Supraclavicular block: A review of the methodology of blocking the brachial plexus

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Three methods of blocking the brachial plexus with a supraclavicular approach are presented. The pros and cons of using this technique, as well as its usefulness, are discussed. The four most commonly used drugs for blocks also are examined. A 270% increase in blood flow to the arm is achieved by this block but, with the addition of epinephrine, it can be increased to 430%. The permeability of the anterior scalenus fascia is offered as a possible reason for a significant incidence of phrenic nerve paralysis. A greater success rate is possible if paresthesias of the index, middle and ring fingers can be elicited.

A little more than 100 years ago, in 1884, Halsted first anesthetized the brachial plexus using cocaine. Three years later, Crile disarticulated a shoulder using 0.5% cocaine injected into the brachial plexus under direct vision. But it was not until 1911 that Kulenkampft and Hirschel described percutaneous injection and Kulenkampft, in association with Persy, first described a classical supraclavicular block of the brachial plexus.

Various modifications of the brachial plexus block have come into existence simply because of the anatomy of the plexus itself, which allows intervention at five locations—interscalene, parascalene, supraclavicular, infraclavicular and axillary.

The brachial plexus is formed by the convergence of the anterior rami of the lower cervical nerves (C5, C6, C7, C8) and the greater part of the anterior division of the first thoracic nerve.

The fourth cervical and the second thoracic nerves frequently will send a small branch into the plexus which, together with the subclavian artery, emerges from the neck between the anterior and middle scalenus muscles. These rami form three trunks, which split into anterior and posterior divisions as they pass under the clavicle and over the first rib (Figure 1). These divisions reunite to form cords near the second part of the axillary artery.

The function of the brachial plexus is to supply almost all of the motor and sensory functions of the arm. However, the anesthetist must be aware that the skin of the shoulder and the posterior medial aspect of the upper arm is supplied by other nerves. The skin of the shoulder is supplied by the descending branch of the cervical plexus, and the back of the upper arm is innervated by the intercostobrachial nerve, a branch of T-2.

The supraclavicular approach causes the plexus to be blocked where it is arranged most compactly—at the level of the three trunks. A low volume of solution is required, and a quick onset usually is achieved. There is minimal danger of missing peripheral or proximal nerve branches because of failure of the agent to spread sufficiently, as can happen in the axillary approach.

There is evidence that the connective tissue...
of the neurovascular sheath tends to extend inward, thereby forming septa between the bundle components. Microscopically, this tissue starts at the level of the anterior and medial scalenus muscles. This sheath, or septa, ends at the point where the vessels and the nerves enter the medial intermuscular septum at the level of the upper humerus by blending with the anterior and posterior laminae. This would seem to necessitate paresthesias from each of the three trunks, but in practice this is not the case. This investing fascia also is the only thing separating the plexus from the phrenic nerve. Because these fascias serve no real purpose, they are flimsy and present no real barrier to prevent the agent from bathing the phrenic nerve.

In anatomical drawings, the brachial plexus often is shown as lying in a straight line parallel to the first rib. This relationship is incorrect. The plexus, when seen in a sagittal section, lies within a triangular or tear drop-shaped sheath based in the subclavian arterial groove on the first rib (Figure 2).

Advantages and disadvantages

There are a number of reasons to pick the supraclavicular approach to the brachial plexus as the block of choice for procedures on the arm, such as when the arm cannot be abducted, for postoperative analgesia, to shorten recovery time, to localize the anesthesia, for concomitant sympathectomy of an extremity with compromised circulation, to lessen discomfort from the tourniquet, when infection in the arm necessitates a higher anesthetic approach and when the shoulder girdle is operated upon.

The supraclavicular block is most appropriate for surgery of the upper arm, elbow, forearm and radial aspect of the hand. The axillary technique results in preferential blockade of the median and ulnar nerves and, possibly, in blockade of the radial nerve. Some 90% of successful supraclavicular blocks show signs of success within five minutes of the injection, because of the rapid development of motor blockade. This blockade is attributable to the fact that, at this point, the motor fibers comprise the mantle while the sensory fibers are in the core of the trunks and cords. Therefore, the anesthetic agent must first diffuse through the motor fibers to reach the sensory fibers.

The T-2 branch that supplies sensation to the posterior aspect of the upper arm frequently is missed in the axillary approach. The discomfort of a tourniquet, when it is required, is one of the most frequent complaints of patients. The T-2, as a component of the trunks lying above the first rib, can be blocked by a successful supraclavicular approach.

One accepted method of doing an axillary block is to puncture the artery to help locate the nerves. This may cause the artery to go into spasm. If the block is being done for a vascular procedure, then the spasm may interfere with the contemplated surgery. By doing the supraclavicular block,

![Figure 1](image1.png)

Figure 1
Anatomical drawing of the brachial plexus as it emerges from the cervical vertebra and proceeds under the clavicle and over the first rib.

![Figure 2](image2.png)

Figure 2
The brachial plexus as it lies on the first rib. Note the groove worn in the rib by the artery.
such an occurrence can be avoided. Puncture of an artery is not sought, and if it does happen it does not result in a reduction of blood flow within the arm. In fact, there is a 270% rise in blood flow within an arm that has a supraclavicular block.6

In the event that anesthesia is needed for a surgery on the macrocirculation or microcirculation of the arm, then a supraclavicular block will increase the flow volume by 270%, the flow velocity by 240% and the mean skin temperature by 2.8° C. If epinephrine is added to the injected solution, then the flow volume will increase 430% and the flow velocity 380%, as the temperature rises 6.4° C. This finding seems to indicate that the addition of epinephrine is indicated clinically where increased flow to the arm would be advantageous postoperatively. These increases had not returned to normal values after 24 hours in one of the author’s patients in whom they were checked.8

As with all techniques and procedures there are contraindications, including an uncooperative patient, a patient with a frame in which bone and muscle landmarks are not clear or a respiratory cripple.6 The techniques also are not suitable for patients with a fear of needles, coagulopathy, a platelet count less than 100,000 or an infection in the area of the needle insertion. They should be avoided in the oversedated patient and the patient without sufficient mental capacity, as well.

The main disadvantage of supraclavicular block is pneumothorax, which occurs at a rate of 0.5% in between 4% and 6% of patients, depending upon the author being cited. Coughing while paresthesias are being sought may indicate a pleural puncture, thereby necessitating immediate termination of the block procedure.10 However, the rate of pneumothorax will decrease as the anesthesia operator becomes more skilled. Other complications include block of the phrenic nerve (a chest film taken shortly after the block not uncommonly will show an elevated diaphragm 67% of the time), Horner’s syndrome and high blood levels of the anesthetic agent secondary to inadvertent intravascular injection or rapid absorption.

Techniques

The classic Kulenkampf approach involves blocking the plexus as it lies superior to the first rib, lateral to the subclavian artery. The patient lies with his head turned to the contralateral side. A skin wheal is raised 1 cm over and immediately lateral to the midpoint of the clavical. A 5 cm long, fine-gauge needle is inserted at an angle of about 80° to the skin. Cautiously, the needle is directed caudad, mesiad and dorsad until contact is made either with the first rib or the brachial plexus.1,12 In case of contact with the first rib, the needle tip is beyond the plexus. In this instance, the needle should be withdrawn and redirected.2

The main problem with teaching the Kulenkampf technique is that it is rather difficult to describe. The needle is directed caudad, or toward the tail; mesiad, or toward the sagittal plane, or dorsad, or toward the spine. These three separate directions can be incorporated into one direction, aimed at the midpoint between the coccyx and the anus.

The technique advocated by Dupre et al. in their 1982 article relies on superficial and easily identifiable landmarks.2 It also starts with the patient’s head turned contralaterally and with the arm adducted to the side. The patient is instructed to raise his head, bringing the clavicular and sternal heads of the sternocleidomastoid (SCM) muscle into view. The location of the top of the supraclavicularis minor fossa is marked on the skin with ink. The anesthetist then moves his or her index finger laterally along the upper border of the clavicle until the internal clavicular insertion of the trapezius muscle is palpated. This point also is marked with ink. A line then is drawn on the skin between these points. Next, the external jugular vein is located. (Positioning the patient in the Trendelenberg position and/or having the patient cough will help make locating the vein easier). This intersection is the point of insertion of the needle. Make a skin wheal with the local at this point. Insert a 2.5 cm needle (note the length) through the wheal and advance it slowly caudad, slightly lateral and forward. Avoid puncturing the external jugular vein. During insertion, the operator’s hand should rest upon the auricle of the patient’s ear. By using this technique, inexperienced anesthesiologists in Dupre’s study had a failure rate of only 2.2%.2

Winnie’s single injection technique within an interfascial compartment has some aspects similar to Dupre’s technique. Winnie has the patient reach for his or her knee to lower the clavicle. The patient then relaxes and turns his or her head to the side and lifts it, bringing the clavicular head of the SCM into prominence. Starting at the lateral border of the SCM, roll the index finger laterally until the interscalene groove is found. Then move the finger down the groove until the subclavian artery is found. Insert the needle just above the finger. Direct the needle parallel to the borders of the scalene muscles, which insert on the first rib. Slowly advance the needle until the click of sheath
penetration can be felt, then elicit paresthesia. After aspiration inject the entire amount of local solution.\(^\text{11}\)

The relationship between the amount of solution and the extent of the area anesthetized has been shown. A 20 ml dose will almost exactly duplicate a block to 40 ml in an axillary block (Figure 3). A 40 ml dose will have a higher and lower spread, so that cervical, as well as brachial plexus, blockade can occur\(^\text{11}\) (Figure 4). No matter how great the volume injected, the solution must be placed correctly. This author has found that, whichever technique is chosen, the principle of "no paresthesia, no anesthesia" is of great value in keeping the failure rate to a minimum.

The three most commonly used drugs in brachial plexus blocks are lidocaine, 2-chloroprocaine and bupivacaine. Lidocaine is chosen because of its slim molecular shape, a pKa close to the physiologic pH, and a moderate lipid solubility that has an excellent spreading capability. The duration of the block is approximately 60 minutes. A safe dosage range of this drug is 4.5 mg/kg without epinephrine.\(^\text{12}\)

Chloroprocaine, the only ester linkage (-COO-) drug of the three, is one of the least toxic anesthetic agents in common use today. Compared to procaine, chloroprocaine has improved spreading qualities and achieves a more reliable blockade. The essential difference between procaine and chloroprocaine is that procaine is hydrolyzed in the blood four times more rapidly. This same characteristic also is the drug's primary disadvantage—a duration of about 45 minutes. After injection and prepping of the surgical area, this short duration leaves very little time for the procedure itself. A safe dosage range of chloroprocaine is 11 mg/kg, or a maximum total dose of 600-800 mg.

All ester local anesthetics are derived from para-aminobenzoic acid (PABA), except cocaine; the

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**Figure 3**
The extent of anesthesia with 40 ml of local anesthetic in an axillary block or 20 ml of local anesthetic in a supraclavicular block. The shaded areas are those most likely to be missed by an axillary block.

**Figure 4**
The area of spread of 40 ml of local anesthetic given in a supraclavicular block.
original ester of this family. Ester locals are degraded within the body through hydrolysis by pseudocholinesterase within the plasma.\(^9\) Sometimes a patient who has an allergy to one ester local will have problems with others of the same class because of the PABA base. Therefore, it always is important to be cognizant of any known drug allergies with which the patient may present.

The short duration of these drugs is the reason why they frequently are mixed with bupiva-
caine for a longer duration block in many institu-
tions. Bupivacaine is approximately four times more potent than lidocaine, an increase that is accompanied by proportionately greater toxicity. The drug is not taken up by erythrocytes to any extent; therefore, whole blood concentrations are considerably lower than plasma concentrations. The duration is approximately three hours with both the 0.25% and the 0.5% concentrations (an-
algesia can last up to 24 hours), but the time of onset also can be extended.\(^9\) A 0.75% concentration is not recommended for use in this block; the maximum safe dose for bupivacaine is 175 mg.\(^{12}\)

These safe dosage ranges are for total body dosages, not for a single brachial block. Therefore, caution should be used if bilateral blocks or a block with supplemental local infiltration is contemplated. Remember, the smallest dose and the lowest concentration required to produce the desired result should be used in any case.

R.H. deSong has compared the action of local anesthetics on a nerve to that of water on a fuse. A short, damp portion will slow the progress to a sputtering, slow motion or a complete stop, but once it is across the dampness, the spark moves normally.\(^{18}\)

Local anesthetic agents have the property of blocking nerve impulse conduction. Other agents also have this property (phenol and alcohol), but local anesthetics are the only ones capable of reversal. These drugs progressively lower the amplitude of the action potential, retard the rate of rise of the threshold, elevate the firing threshold, slow the velocity of impulse conduction and lengthen the refractory period.

Evidence exists that local anesthetics impede sodium ion access to the axon interior by way of the sodium pump. With the entrance to sodium denied, depolarization cannot take place; thus, the axon remains polarized. The exact location of the local anesthetic's channel blocking action still is uncertain.

Local anesthetics and their attachment to phospholipid membrane components is known. The negatively charged phosphate tails of the phospholipid molecule are essential to excitability. Local anesthetics have two positively charged ends which attach to these anionic phosphate tails. This stable molecule may be responsible for the inability of the sodium gate to open.\(^9\)

In recent years, the advent of electrolocation has gone a long way toward replacing the "feel" or "click" of regional anesthesia administration. Nerve stimulators may be utilized to ensure close prox-
imity to the desired nerve.

An insulated needle is very advantageous, but not an absolute necessity. If it is used, then one electrode is clipped to an ECG pad on the arm or shoulder while the other is clamped directly onto the needle. The needle is inserted and di-
rected using one of the techniques discussed earlier. As the needle tip comes into proximity with the nerve, muscle contractions will occur within the extremity. Then the stimulator is turned to its lowest setting (0.3-0.5 mA) and the needle is repositioned to cause maximal muscle contraction. A 1 ml test dose of the chosen local anesthetic is given after gentle aspiration. If the contractions disappear rap-
idly, the needle is in very close approximation to the nerve trunk. After aspirating again, the re-
maining dose is injected.

It has been shown that if the paresthesia is in the index, middle or ring finger, the success rate is much higher (99%) than if it is felt in the thumb, little finger or hand.\(^{14}\) The author believes this should be the only exception to the "no pares-
esthesia" rule.

If electrolocation is not used to find the bra-
chial plexus then, whichever technique is chosen, the cooperation of the patient is essential to the suc-
cessful administration of a supraclavicular block. The anesthetist is responsible for inserting the needle and injecting the local anesthesia agent, but the patient is a necessary component of the tech-
nique. He or she must be awake enough to tell the anesthetist when the placement is correct. This re-
ationship should be explained to the patient prior to initiation of the block. An oversedated patient cannot respond adequately to tell the anesthetist "now" when a paresthesia is felt, as opposed to uttering a simple "ouch" whenever some discom-
fort is felt in the area of needle insertion.

Whichever technique is used, the landmarks can be identified and the block accomplished in a relatively short period of time. The lessening of tourniquet discomfort makes the supraclavicular a more pleasant block for the patient who is having a procedure that lasts more than 30 minutes.
greater speed of onset relative to an axillary block, if lidocaine or chloroprocaine is used, and the absence of shouler movement in response to tourniquet pain make the supraclavicular a block that both the anesthetist and the surgeon can appreciate.

The use of the supraclavicular block has waxed and waned over the years, as has the use of all regional anesthesia. But with the local anesthesia agents available today and the resurgence of interest in all forms of regional blocks, the supraclavicular block is a valuable tool for use as a first-line anesthetic approach.

REFERENCES

SUGGESTED READING

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