The Supraclavicular Brachial Plexus Block

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1. INTRODUCTION.

We here define the supraclavicular brachial plexus block as one related to a specific injection point for the local anesthetic drug. We refer to the position of the nerve block needle tip at the time of injection. We are not referring to the needle initial skin puncture point. We are not referring to the direction in which the needle is aimed. The drug-injection point is in the immediate region of the brachial plexus divisions. That is superior to the first rib where the brachial plexus crosses the rib, or just off the medial edge or lateral edge of the first rib.

There are a wide variety of nerve blocks for discussion, many with unconventional names. These various nerve blocks approach the supraclavicular brachial plexus with needles aimed (i) from high in the neck towards infero-lateral, (ii) from below the clavicle aimed towards posterior, (iii) from postero-lateral aimed towards antero-medial, and (iv) from superior aiming cephalad to caudad. The supraclavicular injection point is more lateral than an interscalene block and more medial than an infraclavicular block. In the era before the use of nerve stimulation confirmation of good needle tip position or visual ultrasound needle guidance, the key anatomical feature for position confirmation was needle-tip contact with the first rib.

Now with the modern use of visual needle-tip guidance the key anatomical reference feature is the subclavian artery. That is at the point where the artery meets the brachial plexus and they cross the first rib together. Using visual cues, it does not affect the nerve block outcome whether the injection point is fractionally medial to the first rib, above the rib, or immediately lateral to the rib.

The supraclavicular brachial plexus block is primarily a nerve block for arm surgery caudad to the shoulder joint.

2. HISTORY OF THE SUPRACLAVICULAR PLEXUS BLOCK

The old supraclavicular approach of **Kulenkampf** (1911) of "walking" the needle tip over the first rib was the only brachial plexus block for 50 years. It was described in Pauchet's French book on Regional Anesthesia in 1921. It was Pauchet who popularized the term "supraclavicular block". Users of the Kulenkampf technique then injected some drug at a number of points along the lateral part of the curve of the first rib. The needle tip had to touch bone each time. The assumption was that at least one of the injections would be successful. It was a blind technique requiring very thin patients for best success.

That technique was later superseded by **Winnie's** variation which reduced the high pneumothorax incidence slightly. Winnie also used a supraclavicular puncture point starting slightly more medial, but aiming caudal and lateral and just posterior to the subclavian artery after locating it by palpation. Palpation of the artery was the defining landmark guide. That was the "subclavian perivascular brachial plexus block".

In the earliest experience with the supraclavicular plexus block using historic techniques pneumothorax was the foremost complication of the nerve block. The interscalene approach to the brachial plexus, once described, superseded the supraclavicular plexus block in popularity. The interscalene block using paresthesias for needle tip position confirmation, significantly reduced the incidence of pneumothorax seen with brachial plexus blocks. The interscalene block however, was found to usually miss the C8 and T1 nerve roots of the brachial plexus. That made the interscalene block unsuitable for surgery of the arm, distal to the shoulder joint.

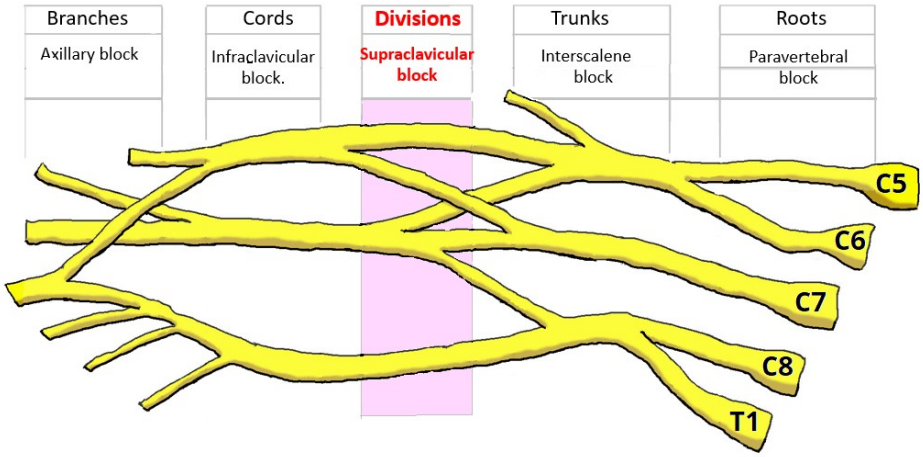
The axillary approach to the brachial plexus next found popularity as a nerve block for the distal arm, during this evolution of regional anesthesia. The axillary block was fully free of pneumothorax risk, and definitely blocked the nerves with C8 and T1 root origin better than an interscalene block did. The axillary block using a variety of land-mark based techniques was limited by the fact it was frequently "patchy" in its results. That meant results were often incomplete. It was poor for shoulder surgery, and often missed key cutaneous nerves of the inner upper arm, apart from other nerves. Success with the axillary block required (i) multiple injections, (ii) supplementary distal injections, and (iii) large drug volumes, up to 60 ml as recommended by some teachers.

The advent of the nerve stimulator led many regional anesthesia pioneers to describe yet more approaches to the supraclavicular brachial plexus, in the quest to find a better nerve block technique for arm surgery distal to the shoulder joint. Two techniques were described inserting the needle directly from anterior towards posterior. They were called "plumb-bob" techniques because if the patient was fully supine, the needle followed the direction as a small weight tied to a string and pulled by gravity, would point. One technique was from just above the clavicle and immediately lateral to the insertion of the sternocleidomastoid muscle onto the clavicle. The other was injected immediately caudad, to the center of the clavicle. With the first technique the needle mostly met the plexus medial to the medial edge of the first rib but *mostly* cephalad to the dome of the long. With the second technique the needle mostly met the plexus at a position above the first rib, or fractionally lateral to the first rib. Neither technique was free of pneumothorax risk. Firstly, there is too much inter-individual anatomical variation in the length of the clavicle. Clavicle length influences the distance of the land mark "center of the clavicle" from the midline. Secondly, there is too much interindividual variation in how forward the lateral tip of the clavicle lies with variation in age, chest hyperinflation and hunching kyphosis of the thoracic spine. Thirdly there is too much interindividual variation in the protrusion of the dome of the lung contained within the curve of the first rib. That varies with individual lung hyperinflation, length of the neck and general body morphology. The plumb bob techniques should be generally abandoned, despite the fact gifted individuals with a lot of experience can master them.

The introduction of ultrasound-guidance of nerve block needles to regional anesthesia was revolutionary. That refocussed interest back onto the supraclavicular block. That made it a relatively expedient nerve block to do for surgeries distal to the shoulder joint. Pneumothorax risk was dramatically reduced. The ultrasound-guided supraclavicular block became very popular.

Many studies have compared it for all surgical indications, and to all the other brachial plexus blocks. These will be discussed later.

3. ANATOMY OF THE BRACHIAL PLEXUS.



The brachial plexus is typically formed by the anterior rami of nerves roots C5 through to T1. The plexus roots alternately fuse and bifurcate repeatedly. The roots combine into three trunks at the lateral edge of the scalene muscles, and pass over the 1st rib. There they usually lie posterior and superior to the subclavian artery. The trunks then each divide into an anterior and a posterior division behind the clavicle, at the lateral edge to the 1st rib. The three posterior divisions form the posterior cord, the anterior divisions of the upper and middle trunk form the lateral cord and the anterior division of the lower trunk forms the medial cord. The cords then rearrange in an embrace around the axillary artery in the infraclavicular region. Inferior to the coracoid process, the cords give off their final terminal branches. All flexor functions are supplied by the medial and lateral cords, and all extensor functions by the posterior cord.

The subclavian artery becomes named the axillary artery lateral to the first rib, and the axillary artery is divided into three parts, the 1st part being medial to, the second part being behind, and the 3rd part being lateral to the pectoralis minor muscle near its coracoid tip attachment.

The pectoral nerves are formed at the level of the trunks and or divisions. The pectoral nerves initially keep close association with the plexus cords, lateral and medial, after which they are respectively named.

- BRACHIAL PLEXUS SHEATH OR NOT?

  The simple circumferential tubular concept of a brachial plexus sheath proposed by Winnie is untrue. Gayle Thompson showed the epineureum partitions off into compartments around components of the brachial plexus[1]. Thompson's paper, to date, remains the sole scientific paper to have so comprehensively studied fresh cadaver dissections of the brachial plexus at multiple points. Thompson's 1985 paper described the fascial compartmentalization of the brachial plexus at various points. The compartments generally communicate proximally or distally with one or more other compartments. This explains why circumferential spread of fluid around a nerve mass does not guarantee complete block, and also why a complete block can result from a large volume of drug being injected into one compartment only. These septae of epineurium offer varying grades of impediment to flow of injected fluids transversely across into adjacent compartments. Those septae however encourage axial spread of drug solution injected, within the septae, along the compartment. That drug fluid will enter other compartments where they communicate more to proximal or to distal. This is the main effect that will produce the effective multi-compartment block. Thompson's theories however allow for slow molecular diffusion across fasciae. The nerves do not all lie within one surrounding sheath as Winnie postulated.

  Spread of drug injected within one compartment to other compartments can, in general in regional anesthesia, be facilitated by various strategies;

  1. Injection of very large volumes to spread axial within the compartment, towards where compartments communicate with each other as nerve plexus components fuse or divide.

2. Injection of large volume s of drug to create hydrostatic pressure. That stretches the compartment fascial boundaries sometime to the point where they become porous.
3. Use high concentrations of drug to facilitate molecular transverse diffusion across fascia along concentration gradients.
4. Inject into multiple compartments. This follows the "multi-twitch" technique as popularized by Guido Fanelli.
5. Wait for longer "soak times" before permitting surgery.

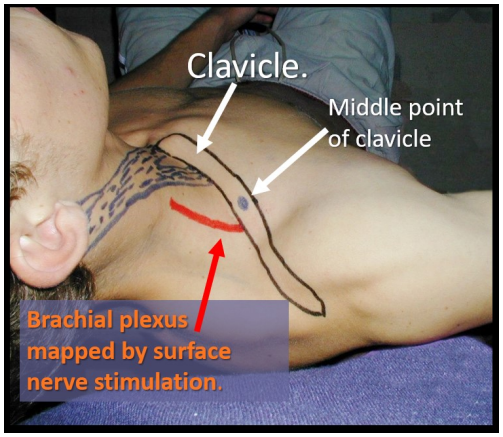
There are pros and cons for each of those various strategies. Those pros and cons have different relevance at different places along the course of the brachial plexus.

The supraclavicular brachial plexus, despite representing the most compact cross-sectional part of the entire brachial plexus is notorious for the poor grade of its nerve block of the C8-T1 nerve components. That is because the sub-compartment fascial divisions are the most substantial (thick) at that point. Multi-injection techniques do improve the nerve block, but the block still performs inferior to a single injection infraclavicular plexus block. More critically, the addition of the second injection in close proximity to the pleura has increased the incidence of pneumothorax complications.

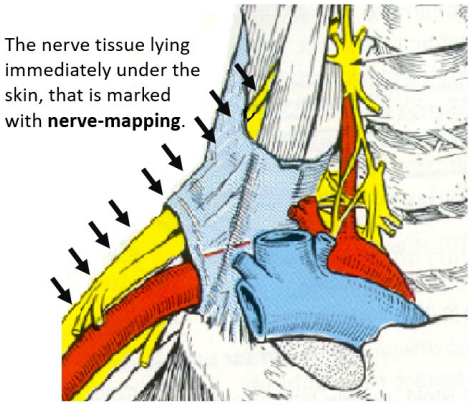
- THE BRACHIAL LINE

The brachial line is a straight line from Chassaignac's tubercle where the C5 nerve root, to the axillary artery as it is palpated in the axilla. It will be seen that it passes under the mid-zone of the clavicle, descending at 45 degrees from the long axis and also going lateral some 15 degrees anterior to the coronal axis. Drawing this line on a patient helps visualize the invisible brachial plexus before nerve blocks sometimes.

In these two photographs the brachial line was identified by transcutaneous surface nerve mapping. This used a nerve stimulator applied to the skin using currents of 5 to 15 mAmp and round tip metallic blunt skin probe for the purpose. The brachial plexus motor responses all along the line corresponded to the muscle supplied with C5 nerve root axons. Those would be the axons closet to skin, and the nerve stimulator.



Drawing the brachial line prior to performing a supraclavicular brachial plexus lines, helps with orientation as to where to expect to find the plexus.



The Brachial Line

- **ANATOMICAL VARIATIONS**

The brachial plexus has many known anatomical variations. Sometimes the plexus is pre-fixed or post-fixed with altered nerve root origins. It is not yet described how those two variations affect the supraclavicular block.

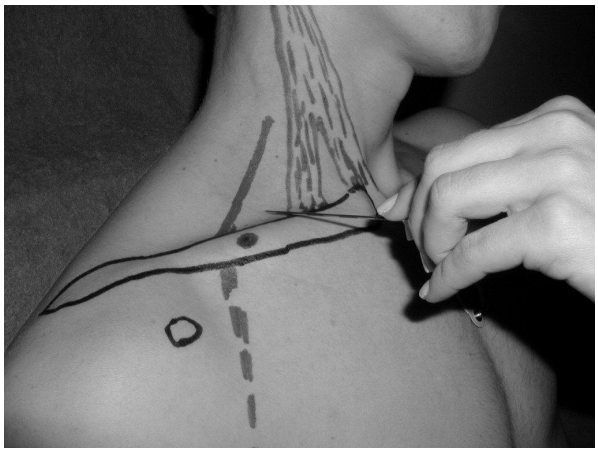
Supraclavicular plexus block in the presence of cervical rib has been described[2]. It was observed in a patient that there was a large space between the lowest brachial plexus parts and the rest in the supraclavicular region. Scanning up the neck with ultrasound revealed a hyperechoic structure lifting the middle and upper trunks. Chest-neck X-ray confirmed that was a cervical rib. The nerve block was successfully achieved after separate injections onto each of the two plexus portions. Portion. It could be generally concluded that whenever the plexus is visibly divided into two portions with a space in between, then each portion should be injected individually.

Another described variation had the upper trunk derived from roots C5-6 lie *anterior* to the anterior scalene muscle at the interscalene block level. That C5-6 derived plexus portion finally lay fully *anterior* to the subclavian artery when the plexus was viewed at the lateral edge of the first rib prior to attempting a supraclavicular plexus block[3]. The rest of the plexus in the supraclavicular brachial plexus block zone (lateral edge of the first rib) lay conventionally posterior to the subclavian artery. A successful nerve block was performed by simply injecting each portion of the brachial plexus separately via two different needle approaches.

4. LANDMARK BASED NERVE BLOCKS OF THE DIVISIONS OF THE BRACHIAL PLEXUS.

- **THE SUPRACLAVICULAR PLUMB-BOB TECHNIQUE of MOORTHY[4].**

It is a nerve block approach with a skin puncture point from just above the clavicle aiming para-Sagittal and direct towards posterior. Direct to posterior means as if using a plumb-bob line in a supine patient. The Brachial plexus will be contacted in between an interscalene and traditional supraclavicular position. This risk of pneumothorax seems lower than with the historic “onto the bone” supraclavicular approach. This supraclavicular block variation was proposed by Moorthy using the lateral edge of the Sternocleidomastoid muscle on the clavicle, moving 1 cm lateral to that and then directing the needle to posterior.



TECHNIQUE.

Insert the needle at the junction of the medial quarter and lateral 3/4 mark on the clavicle. This also correlates with a point immediately lateral to the lateral edge of the sternocleidomastoid muscle insertion onto the clavicle. Use a nerve locator needle and advance directly para-sagittal (paramedian) and posterior, as if using a plumb-bob in the supine patient. If the plexus nerve is not found by over half way to the back, then start again and vary the angle very slightly caudad or cephalad, but never diverting medial or lateral. That is the needle must at all times remain within a consistent parasagittal plane. The safety of the technique depends on making only small angle changes between each reinsertion. As the nerves

pass at right angles to the plane of probing, the nerves have to be touched at some point if the serial needle paths are sufficiently close to each other. This nerve block technique is otherwise reasonably reliable, and the pneumothorax risk is modestly small.

It can be kept in mind that the dome of the lung rises above the clavicle towards the posterior side of the patient, but this is only within the inner curve of the first rib. Theoretically a needle kept from deviating medial will never touch the pleura within the curve of the first rib as the needle insertion point is further lateral than this region. This nerve block needle could however penetrate to the pleura between the first and second ribs if aimed sufficiently steeply downwards. The hope is that the plexus will be met by the needle before the pleura is met by the needle.

Use only blunt nerve block needles together with electro-stimulation to confirm nerve location.

INDICATIONS

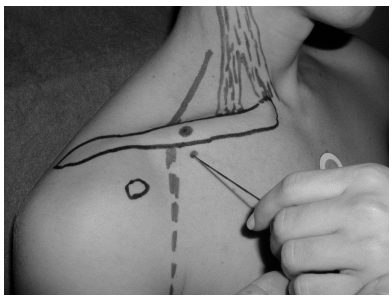
This is for "one-shot" brachial plexus blocks for arm surgery distal to the shoulder joint. to the elbow and lower, particularly when other options are excluded, e.g. due to local sepsis. This was modestly popular block prior to the advent of ultrasound needle guidance. It was fairly easy being a one-plane technique. This author found this block easy and generally successful in those early days. This author would only use this approach again, in a third world healthcare situation, in the absence of an ultrasound machine, and where the infraclavicular brachial plexus approach was inaccessible for some unique reason.

- **INFRACLAVICULAR PLUMB-BOB TECHNIQUE[5].**

Also known as the *Vertical-infraclavicular technique (VIB).* This approach was designed as an improvement on the axillary plexus block for distal arm surgery. It is considered by its proponents, as reliable, with less pneumothorax risk. It was popular in Europe. The brachial plexus is blocked immediately lateral to the first rib, at the level of the divisions.

TECHNIQUE.

Patient lies supine with the arm in any comfortable position. At the midpoint of the clavicle insert the needle 1cm caudad to the bone and aim the locator needle para-Sagittal and direct towards posterior. That is follow a plumb-bob direction. Do not ever aim to medial, in order to avoid the pleura. Aiming towards lateral will be futile and the plexus never discovered. If after passing half way to the back the nerves have not been found withdraw the needle to about 1 cm from the skin. Then re-advance the needle with a small alteration in direction towards caudad. Do not deviate medial or lateral. Make small serial adjustments to needle direction with each probing. The plexus is at right angles to the plane of probing. Stop advancing the needle once a suitable arm muscle contraction is obtained. Any contraction in the shoulder or arm is suitable, excluding a pectoral muscle twitch.



A pneumothorax is achievable if the needle is passed very steeply towards caudad. That should not happen if the needle directions changes are small enough. The brachial plexus should be met by the needle tip first.

Use only blunt nerve block needles together with electro-stimulation to confirm nerve location.

INDICATIONS.

Any surgery, distal to the shoulder joint.

SPECIAL COMPLICATIONS.

Blood vessel puncture, and pneumothorax. With this nerve block, the Ulm hospital, in an educational book, reported their experience and incidences of complications 0.7% pneumothoraxes, 10% venous punctures. 3% Horner's syndromes, and a 2% failure to identify the plexus at all (total failure).

A pneumothorax is only possible with steep downwards and sharp medial wards aiming, or from starting medial of the clavicle midline. Safety lies in never deviating towards medial, and in only making small incremental directional needle changes as one searches increasingly towards inferior for the very large plexus.

SPECIAL COMMENTS

It is critical to identify the lateral end of the clavicle correctly in order to identify the midpoint of the clavicle clearly. The "end of the shoulder" is not the end of the clavicle. Seek the acromio-clavicular joint (AC joint) to identify the lateral tip of the clavicle. The AC-joint cannot be identified if palpated from superior. If, however, the palpating finger is run along the anterior or leading edge of the lateral clavicle the AC joint is easily identified by a wedge in the bone edge.

Using the length of the clavicle to determine the needle insertion point is the weak aspect of this technique. Starting too lateral will result in missing the nerves due to being far too high over the plexus which angles downwards as it moves laterally in this zone. The clavicle lateral point can easily be confused with the acromion, or humerus greater trochanter. Use a 50mm locator needle. Seek any motor response other than biceps (musculo-cutaneous) which if used as the point of injection results in a high incidence of incomplete blocks. Final localisation must be at 0.3-0.6mAmp current. Inject 40 ml of local anaesthetic. Upper arm tourniquets can be tolerated without additional nerve blockade. If blood is aspirated, re-aim more lateral.

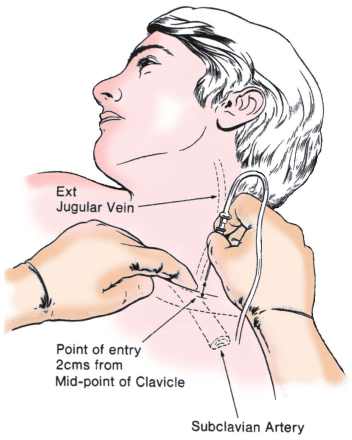
Never (1) go deeper than 6cm, and (2) never aim medial.

This block is generally not recommended. Because single exceptional regional anesthesia experts can acquire instincts perform a nerve block safely and successfully does not make it suitable for the masses of anesthesiologists who are less gifted and with relatively rare opportunity to practice regional anesthesia.

The clavicle is a bone subject to immense variation in length between individuals, even of the same height. The clavicle length is what determines the impression of an individual having "broad shoulders' or not. Some individuals have broach shoulders, and others do not. Each "shoulder type" will yield very different land marks for this block.

- **THE HISTORIC "WALK-ALONG-BONE" TECHNIQUE OF KULKENKAMPF**. (1921)

This was in the far past, a technique that was only useful in the hands of the few regional anesthesia enthusiasts with large experience, and good 3-Dimensional perception for the unseen needle position, as well as advanced knowledge of the unseen anatomy deep to the skin. It was very risky procedure for the inexpert and occasional practitioner of regional anesthesia. In the current era, it has to be considered completely contra-indicated in this era of ultrasound-guided regional anesthesia. The absence of an ultra-sound machine must



be considered in itself an absolute contra-indication to performing this historic nerve block. This all concerns the risk for a needle induced pneumothorax.

TECHNIQUE;

Identify the center of the clavicle. Do not include the acromion in that measurement, lest the point be wrongly assessed too far lateral. Insert the needle immediately posterior to the midpoint of the clavicle. Aim the needle simultaneously towards caudad, towards medial and towards posterior. If the subclavian artery can be palpated, aim slightly posterior to the artery. Palpation of the artery greatly improves the technique accuracy. If the patient can inflate their external jugular vein with a strong Valsalva maneuver it is an additional usable landmark. The needle should also have a track that runs posterior to the vein. Once the needle tip contacts the bone of the first rib, it can be serially adjusted "walking" a centimeter or two towards posterior and then towards anterior until a paresthesia feeling can be elicited down the patient's arm. Paresthesia indicates the needle tip is in contact with the brachial plexus. Paresthesia are best elicited using sharp point needles, like an 80 mm 22G Quincke point spinal needle. Inject all the local anesthetic at one point. Be alert for symptoms of pneumothorax. Have equipment available to drain a severe symptomatic pneumothorax. Have the personal ability to drain a critically symptomatic pneumothorax.

CONCLUSION;

Readers are highly cautioned against ever using this technique.

5. ULTRASOUND GUIDED SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK[6]

INTRODUCTION;

This nerve block is very popular. It was first described by Vincent Chan in 2003[7].The attractive feature it offers, is the presence of most of the brachial plexus tightly bunched together. Also, the plexus lies relatively close to the skin and is thus very amenable to sonographic visualization. Unfortunately, some critical nerves needed for shoulder surgery are no longer closely associated with the brachial plexus at this point about the first rib. Those nerves branch away well proximal to the first rib. Those nerves are dependent on substantial retrograde spread of local anesthetic drug in order to be blocked. This makes the success of blocking those nerve very inconsistent. Those nerves are the suprascapular nerve that branches off high in the interscalene groove, and the superficial cervical plexus nerves from root C4.

That makes the supraclavicular brachial plexus block better suited to arm surgery, distal to the shoulder joint, than to shoulder surgery. Even an isolated selective suprascapular nerve block provides better analgesia for shoulder surgery than a supraclavicular block on its own[17]. If the supraclavicular block is used for shoulder surgery, both the supraclavicular nerve and the superficial cervical plexus nerves should be nerve blocked in addition.

Conversely the interscalene block, in full dose, blocks the suprascapular nerve and the C4 roots of the superficial cervical plexus making it the best nerve block or shoulder surgery. The interscalene block, in turn, blocks the nerve roots C8 and T1 poorly due to the distance the drug has to flow. That makes the interscalene block a poor choice for finger, forearm and elbow surgery.

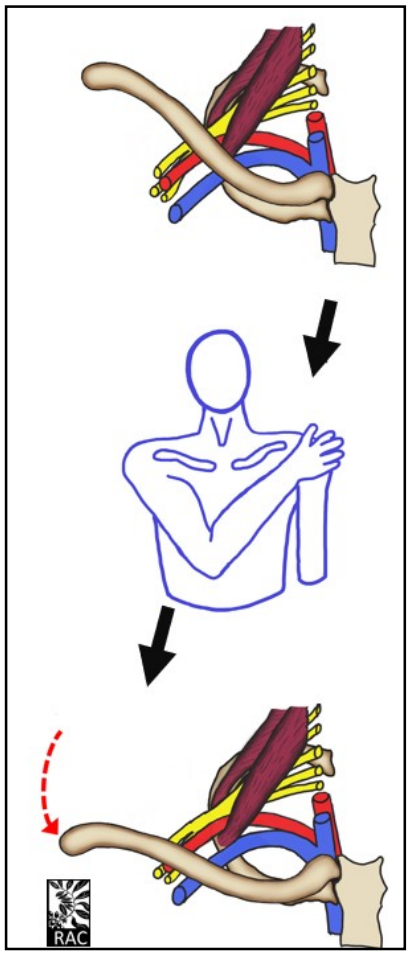
The phrenic nerve which is blocked about 100% of the time in full dose interscalene blocks, is only blocked about 20% of the time in supraclavicular blocks using full doses. That fact has relevance in patients with critical needs to avoid a phrenic nerve block. The reduction in phrenic nerve blockade risk is however insufficient to justify using the supraclavicular block as a phrenic nerve sparing strategy. It is noted however, that the presence of an

incidental unilateral phrenic nerve block in the vast majority of reasonably healthy patients is totally asymptomatic and inconsequential.

INDICATIONS;

The ultrasound guided supraclavicular brachial plexus block finds its best application for any surgery to the arm distal to the shoulder joint. Awake surgery is generally possible even if an upper arm tourniquet is used. The intercostobrachial nerve should be nerve blocked as well to yield complete awake patient comfort with an upper arm tourniquet.

TECHNIQUE;



- **Patient positioning**. The patient should lie flat and supine, with their head turned to the opposite side to that of the nerve block.

The clavicle can be swung forward to increase the space posterior to the clavicle in which to manipulate the ultrasound transducer. This is the *anterior-clavicle-swing* maneuver. The *anterior-clavicle-swing* is achieved by placing the ipsilateral hand across the chest to hold the head of the opposite side humerus. That maneuver pulls the elbow across onto the chest. The elbow should lie approximately in mid-clavicular line.

The bony shoulder girdle consists of the scapula, the head of the humerus and the clavicle. The shoulder girdle's fixed attachment to the torso is at the sterno-clavicular joint. The shoulder girdle can rotate about the torso back and forth about the sternoclavicular joint. When the hand is placed with fingers around the opposite humerus head the entire shoulder girdle is pulled towards anterior. The scapular will move from posterior, onto the lateral side of the chest. The elbow will move from lying lateral to the chest, to lying in front of the chest over the lowest ribs. Most importantly the lateral tip of the clavicle, will be moved towards anterior by 5 to 10 centimeters. In the center to medial side of the clavicle, the space between the clavicle and neck base will be increased by 1 to 3 centimeters.

The *anterior-clavicle-swing* can greatly make the nerve block easier by giving more space for transducer maneuvering.

- **Place the transducer posterior to the clavicle, and over the *brachial line***. (described earlier)

Orientate the side marker on the transducer towards medial and anterior. That will orientate the anteromedial image side to the left on the ultrasound screen.

Adjust the degree of tilt of the transducer in order to define the nerve elements best. That may not correlate with having the most defined images of the muscles arteries and bones. Each tissue element will appear most defined at different angles of tilt. One has to prioritize the tissue of most interest. Alternatively, it is reasonable to optimize the imaging of ribs, pleura and subclavian artery and let the plexus nerves be more hazily defined. The "ZONE" where the nerves lie will remain as large and generally identifiable behind the artery.

Try to achieve the following additional sonographic goals;

i. Have the subclavian artery touch the left side of the ultrasound image screen.

ii. Position rib rather than pleura below the nerves and artery.
iii. Have the needle be as horizontal as possible within the sonogram.
- That will require it be inserted in-plane
- Puncture the skin a short distance of 1 to 3 centimeters *away* from the transducer.
- Also, if needed to achieve a fully horizontal needle in view, dip the anterior edge of the transducer a few degrees deeper into the soft tissues. That should make the needle track and the transducer surface perfectly parallel to each other. This is described in a review on avoiding pneumothorax[8].

The patient is breathing and all the tissues will be moving slightly. This makes this a challenging block to achieve a perfect sonographic image, as well as sustain it throughout the course of the nerve block. It is achievable however with (i) practice, and (ii) a good understanding of imaging and transducer movements. (see chapter on transducer handling).

Advance the needle aiming at the dead center of the nerve cluster. See the video on this block at www.regional-anesthesia.com.

When the nerve stimulator induces any motor twitch from the shoulder to the fingers at a current of 0.5 mAmp and less, the drug can be injected. Follow standardized test injection and safety routines.

Sometimes if the imaging is very clear and the needle tip seems center positioned amongst the nerve elements of the brachial plexus, there can be no observable muscle twitches. Then give the first test injection of dextrose water with adrenaline (epinephrine). If the dextrose-water dispersal seems fine, the main dose can be injected even in the absence of a muscle twitch. The brachial plexus portions supplying the hand has more sensory axons than motor axons. It is possible the needle tip can lie between sensory fascicles making stimulation of muscle contractions impossible at standard currents.

This author always uses a nerve stimulator and generally likes to see a muscle twitch before injecting the drugs. However, if the image is immaculate, and if no muscle twitch is observed, despite a visually seemingly optimal needle position and test dose fluid dispersal, this author will rather inject the drugs than probe further for a muscle twitch. This minimize tissue trauma and minimizes opportunity from injected drug to enter small damaged blood vessels. The good saying is KISS – *keep it simple Sam*. Minimize puncturing needle movements within the nerve cluster.

- **The "8-ball corner pocket" injection[9],[10].**

As initial experience grew with the ultrasound guided brachial plexus block an observation was soon made. A single point injection did not produce a consistent fast onset dense nerve block of the entire brachial plexus. Frequently the most caudad elements with nerve root origins of C8 and T1 were slow to nerve block, and occasionally not at all. It was postulated that second injection on the deep side of the plexus and close to the artery would eliminate that slow nerve block problem. That second injection point was named the 8-ball corner pocket injection. The corner-pocket injection did result in improved nerve block results[11]. It is however widely reported in anecdote at conferences, that nearly all anesthesia centers have experienced a pneumothorax associated with this added injection.

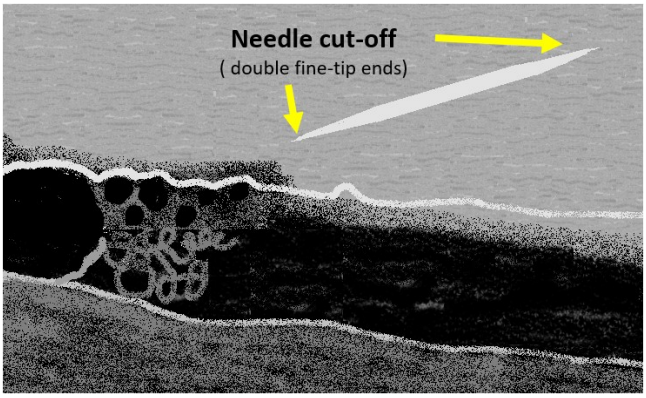
With the nature of having (i) a dynamic ultrasound image and (ii) a living moving breathing patient, it easily happened that the needle tip was not perfectly seen, and that fact was not recognized. The needle was advanced thinking the visible end of the needle was the actual tip. The actual tip was deeper into the tissues and out of sight. This phenomenon of the needle tip being deeper into the tissues than what the ultrasound reveals is called "*needle cut-off*". Pneumothorax resulted. The phenomenon of *needle cut-off* can occur in any nerve block. It however occurs most easily with the supraclavicular brachial plexus block, and that is the nerve block where it is most critical to not occur. The

problem is less than that it just occurs. The biggest problem is when the operator does not recognize it and understand it.

To avoid a supraclavicular block induced pneumothorax the strategies are;

- Never aim at the corner pocket.
- Never have a steeply descending needle in a path towards the pleura.
- Never advance the needle if once is not confident the actual tip is in view.
- Understand the phenomenon of *needle cut-off*.

It has been pointed out that the supraclavicular block is a challenging one in which to consistently achieve best example sonographic views[12]. It has been pointed out that retaining such a steady view in a living breathing and moving patient with preservation of the full length of the needle throughout the block is difficult. Thus, opinions have cautioned against the use of the corner pocket injection due to it increasing the likelihood of a pneumothorax.



There is a very noteworthy feature in the review on the risks of pneumothorax by Abell[8]. In their figure number 2, first images "A" left sonogram, they have a perfect example of a *needle-cut off* phenomenon. They clearly did not recognize it, as they did not comment on it. The needle tapers to a thin point at its visible front and back. That implies the *actual needle tip* is deeper within the tissues than what the sonogram view reveals. This occurs when the needle and plane of soundwaves (transducer) are not both parallel and aligned. It is a very easy oversight when dealing with lot of intellectual input and focusing strongly on so many view aspects. That is when a pneumothorax can occur from unknowingly inserting the needle too deep.

Accordingly, this author recommends against the use of the corner-pocket injection. Just inject once into the center of the nerve collection cluster as best as one can, and be patient.

REMEDIES AND OPTIONS TO OPTIMIZE THE RESULTS of the supraclavicular brachial plexus block are multiple. One must choose considering all aspects of the patient care, the surgery, and the working circumstances.

- Use a full drug volume. A typical adult needs a 40 ml injection of local anesthetic. Using lesser drug volumes will result in slower development of a full block, a block of shorter duration and a higher incidence of significantly incomplete nerve blocks. One study using an up-and-down method determined the optimum drug volume for the ultrasound guided supraclavicular block to be 42 ml[13].
- Use a maximum drug concentration. For a typical adult 35 ml of 0.5% bupivacaine will be within generally considered safe doses, and will give the longest single shot block duration. An alternative drug to achieve a very long block duration is 0.6% levobupivacaine. An optimum drug will be 0.75% ropivacaine. That 0.75% ropivacaine won't achieve the duration of post-surgical analgesia the two first mentioned drugs, will achieve but the block will have very highest incidence of fast and complete onset which is the bigger priority.
- Simply combine the nerve block with general anesthesia. The analgesia achieved by the time of awakening will be virtually 100%. This also bypasses the soaking-time needed for the block if awake surgery is planned.

- Use deep sedation over the beginning of the surgery. The optimum analgesic is ketamine, at a dose of 50 mg for all average adults. Combine that with 1 mg midazolam. The dose should precede surgical incision by 3 minutes and may be repeated every 15 minutes for 3 times or so. Additional background supplementary infusions of sedative drugs may be used, as per individual anesthesiologist experience and preferences.
- Extending the nerve block soaking time by 30 minutes increases the nerve block success rates very significantly. This can be facilitated by good organization without causing loss of operating room time usage.
- Do distal rescue nerve blocks of the "slow nerves" at the elbow. This requires repeated precision assessments of all of the brachial plexus nerves. An unusually slow component is recognized very soon by the anesthesiologist who routinely examines his/her patients after nerve blocks. The decision to do supplementary distal rescue nerve block does not have to be waited long for to be taken. The best regional anesthesiologist does this often and swiftly. This is a basic part of successful top-level regional anesthesia practice.
- Perform an infraclavicular block preferably for routine surgery to the arm distal to the shoulder joint. The infraclavicular plexus block is measurably and significantly superior even to a double injection supraclavicular brachial plexus block. Although it is much less of a visual block than the supraclavicular block, the drug performs much better at this point of injection due to the fascial partitions between plexus components being flimsier, and more porous than those in the supraclavicular region. Injected drug spreads easily to all elements of the infraclavicular plexus. It is also a safe block. The need for rescue block is very rare.
- Use of additives. There are lengthy arguments against using additives with local anesthetics generally. One study of the supraclavicular plexus block found no advantage of injecting dexamethasone perineural over injecting it intravenous[14].

- **Continuous infusions.**

Any nerve that can be injected, can equally have a perineural catheter placed onto it for the purpose of maintaining the nerve block via infusion of local anesthetic drug. A typical infusion would consist of 0.2% ropivacaine infused at 8ml per hour. The option of a 4 ml bolus every 30 minutes can be added, but is not critical if the disposable pump devices do not cater for that option. In one study, by a methodologically world best research group, that infusion protocol was compared between infraclavicular blocks and supraclavicular blocks[15]. Both catheters provided analgesia. The analgesia achieved via the infraclavicular catheter however resulted in significantly better pain scores.

6. COMPLICATIONS

The common complications, as occur with all nerve blocks are;

I. Local anesthetic toxicity.
II. Nerve injury.
III. Block field hematoma.
IV. Block failure.

The most specific and severe complication of the supraclavicular brachial plexus block is needle induced pneumothorax. Ultrasound guidance of the nerve block needle very dramatically reduced the incidence of pneumothorax. It has not been eliminated though, and remains a reported periodic event. Using only an electrostimulation technique to locate the plexus an incidence of pneumothorax of 4% has been described[18.]

Phrenic nerve block also occurs with supraclavicular brachial plexus blocks. In patients already in or near to respiratory distress a phrenic nerve block can be fatal if left untreated[16]. The incidence is however less, the severity is less and the duration is less than that seen with interscalene blocks[17].

Another trivial complication is Horner syndrome. It occurs in 50% of patients with a supraclavicular brachial plexus block[18].

The complication most overlooked in discussions is failure of the nerve block. The highest standard for nerve block success would be to expect achieving a 100% incidence of awake surgery and a smiling patient. Many studies are underpowered and utilize very soft measures of success. A story in point; one 2009 study compared ultrasound guided axillary blocks, supraclavicular blocks and infraclavicular blocks[19]. That small limited and underpowered study that only assessed patients for 30 minutes, failed to show any meaningful difference in results between the three nerve blocks. It stands in contrast to broader experiences of these three nerve blocks. Certainly, all three blocks are sufficiently worthy in results to be all considered for use generally. They are definitely not equal however in their success rates, and needs for supplementary analgesia therapies. The supraclavicular plexus block exceeds the axially block for success and the infraclavicular plexus block is the most successful of the three. Koscielniak-Nielsen, in a larger study found a dramatic advantage for the infraclavicular block over the supraclavicular plexus block using a two-injection technique for each block[20]. Another study from New Zealand equally showed very substantial advantage for the infraclavicular plexus block over the supraclavicular plexus block for nerve block success, despite a double injection technique[21].

7. CONCLUSION

The ultrasound guided supraclavicular brachial plexus nerve block has a place in regional anesthesia. All practitioners of perioperative regional anesthesia should include this in their repertoire of expertise. Be concerned for the phenomenon of *needle cut-off* in the image when performing this nerve block. Keep the block simple and safe. Use it for any surgery of the arm distal to the shoulder joint. Consider using a supplementary intercosto-brachial block for tourniquet comfort when planning awake surgery. Have a low threshold to perform an early supplementary rescue block at the elbow.

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