

# Ultrasound-Guided Supraclavicular Brachial Plexus Blocks: A Review Article

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## **Abstract**

**Back ground:** The brachial plexus provides somatic motor and sensory innervations to the upper limb including the scapular region. Brachial plexus block is used to provide anesthesia and analgesia to the upper limb from the shoulder to the fingertips.

**The purpose of this review article:** It is highlighting on the anatomy of brachial plexus, ultrasound anatomical structures that are seen from the supraclavicular approach, indications, contraindications, preoperative evaluation and preparation, equipment, technique, the commonly used local anesthetics, the commonly used adjuvant, advantages, disadvantages and complications of US-guided supra-clavicular brachial plexus block.

**In conclusion:** Brachial plexus block can provide significant intra and postoperative pain relief in upper limb surgical procedures compared to general anesthesia alone. The use of ultrasound guidance has not only allowed for a reduction in complications due to incorrect needle placement, but also avoidance of other complications and improved overall block efficacy, especially in patients with anatomical variations.

**Keywords:** Anatomy of brachial plexus; Approaches of brachial plexus block; Method of nerve localization for regional anesthesia; Regional anesthesia for upper limb; Ultrasound guided brachial plexus block.

## **Introduction:**

Brachial plexus block is popular and commonly used for providing perioperative anesthesia and analgesia to upper limb from the shoulder to the fingertips [1].

It is well established that brachial plexus blocks provide superior postoperative pain management compared to general anesthesia alone. Using catheter-based continuous infusions for brachial plexus blocks is superior to single-injection brachial plexus blocks for decreasing perioperative pain scores and opioid consumption requirements for various upper extremity surgeries [2,3].

There are four approaches for block of brachial plexus. These approaches are interscalene [4], supraclavicular [5], infraclavicular [6] and axillary approaches [7].

Blind localization of brachial plexus as via elicitation of paraesthesia by mechanical stimulation or elicitation of motor response by electric stimulation was associated with some complications as block failure, vascular injury, nerve injury, pneumothorax, injection of local anesthetic into the spinal column or vascular system [8,9].

With introduction of ultrasound as a guide for brachial plexus block, the incidence of these complications decreased because of the ability of visualization of vascular, nervous and pleural structures [10] The use of ultrasound has also resulted in faster block performance time and onset time [11] improving the efficiency and block success [12].

The selected approach to blocking the brachial plexus depend on the indication, the region of the planned surgical procedure, the associated medical co morbidities, and individual anatomical variants [4,13].

Exact needle placement is vital for successful block delivery. The choice and placement of the ultrasound probe are key factors in successfully using brachial plexus blocks. In addition, proper anatomic recognition is essential for successful ultrasound-guided brachial plexus blockade and patient safety [14].

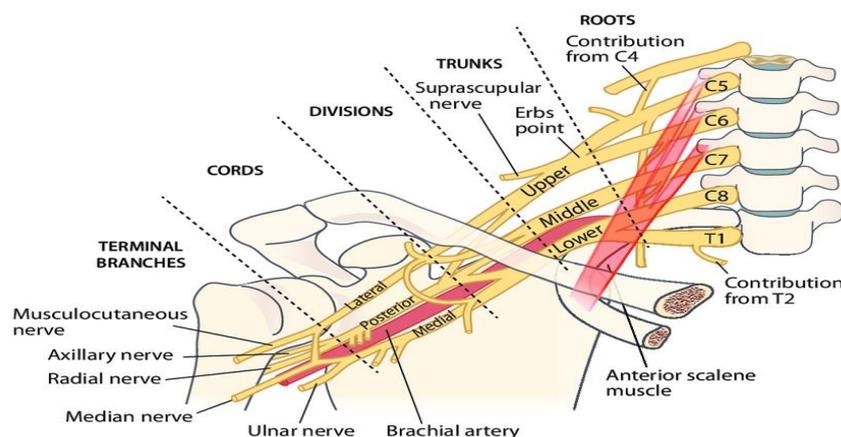
This review article highlights the anatomy of brachial plexus, the methods of nerve localization in regional anesthesia, the various approaches for block of brachial plexus, the indications, contraindications, technique of using ultrasound for nerve localization, the commonly used local anesthetics in regional block, the commonly used adjuvant to local anesthetics, block dynamic, the advantages, the disadvantages and the complications of the ultrasound-guided supraclavicular brachial plexus block.

This review article highlights on the anatomy of brachial plexus, ultrasound anatomical structures that are seen from the supraclavicular approach, indications, contraindications, preoperative evaluation and preparation, equipment, technique, the commonly used local anesthetics, the commonly used adjuvant, advantages, disadvantages and complications of US-guided supra-clavicular brachial plexus block.

### **Anatomy of brachial plexus:**

The anatomy of the brachial plexus comprises five anatomical structures. These are nerve roots, trunks, divisions, cords, and terminal branches [15].

The nerve roots arise from C5 to T1. These roots join above the clavicle to form the superior (C5, C6), middle (C7), and inferior trunks (C8, T1). The trunks pass under and in close proximity to the clavicle; they can easily be blocked at this level. Distal to the clavicle, the trunks split into the lateral (C5 to C7), posterior (C5 to T1), and medial (C8, T1) cords, found adjacent to the axillary artery. Finally, the terminal nerve branches are formed from the cords in the axilla (**Figure 1**). The median nerve is formed from the medial and lateral cords and is usually superficial to the axillary artery. The ulnar nerve is formed from the medial cord and is generally located lateral to the axillary artery. The radial nerve is located deep and lateral to the axillary artery. The last terminal branch, the musculocutaneous nerve, branches off from the lateral cord and pierces through the coracobrachialis in the proximal axilla [16].

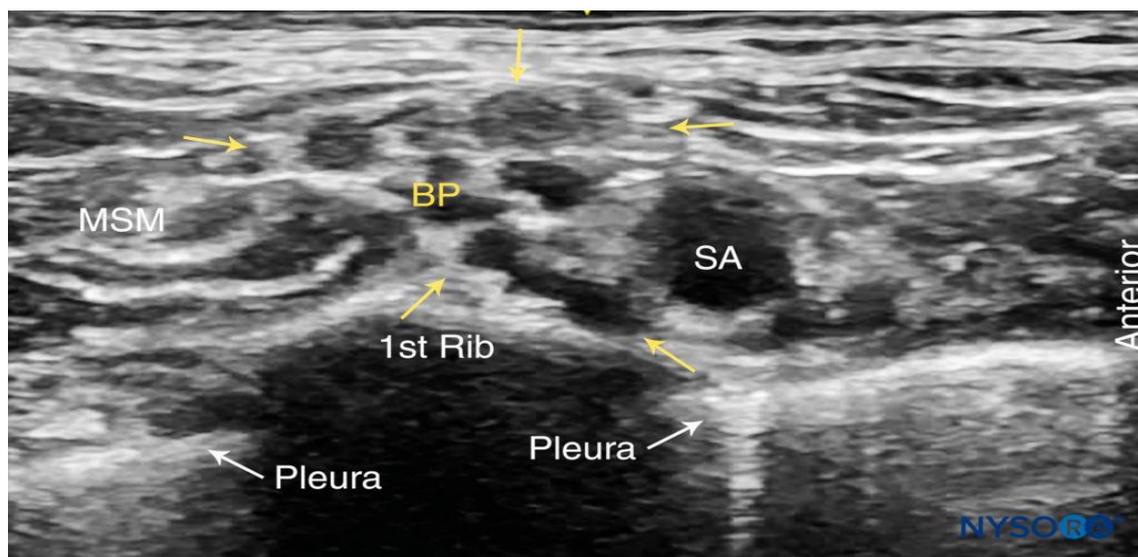


**Figure (1):** Anatomical illustration showing the five anatomical structures (nerve roots, trunks, divisions, cords, and terminal branches) of the brachial plexus [17].

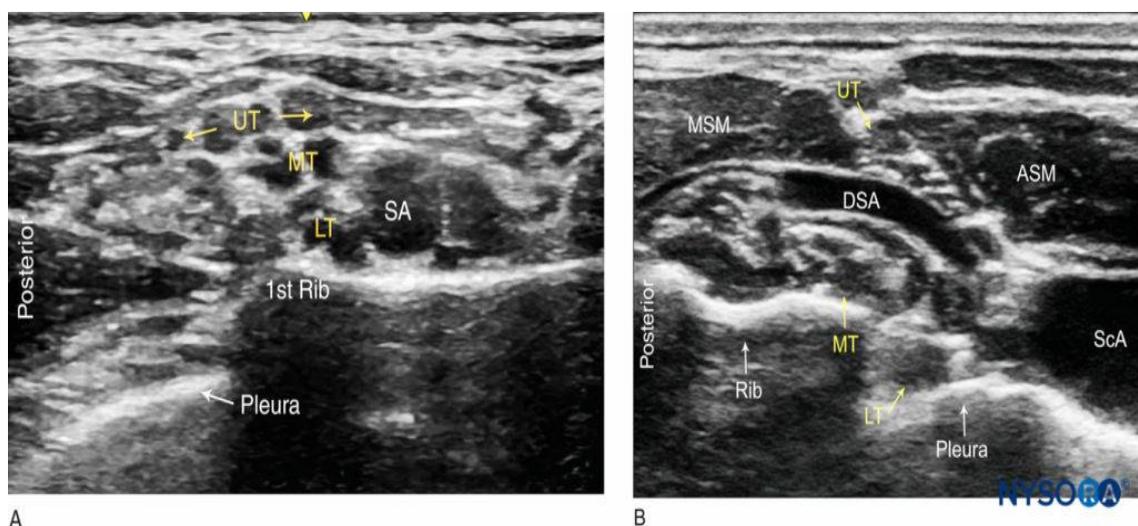
### **Ultrasound anatomical structures that are seen from the supraclavicular approach:**

The subclavian artery (SCA) crosses over the first rib between the insertions of the anterior and middle scalene muscles, posterior to the midpoint of the clavicle. The SCA is readily apparent as an anechoic round structure, whereas the parietal pleura and the first rib can be seen as a linear hyperechoic structure immediately lateral and deep to the SCA (**Figure 2**). The rib casts an acoustic shadow so that the image field deep to the rib appears anechoic.

The brachial plexus (BP) can be seen as a bundle of hypoechoic round nodules just posterior and superficial to SCA (**Figure 2 and 3**). It is often possible to see the fascial sheath of the muscles surrounding the BP. Adjusting the transducer orientation, the upper, middle and lower trunks of BP can be individually identified, as they join together at the costoclavicular space. To visualize the lower trunk, the transducer is oriented in the sagittal plane, until the first rib is seen deep to BP and SCA (**Figure 3**). Anterior or posterior to the first rib is the hyperechoic pleura, with lung tissue deep to it. This structure can be confirmed by observing a “sliding” motion of the viscera pleura in synchrony with the patient’s respiration. The BP is typically visualized at a 1- to 2-cm depth at this location. The presence of two separate clusters of elements of the BP may be more or less obvious, sometimes with separation by a SCA (**Figure 3**). The dorsal scapular artery commonly passes through or within the vicinity of BP. It is important to recognize that the more superficial and lateral branches come from C5–C7 (shoulder, lateral aspect of arm, and forearm) and can be tracked up to the interscalene area, whereas the deeper and more medial contingent are branches of C8 and T1 (hand and medial aspect of forearm). Adequate spread of local anesthetic in both areas is necessary for successful nerve block of the arm and hand [18].



**Figure (2):** Supraclavicular brachial plexus (BP; yellow arrows) seen slightly superficial and posterolateral to the subclavian artery (SA). The brachial plexus is enveloped by a connective tissue sheath. Note the intimate location of the pleura and lung to the brachial plexus and subclavian artery. MSM, middle scalene muscle [18].



**Figure (3):** Ultrasound images of the brachial plexus cephalad to the clavicle. (A) Sagittal view: The upper (UT), Middle (MT) and lower (LT) trunks of the brachial plexus are seen posterior to the subclavian artery (SA) and superficial to the first rib. (B) Oblique view: The upper trunk (UT) is positioned between the anterior

(ASM) and middle (MSM) scalene muscles. The lower trunk (LT) and the subclavian artery are superficial to the pleura [18].

**Indications of supraclavicular brachial plexus block [19, 20]:**

**a. Anesthetic indications:**

- As sole anesthesia for upper limb surgery from the mid-humerus to the fingertips.

**b. Analgesic indications:**

- For providing post-operative analgesia in upper limb surgery from the mid-humerus to the fingertips.
- The duration of the block can be prolonged by the addition of adjuvant as opiate (pethidine 0.5 mg/kg) to the local anesthetic or by continuous infusion of LA via insertion of epidural catheter.

**c. Therapeutic indication:**

- For providing analgesia in chronic pain problems in upper limb from the mid-humerus to the fingertips.

**d. As adjuvant to general anesthesia (GA).**

- For upper limb surgery from the mid-humerus to the fingertips.

**e. As pre-emptive analgesia i.e.** before upper limb surgery from the mid-humerus to the fingertips under GA to avoid post operative pain.

**Contraindications [21-23].**

1. Patient or (parents in pediatrics) refusal.
2. Uncooperative adult patients.
3. Pathological abnormalities at the site of injection as:
  - *Infection near the site of the needle insertion.*
  - *Open wounds at the site of injection.*
  - *Mass at the site of injection.*
5. History of allergy to LA.
6. Peripheral neuritis.
7. Digitalized patient (LA has quinidine like effect).
8. Myasthenic patient (LA has non-depolarizing muscle relaxant effect).
9. Severe liver disease and coagulopathy .
10. Patients using respiratory accessory muscles e.g. chronic obstructive lung disease and bronchial asthma as inevitably accessory respiratory muscles and ipsilateral diaphragmatic paralysis (phrenic nerve block in about 50% of the patients) and pneumothorax (although less likely with ultrasound use) may significantly worsen their respiratory status. An example of this relative contraindication is known pneumonia on the contralateral side.

**Preoperative evaluation and preparation [24, 25]:**

These are like prior to general anesthesia but with the following considerations:

- The patient's cardiac, hepatic, muscles status should be examined.
- The site of injection should be examined for its suitability for injection.
- History of digitalis, anticoagulants.

- Laboratory assessment of the patient's coagulation status is necessary if there is any doubt regarding coagulopathy or anticoagulation therapy.
- INR (or prothrombin time), activated partial thromboplastin clotting time (APTT) and absolute platelet count should be within the normal range.
- If there is doubt about platelet function in the presence of a normal platelet count, a haematologist's advice should be sought.
- Procedure explanation.
- Obtaining patient informed consent.
- Control of any medical problems.
- Giving instruction for the fasting period if an elective procedure is planned.
- Prescribing pre-medication if indicated.

#### **Equipment:**

The equipment needed for US-guided supraclavicular brachial plexus block include the following: [26].

- A portable ultrasound machine with high-frequency (more than 10 MHz) linear ultrasound probe, sterile sleeve and gel.
- Sterile skin preparation solution, sponges/gauze, drape, marking pen, ultrasound gel, hypodermic needles for skin infiltration and dressings for covering the needle or catheter insertion.
- Skin disinfectant solution (Chlorhexidine 2% or povidone-iodine), sponges/gauze, drape, marking pen, hypodermic needles for skin infiltration.
- A 3 ml syringe with 25- to 27-gauge needle for skin infiltration.
- A 20 ml syringe with extension tubing.
- Short bevel echogenic block needle (10 cm, 22 gauge for single-injection or 10 cm, 18 gauge for a continuous catheter).
- Sterile gloves.
- Local anesthetic; for longer duration blocks, bupivacaine 0.5% or ropivacaine 0.5%; for shorter blocks or skin infiltration, lidocaine 2% or mepivacaine 1.5%
- Standard vital sign monitoring equipment (noninvasive blood pressure and rhythm monitoring, with or without pulse oximetry).

#### **Technique of US-guided supraclavicular block:**

##### **1. Patient and anesthesiologist positions:**

This nerve block can be performed with patient in supine, semi-sitting or slight lateral position with the patient's head turned away from the side to be blocked. The patient is asked to depress the ipsilateral shoulder, abduct the ipsilateral arm and/or flexe the ipsilateral elbow joint (**Figure 4**).

Anesthesiologist performing the block should be positioned at the head of the bed, with the patient, the block area and the ultrasound screen all in line, ensuring a clear view during the procedure [27].



**Figure (4):** Supraclavicular brachial plexus nerve block: A female patient lying in a supine position with slight elevation of her head, that turned to the contralateral side of the block [27].

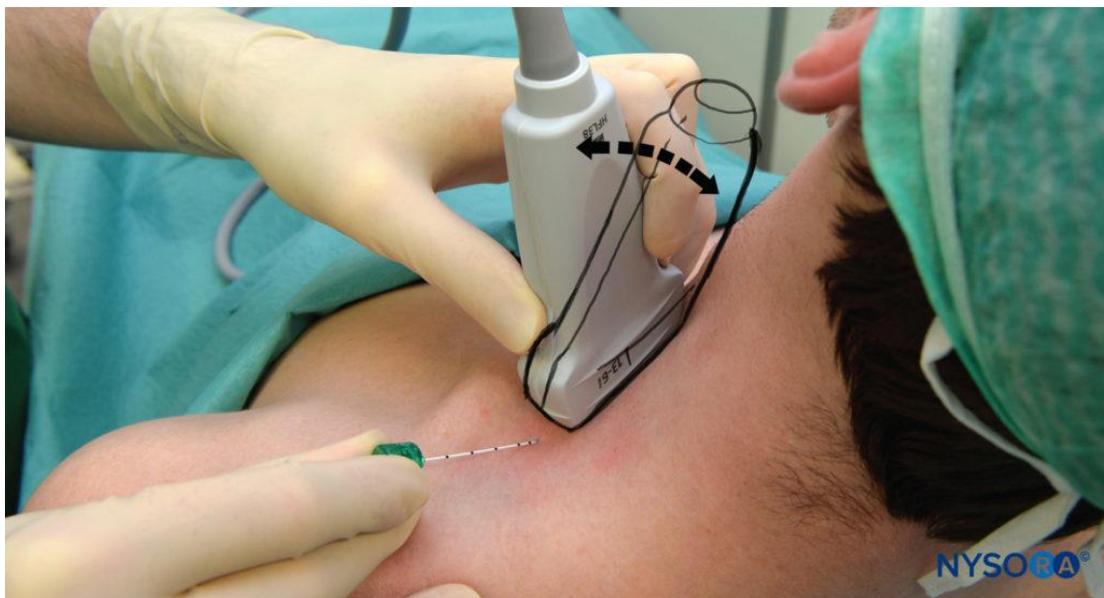
### 3. Cleaning the site of injection:

To ensure cleanliness, the skin over the injection site should be cleansed with skin disinfectant solution (chlorhexidine 2% or povidone-iodine) and allowed to dry. The sterile gel should be applied to the probe; then, a sterile probe cover should be placed with additional sterile gel on the exterior surface of the probe cover [28].

### 4. Probe placement:

The transducer is positioned in the transverse plane immediately proximal to the clavicle, slightly posterior to at its midpoint [18].

The transducer is tilted caudally, as if to image the chest contents, to obtain a cross-sectional view of the SCA (Figure 5). On the ultra-sound screen, SCA (the key sono-graphic landmark) is seen as a round, pulsating hypochoic structure (Figure 6) that confirmed via colour Doppler [29]. Also on ultra-sound screen, BP has a grape-like appearance (Figure 6), with several hypochoic bundles embedded in a hyperechoic supporting connective tissue surrounded by epineurium, found posterolateral to the SCA [30].



**Figure (5):** A photo showing US-guided supraclavicular brachial plexus nerve block: Transducer position just proximal the clavicle and in plane needle position. The BP is very shallow at this location, typically 1–3 cm; therefore, inclination of the needle should be equally shallow. The image also shows the caudal tilt that is useful

in obtaining best image of the plexus. To achieve the best possible view, the transducer often must be tilted slightly inferiorly. The goal is to see the SCA in the transverse view and the brachial plexus just superficial and posterior to the SCA, enclosed within the BP sheath. Transducer rotation clockwise often facilitate best imaging of the tissue space (sheath) containing BP [18].

## 6. Needle insertion:

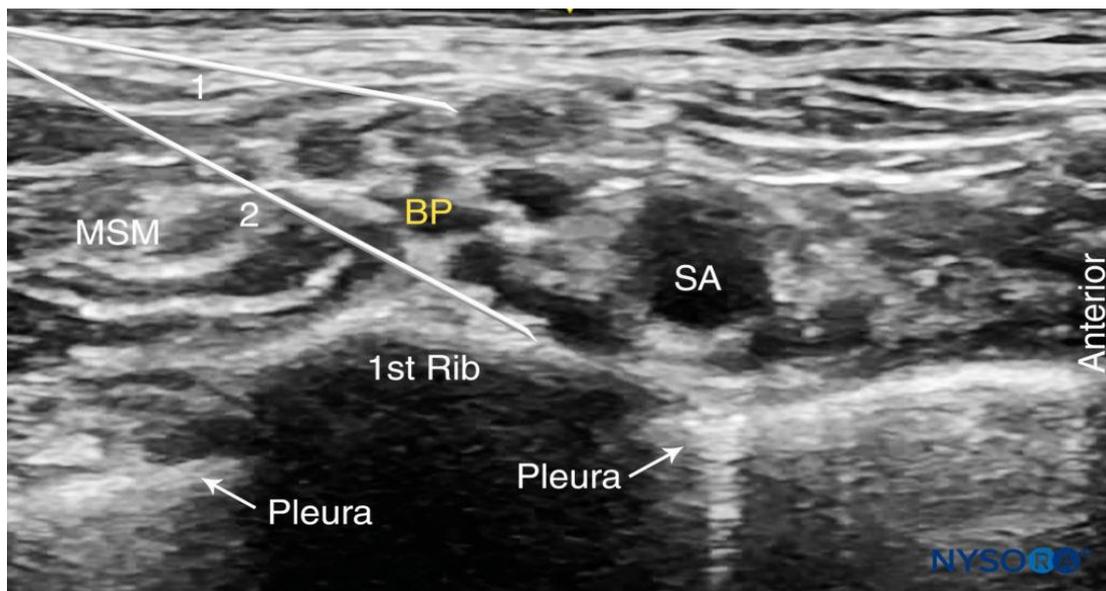
The goal of this nerve block is to place the needle within the brachial plexus sheath posterior to the SCA and inject local anesthetic to surround the trunks and divisions of the BP at this level.

Using a 25- to 27-gauge needle, 1–2 mL of local anesthetic is injected into the skin 1 cm lateral to the transducer to decrease discomfort during insertion of BP block needle.

The needle should be inserted using the in-plane technique at the lateral border of the probe (**Figure 5**). Once the skin has been pierced, the needle should be advanced in a lateral to medial direction—in the same plane as the ultrasound beam—towards the BP located posterolateral to the subclavian artery (**Figure 6**). The reason for advancing the needle in the same plane as the ultrasound probe is so that the entire length of the needle and the needle tip is visible as it is directed towards the brachial plexus. The needle should pierce the axillary sheath, which offers a small amount of resistance or the characteristic ‘pop’ sensation. The needle tip is then carefully directed as close to the brachial plexus as possible. The ideal location is at the junction of the brachial plexus and the posterolateral border of the subclavian artery, superior to the first rib (**Figure 6**). This area is referred to as the ‘corner pocket’ or common injection site for this approach [31].

To avoid inadvertent puncture of and injection into BP, the block needle should not be initially inserted deeper than 1 cm, then inserted in plane toward BP, in a lateral-to-medial direction [31].

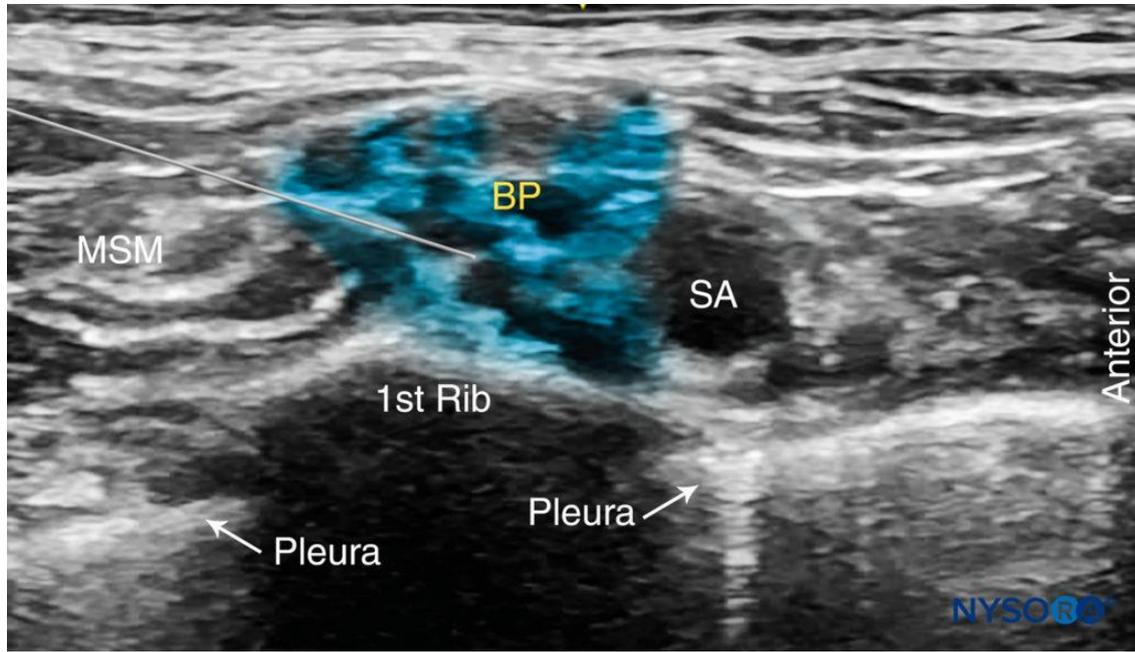
. Two needle path and two needle positions (1 and 2) are used to inject local anesthetic within the connective tissue sheath (arrows) containing BP to cover all trunks and divisions (**Figure 6**).



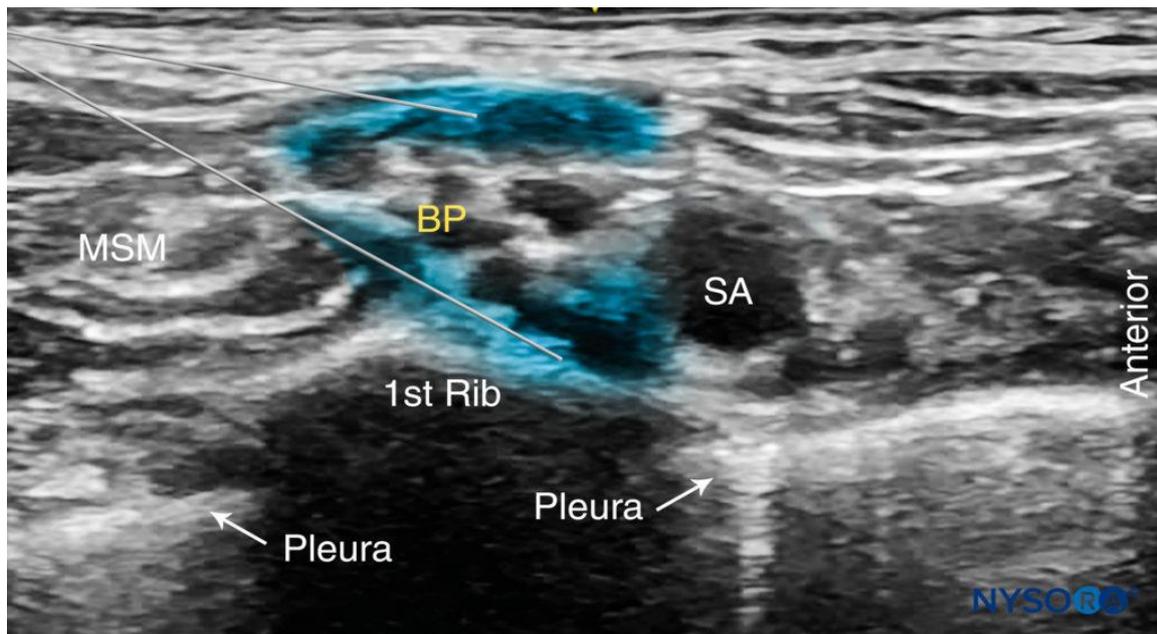
**Figure (6):** Ultrasound image showing: a. SA (the key sono-graphic landmark in US guided supraclavicular brachial plexus) is seen as a round, pulsating hypoechoic structure. b. BP has a grape-like appearance, with several hypoechoic bundles found posterolateral to the SA, c. Two needle path and two needle positions (1 and 2) are used to inject local anesthetic within the connective tissue sheath (arrows) containing the brachial plexus (BP). SA= Subclavian artery, BP= Brachial plexus [18].

### 7. Local anesthetic injection and visualizing its spread:

Once the tip of the needle becomes within the axillary sheath posterior to the SCA, the local anesthetic can be injected. The spread of the solution around the BP should be observed on the screen. Local anesthetic solution appears as a hypoechoic fluid and appears black on the ultrasound image (**Figures 7 and 8**). The exact volume can then be judged, and the injection stopped once all the nerve structures have been bathed in local anesthetic solution, thus avoiding the introduction of excessive and unnecessary amounts of local anesthetic [27].



**Figure (7):** Ultrasound image showing needle path and the spread of local anesthetic (blue-shaded areas) after a single needle injection position within the connective tissue sheath surrounding the brachial plexus (BP) [18].



**Figure (8):** Ultrasound image showing needle path and the desired spread of local anesthetic (blue-shaded areas) after a two different needle injection position within the connective tissue sheath surrounding the brachial plexus (BP) [18].

### **Continuous supra-clavicular brachial plexus block:**

The goal is to place the catheter within the vicinity of the trunks and divisions of the brachial plexus adjacent to the subclavian artery.

The procedure consists of three phases: (1) Needle placement as in single shot technique (2) Catheter advancement; and (3) Securing the catheter.

For the first two phases of the procedure, ultrasound can be used to ensure accuracy in most patients. The needle is typically inserted in plane from the lateral-to-medial direction so that the tip is just posterior to the brachial plexus sheath. The needle is then advanced to pierce the sheath, followed by catheter placement.

The third phase of the procedure involves maintaining the needle in the proper position and inserting the catheter 2–3 cm within the vicinity of the brachial plexus.

Catheter insertion can be performed either by a single operator or with an assistant. Proper catheter location can be confirmed either by visualizing its course or by an injection of local anesthetic through it.

The catheter is secured either by taping to the skin with or without tunneling. Some clinicians prefer one over the other. However, the decision about which method to use can be based on patient age, duration of catheter therapy, and/or anatomy. Tunneling may be preferred in older patients with obesity or sagging skin over the neck or when a longer duration of catheter infusion is expected. Two main disadvantages of tunneling are the risk of catheter dislodgement during tunneling and the potential for scar formation.

The starting infusion regimen is typically 5-8 mL/h of bupivacaine 0.125% with 3-5 mL patient-controlled boluses hourly. A catheter-over-needle technique has also been described [27].

### **The commonly used local anesthetics in regional block:**

The commonly used local anesthetics in regional block are: i. Short-acting as lidocaine and prilocaine, ii. Intermediate-acting as mepivacaine and, iii. Long-acting as bupivacaine and ropivacaine [32].

### **The commonly used adjuvant to local anesthetics in regional block:**

Various drugs are commonly used adjuvant to local anesthetics in regional block as opioids, epinephrine, alpha-2 adrenergic antagonists, steroids, anti-inflammatory drugs, midazolam, ketamine, magnesium sulfate and neostigmine [33].

### **Advantages of supra-clavicular brachial plexus block:**

- It is the easiest and most effective approach for brachial plexus block.
- It provides consistently effective anesthesia and analgesia for upper limb surgery below the shoulder joint [11, 34].
- At this level, the trunks of the brachial plexus are tightly packed giving it the nickname "the spinal of the arm." . This allows for local anesthetic to cover a maximal number of nerves [35].

### **Disadvantages of supra-clavicular brachial plexus block:**

- Liability to pneumo-thorax, vascular injury, Horner syndrome, phrenic nerve block, recurrent laryngeal nerve block, sparing of very distal branches, especially the ulnar nerve, can occur and systemic local anesthetic toxicity [36, 37].

### **Complications of supra-clavicular brachial plexus block:**

**1. Pneumothorax:** It is due to the anatomic proximity of the pleura. The use of US-guidance greatly minimizes the risk of pneumothorax from 6.1% without US-guidance, to 0.06% with US-guidance [37].

**2. The Horner's syndrome:** It is induced by stellate ganglion block. This **syndrome** is characterized by ptosis (drooping or falling of upper eyelid), miosis (constricted pupil), enophthalmus (posterior displacement of the globe), besides Little or no sweating (anhidrosis) and congestion of the face skin on the affected side of the face. This complication is extremely common; when high volumes of anaesthetics are used, its incidence reaches 90%. The Horner's syndrome does not require treatment and subsides spontaneously [38].

**3. Phrenic nerve block:** It causes unilateral paralysis of the diaphragm. In patients without baseline pathologies of the respiratory system, the complication is not a significant problem. The disputable issue regards patients after lung resection on the side opposite to the block or with baseline, limited efficiency of the respiratory system. According to the American Society of Regional Anesthesia, the use of ultrasound-guided block with low volumes of anaesthetics reduces the incidence of this complication. In patients with potentially reduced function of the respiratory system after the block (by about 30%) that would be clinically dangerous, phrenic nerve block is relatively contraindicated [38].

**4. Puncture of blood vessels:** The incidence of this complication is reduced after introduction of ultrasound-guided technique for supra-clavicular block. Besides the subclavian artery which is commonly excellently visualized, the dorsal scapular artery should be closely observed [38].

**5. Infection at the injection site:** It is commonly associated with continuous supra-clavicular brachial plexus block due to catheter colonization. There are no clear cut guidelines concerning possible antibiotic preventive measures [38].

**6. Nerve injury:** The incidence of long-term neurological deficits induced by blocks is very low (0.04%) because it is difficult to introduce the needle into the nerve when the nerve is not fixed (the nerve is moved rather than injected). To prevent nerve injuries, the injection of anaesthetic under high pressure should be avoided or the injection should be discontinued when patients report strong paresthesias or sudden severe pain. Moreover, an increase in the diameter of the injected structure is likely to evidence the injection into the nerve [39].

**7. Local anesthetic systemic toxicity (LAST):** It is a potentially fatal complication. The symptoms in the form of non-specific abnormalities of the central nervous system (including the circulatory arrest) can develop even 30 minutes after the provision of block, although usually occur much earlier. To counteract LAST, it is essential to follow the defined rules. Low doses of anaesthetics are recommended, in each case preceded by aspiration. The injection should be made only when the spread of hypoechogenic fluid is visible. Solutions containing markers of intravascular administration should be used, e.g. adrenaline. Sudden tachycardia and increased arterial pressure are the indication for immediate termination of the procedure. The optimal timing for the infusion of fatty emulsions has not been explicitly determined. The anesthesiological teams should undergo trainings regarding LAST; a suitable checklist should be helpful. Ultrasound-guided regional blocks have been demonstrated to reduce the incidence of LAST by even 65% [40, 41].

**In conclusion:** Brachial plexus block can provide significant intra and postoperative pain relief in upper limb surgical procedures compared to general anesthesia alone. The use of ultrasound guidance has not only allowed for a reduction in complications due to incorrect needle placement, but also avoidance of other complications and improved overall block efficacy, especially in patients with anatomical variations.

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### Conflict of interest

Nothing to declare.

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