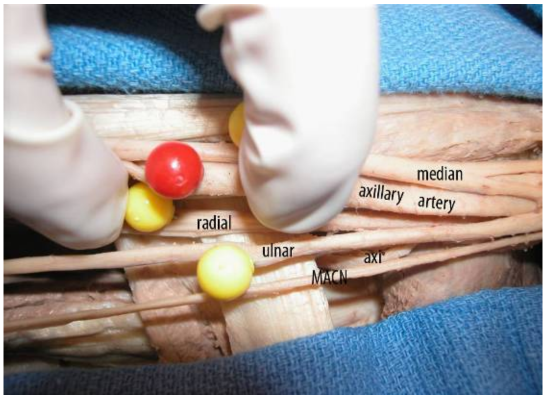

Fig 6-49. Terminal branches. The axillary sheath has been removed to show the relative location of the nerves with respect to the axillary artery. MACN: medial antebrachial cutaneous nerve; axi: axillary nerve. Cadaver dissection by Dr Franco. Image is copyrighted.

Distally in the axilla the radial nerve starts shifting more lateral, but it still remains posterior to the artery. The musculocutaneous is lateral to the artery at all times and it can be traced from its origin in the lateral cord proximally to its location between biceps and coracobrachialis distally. If a single injection is planned it should be made in the proximity of the radial nerve. Individual injections of terminal nerves can be done as needed. An image of the neurovascular bundle of the axilla in cross section is shown in figure 6-50.

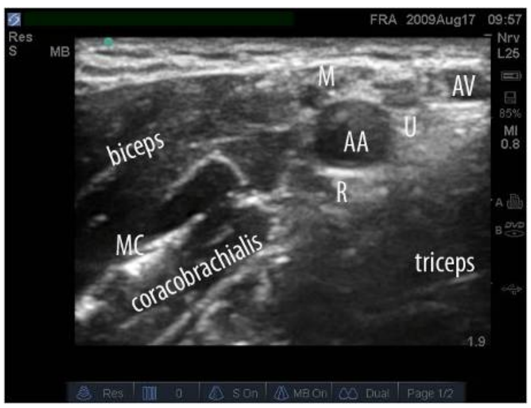

Fig 6-50. Axillary scanning. With the probe across the axilla the axillary artery (AA) is seen surrounded by three main nerves, median (M), Ulnar (U) and Radial (R). Also seen is Musculocutaneous nerve (MC), axillary vein (AV) and some muscles. (Author's archive).

Needle insertion

The needle is advanced in plane from lateral to medial, as shown in figure 6-51.

Fig 6-51. Needle insertion. The needle is advanced in plane from lateral (superior) to medial (inferior) and aimed toward the desired nerve. (On a model with permission).

We usually block first the musculocutaneous nerve located in between biceps and coracobrachialis. To target this nerve the needle needs to be inserted at an angle of 30-45 degrees. Then the rest of the terminal branches are targeted as needed. These branches are more superficial so they need a much smaller angle of insertion, which facilitates needle visualization.

Local anesthetic and volume

Because the nerves can be targeted individually it is possible to inject about 5 mL of local anesthetic solution around the desired nerve(s), usually requiring a total volume of 20-30 mL. For anesthesia we use 1.5% mepivacaine plus 1:400,000 epinephrine, which gives 3-4 hours of surgical anesthesia. For more prolonged anesthesia 0.5% ropivacaine or bupivacaine with epinephrine can be used. For postoperative analgesia we recommend 0.2% ropivacaine.

Side effects and complications

The most common complication at the axillary level is hematoma at the site, but ultrasound usually provides a good visualization of vessels and nerves at this location possibly decreasing the risk for inadvertent vascular punctures.

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