Supraclavicular brachial plexus blocks: review and current practice

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Abstract: This article reviews the possible revival of the supraclavicular brachial plexus blockade due to the use of ultrasound guidance. The brachial plexus is a complex network of nerves, extending from the neck to the axilla, which supplies motor and sensory fibers to the upper extremity. Understanding the complexities of the formation and structure of the brachial plexus remains a cornerstone for effective regional anaesthesia. On the level of the supraclavicular fossa, the plexus is most compactly arranged. The supraclavicular approach of the brachial plexus has a high success rate including blockade of the ulnar and musculocutaneous nerve, which can be missed respectively with the interscalene and axillary approach. However, because of the proximity of the pleura, most anaesthesiologists have been reluctant to perform this supraclavicular approach. The introduction of ultrasound guidance techniques not only reduces the possible risk of pneumothorax but also allows a faster onset time of the block with a reduction of the local anaesthetic dose. This makes the supraclavicular approach a valuable alternative to the axillary, interscalene and infraclavicular approach for upper limb surgery.

History

The history of regional anaesthesia is a long and slowly evolving process without big “Eureka moments”, as Hadzic states in his textbook (1). Both the axillary and supraclavicular approaches for percutaneous brachial plexus blockade anaesthesia, introduced by Hirschel in 1911 (2), were received enthusiastically as safer alternatives to general anaesthesia and all its dreaded complications. Kulenkampff wrote his first article on the brachial plexus in 1928 (3) demonstrating that the supraclavicular approach to the brachial plexus provided a more consistent and effective regional anaesthesia for upper extremity anaesthesia than other approaches. This enthusiasm increased during World War II due to the many upper extremity injuries.

However, since technical and pharmacological improvements after the war led to safer general anaesthesia, and the fact that a supraclavicular block could cause a pneumothorax, the dissemination and use of supraclavicular plexus block were tempered.

In 1964, Winnie introduced the “perivascular concept of the brachial plexus block” (2). This concept is based on the axillary compartment formed by two muscles, containing both vessels and nerves. When this compartment can be identified and entered by a needle, the plexus is blocked by a single injection. Later, nerve stimulation offered new opportunities for regional anaesthesia, but general anaesthesia was still considered safer, even after the development of several alternative approaches in the second half of the 20th century like the peri- or paravascular technique or the introduction of nerve stimulation (4-7).

Until 1990-2000 very few review articles have been published describing different approaches, indications and overall complications of brachial plexus blockade probably because no major changes were revealed for years (8-13). Over the last decade the increasing number of articles (about approaches, indications and complications) on plexus blocks reflects the growing interest in regional techniques taking advantage of ultrasound guidance.

Ultrasound guidance has made it possible to reduce the risk of inadvertent puncture of the pleura performing a supraclavicular block. This technique gained a lot of popularity and induces the development of different approaches and new indications.
The brachial plexus nervous system supplies motor and sensory fibers to the upper extremity. The brachial plexus is a complex system of nerves. They originate from the neck and can be divided into roots, trunks, divisions, cords and major terminal nerves. The brachial plexus can also be divided into regions. The interscalene, infraclavicular, axillary and supraclavicular blocks are the most commonly described approaches.

Both the brachial plexus and the subclavian artery lie on top of the first rib and the pleura. The brachial plexus is located lateral and posterior to the subclavian artery. The subclavian vein and anterior scalene muscle are found medial to the subclavian artery. The pleura is usually situated within 1-2 cm from the brachial plexus (Fig. 1-3).

In 53.5% of the general population a significant variation in the architecture of the brachial plexus is seen (15). The most common variations are contributions from upper cervical roots or thoracic roots. Understanding the complexities of the anatomy of the brachial plexus remains a cornerstone for effective regional anaesthesia. Ultrasound can be the perfect tool to identify these variations in order to facilitate plexus block performance (Fig. 4).

**Indications for Supraclavicular Brachial Plexus Block**

In general, local anaesthesia performed prior to incision, has shown to have a positive effect on the postoperative pain management course (16).

The supraclavicular approach of the brachial plexus has a high success rate including blockade of the ulnar and musculocutaneous nerve, which can be missed respectively with the interscalene and axillary approach. The most common indication for supraclavicular block is upper extremity surgery (17, 18). Theoretically this block was always considered as less useful for shoulder surgery because of the greater difficulty to block the subscapular nerve by this approach (19). Interscalene block was presumed to be more cost effective than general anaesthesia alone (20). Interscalene plexus block however is associated with the highest incidence of permanent neurological complications of all peripheral blocks (21). Ultrasound guidance is suggested to have a superior safety profile, but so
far no large randomized controlled trials (RCT’s) have been able to prove this.

Nevertheless, recently some articles have been published on shoulder surgery as a new indication for supraclavicular plexus block usage (22, 23). Fractures (24, 25), Dupuytren surgery (26), axillo-femoral bypass surgery (27) and pacemaker insertion (28) are a few of the many indications published as case report (29).

**Procedure**

**Classical approach**

The patient is positioned supine, with the head rotated opposite from the side to be blocked. The needle insertion point, according to the Külenkampff approach, is identified as midway between the sternoclavicular and acromioclavicular joint, crossed by a line projected downward from the external jugular vein. The needle needs to be advanced lateral to the subclavian artery (Fig. 1-3).

The needle is introduced at an angle of 80° to the skin directed posteriorly, medially and caudally to the upper border of the first rib. The depth of the plexus is usually at 1-2 cm. Simultaneous flexion of the third and fourth digits with or without other digits after applying nerve stimulation, is associated with the highest success rate of supraclavicular brachial plexus block (4). Bigeleisen stated that a stimulation current of 0.2 mA or less is reliable to detect intraneural placement of the needle during a supraclavicular brachial plexus block (30). Franco et al. injected the local anaesthetics at 0.9 mA if they had a clearly visible response of the fingers. Decreasing the output to 0.5 mA did not seem to improve the overall quality of the block as assessed by the onset time and duration of anaesthesia nor patient satisfaction (5, 31).

**Ultrasound guidance technique**

Ultrasound guidance is used to localise the landmarks needed for the procedure (subclavian artery, clavicle, brachial plexus, pleura and first rib) (32, 33). To obtain a good view of the plexus the transducer has to be placed firmly over the supraclavicular fossa, parallel and immediately posterior to the clavicle. The head is slightly turned to the contra-lateral side. A good transverse view of the subclavian artery and brachial plexus is necessary for a safe approach (Fig. 2). The needle is advanced preferentially in-plane (IP) from lateral to medial until the brachial plexus is reached. A medial to lateral approach of the needle is described by Subramaniam et al. (34) but did not show significant difference in block characteristics (35, 36). The supraclavicular brachial plexus is visualized as a group of hypo-echoic nodules frequently described as a “cluster of grapes”.

The needle is introduced in the supraclavicular fossa and advanced in the (in plane) medial caudal direction. The optimal injection site, according to Soares, has been described as being in the “corner pocket”, which is bordered by the first rib inferiorly, the subclavian artery medially and the brachial plexus superiorly (Fig. 2) (37). This is the localisation of the C8 nerve (important for the ulnar nerve blockade). This “corner pocket injection” was recently revisited by Brull et al. (38). They stated that hydrodissection and relocation of the needle are as important as the “corner pocket” technique to perform a successful block.

A single injection into this “corner pocket” results commonly in partial block failure. Therefore it is important to look at the spread of the local anaesthetic during injection.

**Volume, dose and additives**

The minimum local anaesthetic volume (MLAV 50 and MLAV 95) required for ultrasound guided supraclavicular block, according to Duggan et al. (2009) was 23 mL, and 42 mL (39). They did not observe a significant difference with MLAV 50 or MLAV 95 required for classical neurostimulation technique. However, many different dosages are
An overall volume of 20 to 25 ml of local anaesthetic in combination with ultrasound guidance, is commonly accepted. Nowadays, many studies aim to prove equal efficacy with a reduction of the necessary volume, as proven for e.g. the interscalene brachial plexus block (42), yet without success.

The use of perineural adjuvants added to local anaesthetics to accelerate onset, to prolong duration of activity, or to provide superior analgesia has a history dating back to at least 1892 (43). Clonidine, morphine, meperidine, dexmedetomidine, butorphanol, fentanyl, buprenorphine and tramadol are a few of the commonly used adjuvants to local anaesthetic solutions (44, 45). Morphine, meperidine, butorphanol and midazolam are associated with side effects: sedation, respiratory depression and psycho-mimetic effects. The effect of co-administration of dexamethasone and tramadol on the prolonged duration of the supraclavicular plexus block has been studied by Shrestha et al. (46) and Parrington (47). A possible systemic effect is yet to be proven. Tramadol used with local anaesthetics inhibits the reuptake of serotonin from nerve endings and potentiates the block effects (48-50). The local effect of dexamethasone or other adjuvants on the nerve remains unclear and local neurotoxicity should be ruled out (51).

### Complications and Contraindications

Common complications associated with regional techniques are neural damage, allergic reactions, infections, vascular punctures, recurrent laryngeal nerve blockade, phrenic nerve blockade and systemic toxicity because of unintended intravascular injection or fast absorption (10, 52-54). Pneumothorax used to be a frequent and feared complication of supraclavicular block (incidence of 0.6 to 6.1%) (6, 37). Ultrasound guidance is a good tool to reduce the possibility of pneumothorax and possibly is the reason for the reason for the renewed success of the supraclavicular brachial plexus block (55, 56).

Cardiovascular collapse due to local anaesthetic toxicity after a supraclavicular block was successfully treated with a lipid emulsion (57).

The blockade of the phrenic nerve with diaphragmatic paresis and a reduction in forced vital capacity (FRC) is a known complication of interscalene block (58-61). When an interscalene block is performed using the classical high volume (30 to 40 ml of local anaesthetic), there is a 100% incidence of hemidiaphragmatic paresis accompanied by a 25% reduction in FRC (62). However, when a supraclavicular block is performed, only 50% of patients have hemidiaphragmatic paresis and there is no reduction in FRC when the same amount of local anaesthetic is injected (63). No diaphragm paresis occurred using a lower volume in case of supraclavicular approach (20 ml) (64) and likewise for the interscalene plexus block (10 ml) (65).

Intravascular injections need to be avoided. Vessels to be avoided are the axillary artery, the transverse colli artery, the dorsal scapular artery and their venous counterparts located cephalad of the plexus (66).

Increased Body Mass Index (BMI) and ASA physical status are risk factors for complications when regional techniques are performed (67). The introduction of ultrasound however made it safer because of the improved visualization of the surrounding structures (10, 67). Diabetes, independent of BMI, is speculated to be associated with a “higher success” rate for supraclavicular brachial plexus blocks (68). Reasons could be a higher sensitivity of diabetic nerve fibers to local anaesthetics, possible unknown intraneural penetration, and/or pre-existing neuropathy with accompanying decreased sensation. Further studies are needed to make recommendations.

### Discussion

The supraclavicular brachial plexus block was already introduced in 1911, but remained unpopular for a long time due to the feared complication of pneumothorax. Based on recent literature, an important increase in the popularity of supraclavicular brachial plexus anaesthesia is noted. Liu et al. published the many advantages using ultrasound as guidance for the brachial plexus block (69, 70): the risk of pneumothorax is reduced which made an unpopular block popular again (37, 71). Additionally, ultrasound helps in detecting the many variations in the complex anatomy of the brachial plexus (72). Contradictory information is published on the use of a nerve stimulator and supraclavicular plexus block. Simultaneous flexion of the third and fourth digit is associated with the highest success rate (4). The combination of nerve stimulation and ultrasound guidance is proven to be safer and better (73, 74).

The major indication for the presented block used to be surgery of the arm. Recently shoulder
surgery has also become an important indication (22, 23). The use of the supravacuicular block reduces the risk of laryngeal nerve or phrenic nerve paresis. The superficial cervical plexus, responsible for the innervation of the posterior skin of the shoulder, is not blocked either by the ultrasound guided low dose interscalene or the supravacuicular blockade. The high volumes injected performing an interscalene block without ultrasound guidance, and the cranial spread of this local anaesthetic, are the possible explanation of the lack of blockade of the superficial cervical plexus block using lower volumes.

The optimal injection site is more likely the “corner pocket” (37) but probably the spread of the local anaesthetic is more important than the location of the needle itself (55, 75). An inhomogeneous spread of local anaesthetic should be seen in order to ensure a successful blockade (76). Ultrasound should therefore be used as a dynamic tool to follow the spread of the local anaesthetic.

The minimum volume required for ultrasound guided supravacuicular block remains unclear due to contradictory studies (39, 64, 77). Twenty milliliter of local anaesthetic (e.g. Ropivacaine 0.5 or 0.75%) is recommended but it is more important, as already mentioned, to detect a proper spread of the local anaesthetic using ultrasound. The choice of concentration may also depend on surgical indication.

Recently continuous plexus blocks are becoming more popular, but these techniques are more invasive and need more investigation. The role of adjuvants remains a subject of much discussion between believers and non-believers. Nevertheless, some studies have shown a clear prolongation of the duration of the blockade (47).

Other future issues are the use of regional techniques in anticoagulated and / or anaesthetized patients (78-80). This should be done with caution and performed or supervised by experts (American Society of Regional Anaesthesia and Pain Medicine Evidence-Based Guidelines – Third Edition).

CONCLUSIONS

The supravacuicular block, which in the past was hazardous because of the risk of pneumothorax, can actually be performed in a safe way using ultrasound. This partially forgotten block is an excellent technique for analgesia for upper extremity surgery as well as for shoulder surgery.

Conflicts of interest

There are no conflicts of interest. The authors did not receive any financial support of any kind.

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