International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

An Overview on Brachial Plexus Anesthesia

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Abstract:

Brachial plexus anesthesia represents a cornerstone in regional anesthesia for upper limb surgeries, offering effective analgesia while avoiding the systemic complications associated with general anesthesia. Various approaches to brachial plexus blockade, including interscalene, supraclavicular, infraclavicular, and axillary techniques, allow tailored anesthesia depending on the surgical site. Recent advances, particularly the use of ultrasound guidance, have significantly improved the safety, precision, and success rates of these blocks. Additionally, newer techniques such as the clavipectoral fascia block and cervical plexus block have expanded the scope of regional anesthesia for clavicular and neck procedures. This review aims to provide a comprehensive overview of brachial plexus anesthesia techniques, their anatomical considerations, clinical applications, advantages, and potential complications, with a focus on ultrasound-guided approaches and emerging regional blocks.

Keywords: Brachial plexus block; Interscalene block; Ultrasound-guided anesthesia; Clavipectoral fascia block; Cervical plexus block; Regional anesthesia; Upper limb surgery

Introduction:

Brachial plexus block remains the most important practical alternative to general anaesthesia for significant surgery on the upper limb. It provides a superior quality of analgesia and avoids the common side-effects associated with general anaesthesia such as postoperative nausea and vomiting. It can be extremely useful in patients with significant co-morbidities such as severe respiratory, cardiovascular disease, morbid obesity and in those with potential airway difficulties **(Raju and Coventry, 2014).**

Regional anesthesia of the upper limb can be achieved by blocking the brachial plexus at various locations along the course of the trunks, divisions, cords, and terminal branches, depending on which region of the upper limb is of interest. Brachial plexus blocks (BPBs) are highly important in pain management following postoperative procedures in the shoulder region and distal upper extremities **(Mian et al., 2019).**

Approaches to the Brachial Plexus:

- Interscalene Block
- Periclavicular (Supraclavicular and Infraclavicular Block)
- Axillary Block

Ultrasound-Guided Interscalene Brachial Plexus Nerve Block

General Considerations

US guidance allows for visualization of the spread of the local anesthetic and additional injections around the brachial plexus if needed to ensure an adequate spread of local anesthetic, improving nerve block success. The ability to visualize local anesthetic spread and to inject multiple aliquots also allows for a reduction in the volume of local anesthetic required to accomplish the nerve block. **(Chin et al., 2018).**

Ultrasound Anatomy

The brachial plexus at the interscalene level is seen lateral to the carotid artery and internal jugular vein, between the anterior and middle scalene muscles. The prevertebral fascia, superficial cervical plexus, and sternocleidomastoid muscle are seen superficial to the plexus. The transducer is moved in the proximal-distal direction until two or more of the brachial plexus elements are seen in the space between the scalene muscles. Depending on the depth of field selected and the level at which scanning is performed, the first rib and/or the apex of the lung may be seen. The brachial plexus is typically visualized at a depth of 1-3 cm. **(Strub et al., 2017).**

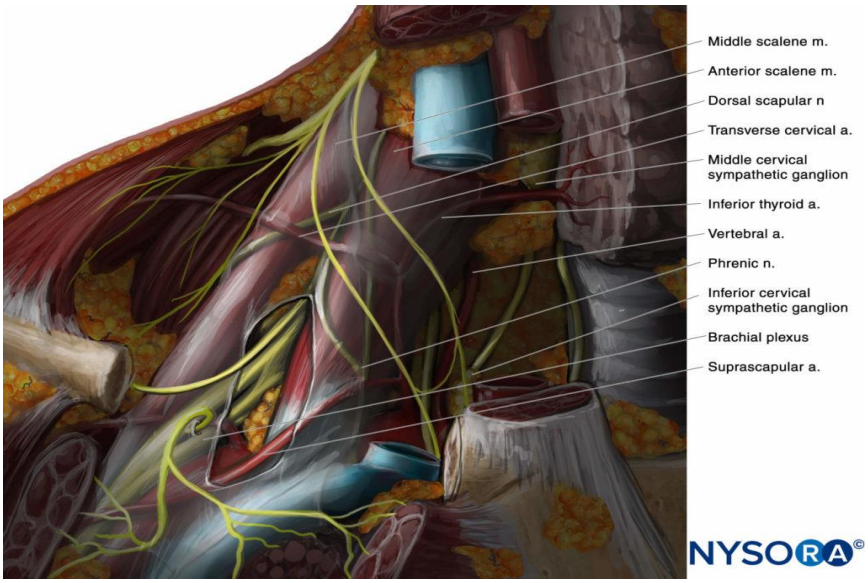

Fig. (1): Anatomic relationships of the brachial plexus at the interscalene level **(Strub et al., 2017).**

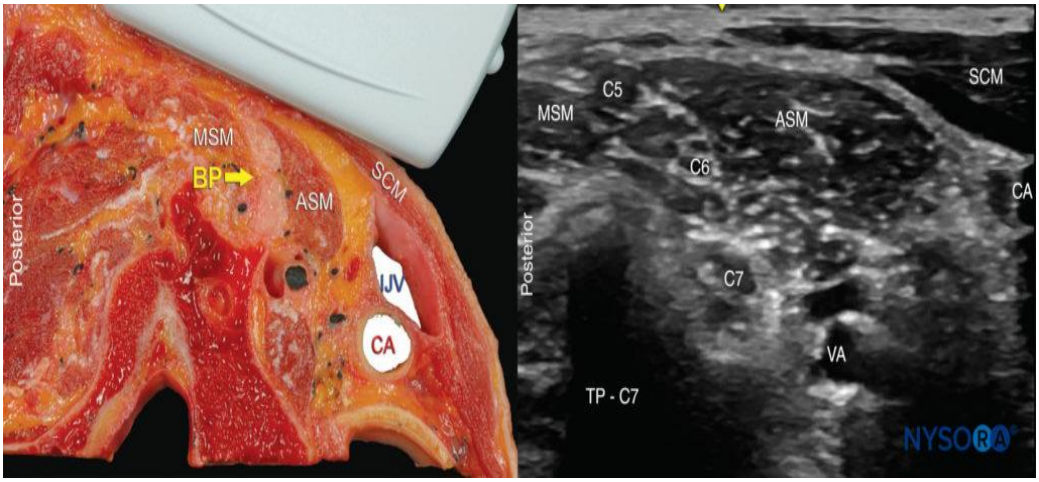

Fig. (2): Cross-section anatomy for interscalene brachial nerve block and transducer position to obtain the desired views. The plexus (BP) is seen between the middle scalene muscle (MSM) laterally and anterior scalene muscle (ASM) medially. The ultrasound image includes a partial view of the lateral border of the sternocleidomastoid muscle (SCM) the internal jugular vein (IJV), carotid artery (CA) and the transverse process of C7 (TP-C7). **(Strub et al., 2017).**

Blockade Distribution

The interscalene approach to brachial plexus blockade results in reliable anesthesia of the shoulder and upper arm. The supraclavicular branches of the cervical plexus, supplying the skin over the acromion and clavicle, are also blocked due to the proximal and superficial spread of local anesthetic. The inferior trunk (C8-T1) is usually spared unless the injection occurs at a more distal level of the brachial plexus. **(Brown, 1993)**

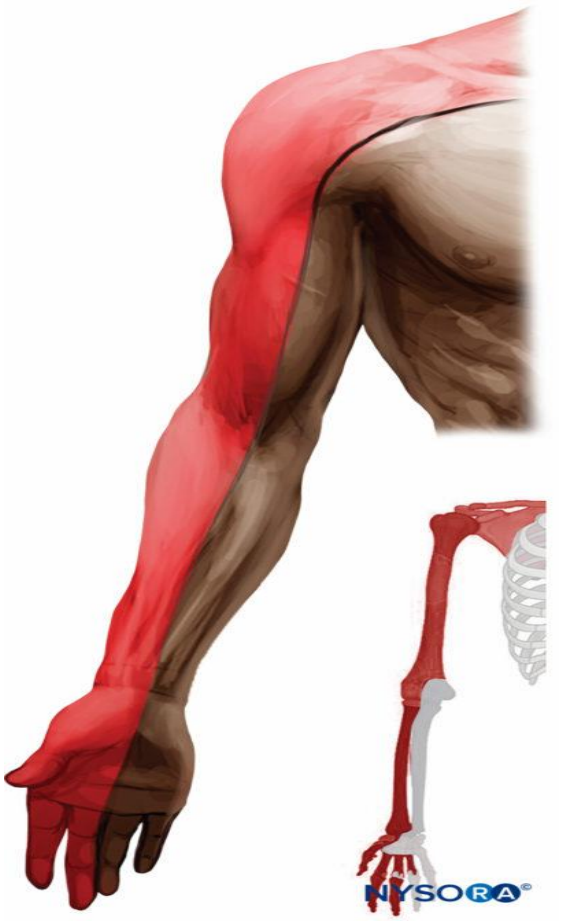

Fig. (3): Sensory distribution of the interscalene brachial plexus nerve block (in red). Ulnar nerve distribution area (C8-T1) can also be accomplished by using larger volume (e.g. 15-20 ml) and using low interscalene nerve block where the injection occurs between the ISB and supraclavicular nerve block **(Brown, 1993).**

Equipment

The equipment needed for an interscalene brachial plexus nerve block includes the following:

- Ultrasound machine with a linear transducer (8-14 MHz), sterile sleeve, and gel
- Standard nerve block tray
- A 20-mL syringe containing the local anesthetic
- A 5-cm, 22-gauge, short-bevel, insulated stimulating needle
- Peripheral nerve stimulator
- Opening injection pressure monitoring system
- Sterile gloves **(Brown, 2010)**

Landmarks and Patient Positioning

Any position that allows for comfortable placement of the ultrasound transducer and needle advancement is appropriate. The nerve block is typically performed with the patient in a supine, beach chair, or semi-lateral decubitus position, with the patients head facing away from the side to be blocked. The latter position may prove more ergonomic, especially during an in-plane approach from the lateral side, in which the needle enters the skin at the posterolateral aspect of the neck. A slight elevation of the head of the bed is often more comfortable for the patient and allows for better drainage and less prominence of the neck veins. **(Brown, 2010).**

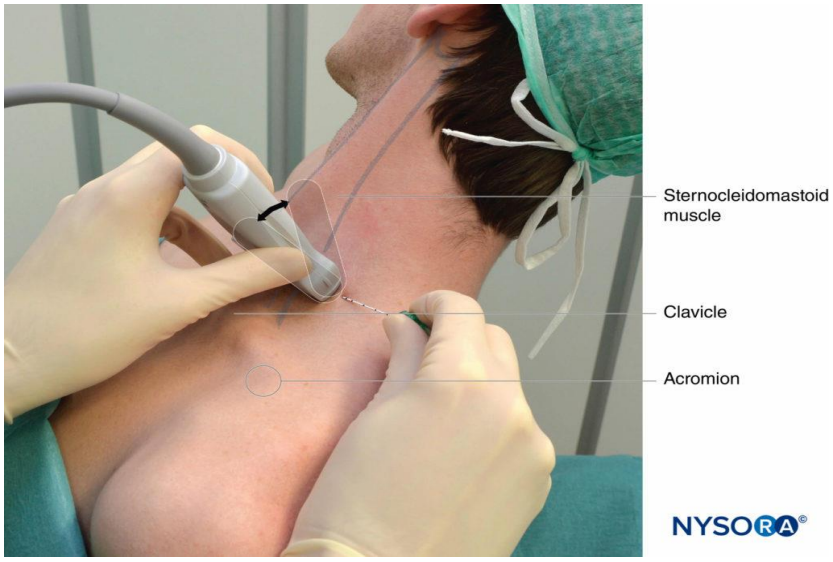

Fig. (4): Ultrasound-guided interscalene brachial plexus nerve block: transducer and needle position to obtain the desired ultrasound image for an in-plane approach. The knowledge of external landmarks substantially facilitates and shortens the time to obtain the view necessary for nerve block performance. The transducer is positioned behind the clavicular head of the sternocleidomastoid muscle (SCM) and over the external jugular vein (not seen). The patient is in a semi-sitting position. Tilting the transducer in the caudad direction can facilitate recognition of the brachial plexus (arrow) **(Brown, 2010).**

Goal

The goal of this nerve block is to place the needle in the tissue space between the anterior and middle scalene muscles and inject local anesthetic until the spread around the brachial plexus is documented by ultrasound. The volume of the local anesthetic and the number of needle insertions are determined during the procedure and depending on the adequacy of the observed spread of local anesthetic. **(Brown, 2010).**

Technique

With the patient in the proper position, the skin is disinfected and the transducer is positioned in the transverse plane to identify the carotid artery. Once the artery has been identified, the transducer is moved slightly laterally across the neck. The goal is to identify the anterior and middle scalene muscles and the elements of the brachial plexus that is located between them. It is recommended to use the color Doppler to identify vascular structures and avoid them. The needle is then inserted in-plane toward the brachial plexus, typically in a lateral-to-medial direction, although a medial-to-lateral needle orientation can also be used if there is no room for the former. The needle should always be aimed in between the roots instead of directly at them in order to minimize the risk of accidental nerve injury. **(Brown, 2010).** As the needle passes through the prevertebral fascia, a certain pop is often appreciated. When nerve stimulation is used (0.5 mA, 0.1 msec), the entrance of the needle in the interscalene groove is often associated with a motor response of the shoulder, arm, or forearm as another confirmation of proper needle placement. After careful aspiration to rule out intravascular needle placement, 1-2 mL of local anesthetic is injected to verify proper needle placement. It is necessary to ensure that high resistance to injection is absent to decrease the risk of intrafascicular injection. Injection of several milliliters of local anesthetic often displaces the brachial plexus away from the needle. Additional advancement of the needle 1-2 mm toward the brachial plexus may be beneficial to ensure the proper spread of the local anesthetic. When injection of the local anesthetic does not appear to result in a spread around the brachial plexus, additional needle repositioning and injections may be necessary **(Brown, 2010).**

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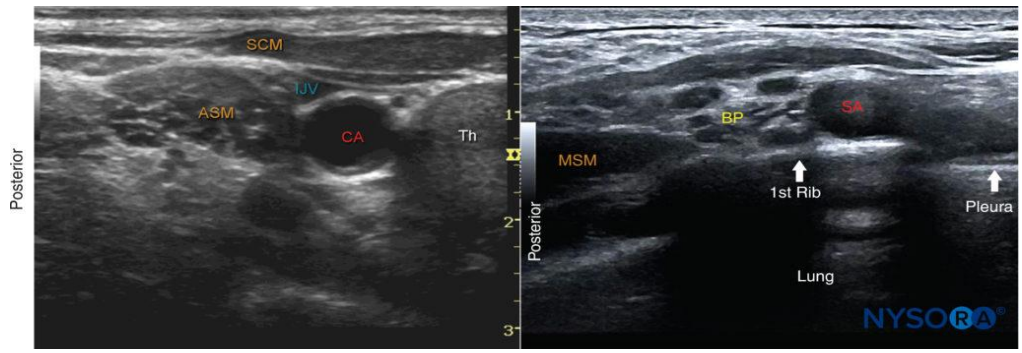

Fig. (5): (A) Ultrasound image just below the level of the cricoid cartilage and medial to the sternocleidomastoid muscle (SCM). ASM, anterior scalene muscle; CA, carotid artery; IJV, internal jugular vein; SCM, sternocleidomastoid muscle; Th, thyroid gland. (B) View of the brachial plexus (BP) at the supraclavicular fossa. When identification of the brachial plexus at the interscalene level proves difficult, the transducer is positioned at the supraclavicular fossa to identify the BP superficial and posterior to the subclavian artery (SA). The transducer is then slowly moved cephalad while continuously visualizing the brachial plexus until the desired level is reached **(Brown, 2010).**

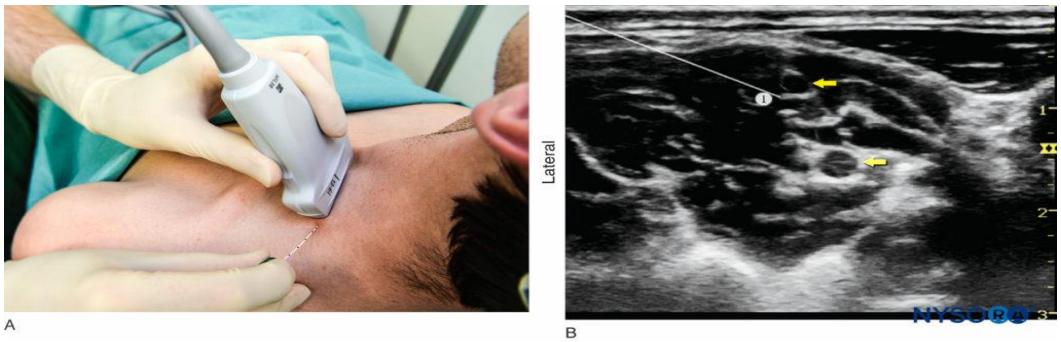

Fig. (6): (A) Transducer placement and needle insertion. (B) Position of the needle (1) for the interscalene brachial plexus nerve block using an in-plane approach. The needle tip is seen in contact with the elements of the brachial plexus (yellow arrows); this always results in high injection pressure (> 15 psi) indicating that the needle should be withdrawn slightly away from the trunk **(Jose and Xavier, 2017).**

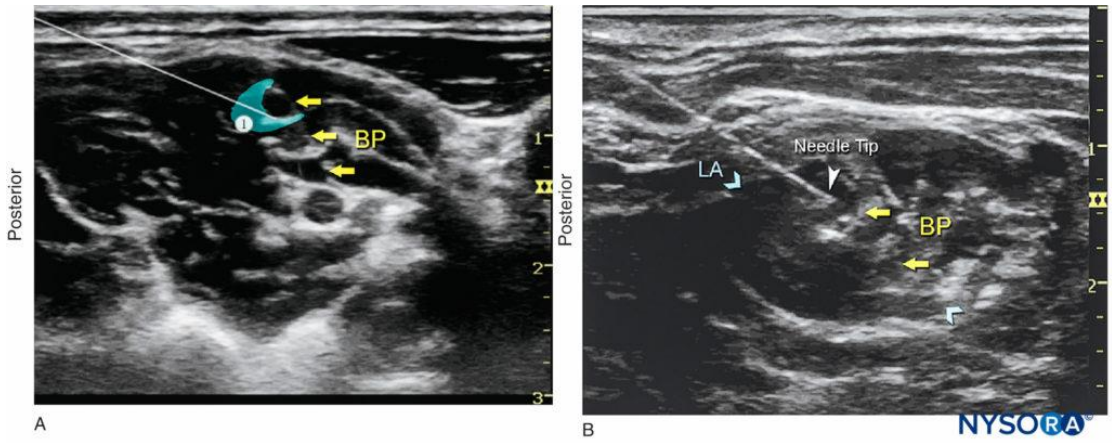

Fig. (7): (A) A small volume of local anesthetic (blue-shaded area) is injected through the needle to confirm proper needle placement. A properly placed needle tip will result in distribution of local anesthetic between and/or alongside roots of the brachial plexus (BP). (B) An actual needle (white arrowhead) placement in the interscalene groove, with dispersion of local anesthetic (LA) (blue-shaded area or arrows) surrounding the BP **(Jose and Xavier, 2017).**

Tips

- It is not necessary to elicit a motor response to nerve stimulation; however, when it occurs at intensities < 0.5 mA, the needle should be slightly withdrawn before injecting as it may be intraneural.
- The neck is a highly vascular area, and care must be exercised to avoid needle placement or injection into the vascular structures. Of particular importance is to avoid the vertebral artery and branches of the thyrocervical trunk: the inferior thyroid artery, suprascapular artery, and transverse cervical artery. **(Jose and Xavier, 2017).**
- One useful maneuver to ensure injection into the proper compartment, after injecting 5-7 mL, is to trace the plexus down to the supraclavicular fossa (while keeping the needle steady to avoid injury). If the injection is performed inside the brachial plexus sheath, the correct spread can be seen very clearly. The probe can then be moved back until the needle is visualized in order to complete the injection. If the brachial plexus appears unchanged in the supraclavicular area, one must question whether the injection was done outside the correct compartment.
- The lateral-to-medial insertion is often chosen to prevent injury to the phrenic nerve, which is typically located anteriorly to the anterior scalene, although one should be aware that the dorsal scapular nerve and the long thoracic nerve usually course through the middle scalene and could potentially be injured **(Jose and Xavier, 2017).**
- It is common for C6 and C7 to split proximally. It is prudent to avoid injecting between the nerves coming from a single root, as this may result in an intraneural injection. Instead, it is safer to inject between C5 and C6, superficial to C5, or deep to C6.
- Another relatively common anatomical variation involves the C5 root traveling through the anterior scalene for part of its course. To nerve block this anatomical variant, the root should be traced distally until it enters the interscalene groove.
- Multiple injections are best avoided as they are not usually needed to successfully nerve block the brachial plexus and may carry higher risk of nerveinjury **(Jose and Xavier, 2017)**.
- In an adult patient, 7-15 mL of local anesthetic is usually adequate for a successful and rapid onset of blockade. Smaller volumes of local anesthetic may also be effective;12,13 however, the rate of success of smaller volumes in everyday clinical practice may be inferior to those reported in meticulously conducted clinical trials. **(Jose and Xavier, 2017).**

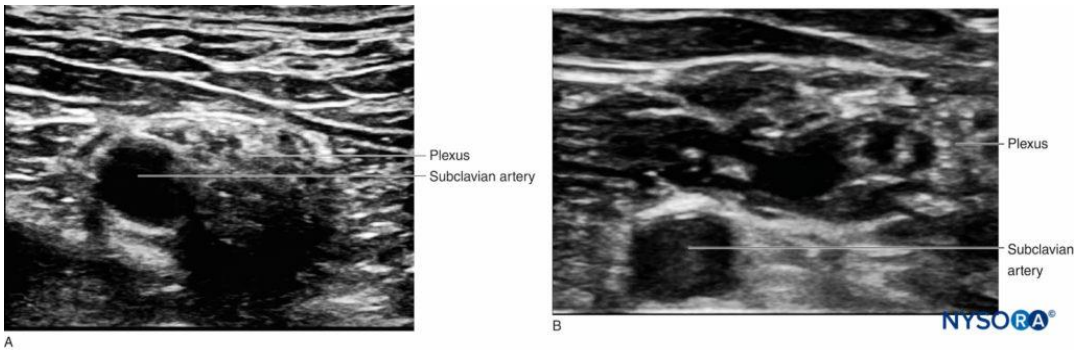

Fig. (8): Diffusion of local anesthetic solution to the supraclavicular area during interscalene nerve block performance. (A) Before injection. (B) After injection of 10 mL at the interscalene level. The nerves lateral to the subclavian artery are surrounded by local anesthetic and appear deeper. This confirms that the injection was performed in the correct space **(Jose and Xavier, 2017).**

Clavipectoral Fascia Block

The clavipectoral fascial plane block (CPB) is a regional anesthesia technique specifically developed to provide effective analgesia and potential surgical anesthesia for clavicle surgery. Unlike classic brachial plexus approaches that primarily target major trunk and cord levels, CPB targets the anatomical plane between the clavipectoral fascia and the periosteum of the clavicle, a region through which terminal sensory nerve branches from both cervical and brachial plexuses traverse **(Labandeyra et al., 2024).**

The CPB is typically performed under ultrasound guidance, using a high-frequency linear probe placed over the anterior clavicle. The clinician identifies the clavipectoral fascia, which lies just deep to the pectoralis major and superficial to the clavicular periosteum, and advances a needle in-plane (usually caudad to cephalad) to position the tip beneath the fascia and adjacent to the bone. Local anesthetic (often 30 mL total) is then injected between the clavipectoral fascia and the clavicular periosteum, generally in two deposits, medial and lateral to the fracture or surgical site ensuring wide spread in the target plane **(Lee et al., 2022).**

The described sonoanatomy includes visualization of the clavicular cortex, overlying fascia, and surrounding muscles, allowing real-time confirmation of local anesthetic spread. Because the target plane is superficial and away from the brachial plexus roots, the risk of deep neural injury or significant motor blockade is reduced compared with interscalene or superior trunk approaches **(Mueed et al., 2026).**

Cervical Plexus Anesthesia

1) The Classical Approach:

The superficial CPB is conventionally described as subcutaneous injection technique performed at the mid-portion of the posterior border of the sterno-cleido-mastoid (SCM) muscle targeting superficial branches of the cervical plexus **(Pandit, et al., 2007) (Fig 9)**

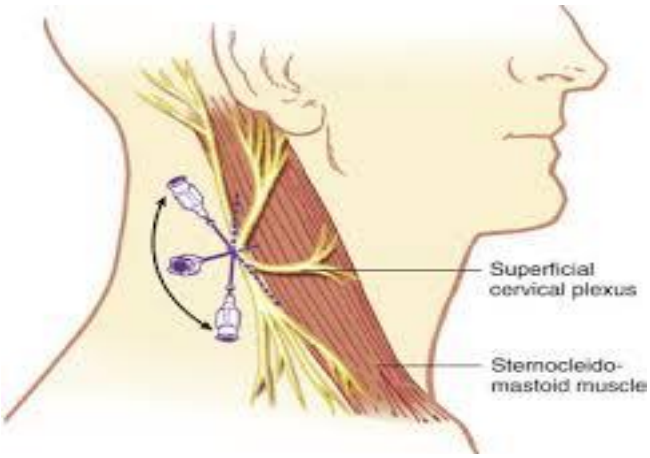

Fig (9): Injection technique of superficial CPB **(Pandit, et al., 2007).**

The deep CPB is described as a paravertebral block targeting the C2-C4 spinal nerves, and this can be achieved either by a single injection or by three separate injections. The deep CPB performed at the paravertebral space not only can block superficial branches but also deep branches of cervical plexus resulting in the relaxation of neck muscles, although, it has not been shown to be important clinically **(Stoneham, et al., 2015).**

2) Ultrasound guided approach:

Ultrasound guided superficial plexus block is not only easy but may also increases the success rate on one hand and on the other, avoids too deep needle insertion and/or inadvertent injections into the important surrounding structures in the neck. Even though landmark based block is easy, the advantage of ultrasound lies in its ability to ensure the spread of LA in the correct plane **(Herring, et al., 2012) (Fig 10).**

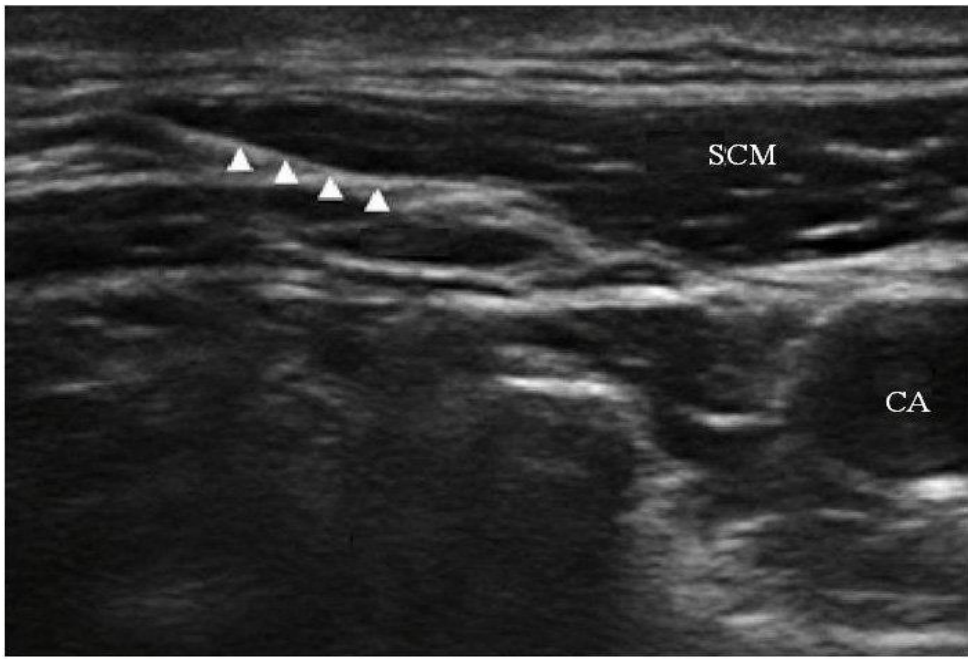

Figure (10): Ultrasound approach view of Superficial CPB **(Herring, et al., 2012).**

With the introduction of ultrasound, the deep CPB has become a relatively safe and simple procedure with several different ultrasound techniques. We can simply injecte local anesthetics into the space between the prevertebral fascia and the cervical transverse process under ultrasound guidance **(Perisanidis, et al., 2013),** but also can inject local anesthetics after the needle touched the target cervical transverse process under ultrasound guidance **(Sandeman, et al., 2006).**

Complication of CERVICAL PLEXUS BLOCKS

Deep CPB can produce major complications such as intravascular injection, epidural or subarachnoid injection, and phrenic nerve Palsy due to its deep endpoint **(Pandit, et al., 2007).**

The superficial CPB, unlike the deep CPB, is known to carry a low risk of complications and is easy to master **(Pintaric, et al., 2007).** Nonetheless, during superficial CPB, it is important to make sure that the needle tip is positioned in the subcutaneous tissue to avoid adverse effects of deep block **(Broderick, and Mannion, 2010).**

References:

1. Raju, P. and Coventry, D. (2014): Ultrasound-guided brachial plexus blocks. Continuing Education in Anesthesia Critical Care and Pain, 14 (4),185–91.
2. Mian, A., Chaudhry, I., and Huang, R. (2019): Brachial plexus anesthesia: A review of the relevant anatomy, complications, and anatomical variations. Clin Anat, 27(2), 210-21.
3. Chin KJ, Niazi A and Chan V. (2018): brachial plexus anatomy in the supraclavicular region detected by ultrasound. Anesth Analg, 107(2),729-31.
4. Strub B, Sonderegger J, Von Campe A, Grünert J and Osterwalder J. (2017): What benefits does ultrasound-guided axillary block for brachial plexus anesthesia offer over the conventional blind approach in hand surgery. J Hand Surg Eur, 36 (9), 778-86.
5. Brown, DL. (2014): Brachial plexus anesthesia: An analysis of options. Yale J Biol Med, 66, 415–31.
6. Brown DL. (1993): Brachial plexus anesthesia: an analysis of options. Yale J Bio Med, 66(5), 415-31.
7. Brown DL. (2010): Upper Extremity Block Anatomy. In: ATLAS OF Regional Anesthesia, 4thed. Saunders, Elsevier Inc, II(3), 33-52.
8. Jose DA and Xavier SB. (2017): Peripheral nerve stimulators in the practice of brachial plexus anesthesia: A Review. RegAnesth Pain Med, 26 (5), 448-83.

9. Labandeyra, H., Heredia-Carques, C., Campoy, J. C., Váldes-Vilches, L. F., Prats-Galino, A., & Sala-Blanch, X. (2024). Clavipectoral fascia plane block spread: an anatomical study. Regional Anesthesia & Pain Medicine, 49(5), 368-372.
10. Lee, C. C. M., Beh, Z. Y., Lua, C. B., Peng, K., Fathil, S. M., Hou, J. D., & Lin, J. A. (2022, August). Regional anesthetic and analgesic techniques for clavicle fractures and clavicle surgeries: part 1—a scoping review. In Healthcare (Vol. 10, No. 8, p. 1487). MDPI.
11. Mueed, A., Inam, K., Rehman, S. U., Ilyas, M., Haq, M. S. U., & Younas, M. (2026). Efficacy and safety of clavipectoral fascial plane block for analgesia in clavicle fracture operations: a meta-analysis of randomized controlled trials. Trauma Surgery & Acute Care Open, 11(1).
12. Pandit, J. J., Satya-Krishna, R., & Gration, P. (2007). Superficial or deep cervical plexus block for carotid endarterectomy: a systematic review of complications. British journal of anaesthesia, 99(2), 159-169.
13. Stoneham, M. D., Stamou, D., & Mason, J. (2015). Regional anaesthesia for carotid endarterectomy. British Journal of Anaesthesia, 114(3), 372-383.
14. Herring, A. A., Stone, M. B., Frenkel, O., Chipman, A., & Nagdev, A. D. (2012). The ultrasound-guided superficial cervical plexus block for anesthesia and analgesia in emergency care settings. The American journal of emergency medicine, 30(7), 1263-1267.
15. Perisanidis, C., Saranteas, T., & Kostopanagiotou, G. (2013). Ultrasound-guided combined intermediate and deep cervical plexus nerve block for regional anaesthesia in oral and maxillofacial surgery. Dentomaxillofacial Radiology, 42(2), 29945724.
16. Sandeman, D. J., Griffiths, M. J., & Lennox, A. F. (2006). Ultrasound guided deep cervical plexus block. Anaesthesia and intensive care, 34(2), 240-244.
17. Pintaric, T. S., Hocevar, M., Jereb, S., Casati, A., & Jankovic, V. N. (2007). A prospective, randomized comparison between combined (deep and superficial) and superficial cervical plexus block with levobupivacaine for minimally invasive parathyroidectomy. Anesthesia & Analgesia, 105(4), 1160-1163.
18. Broderick, A. J., & Mannion, S. (2010). Brachial plexus blockade as a result of aberrant anatomy after superficial cervical plexus block. Regional anesthesia and pain medicine, 35(5), 476-477.