Renaissance of supraclavicular brachial plexus block

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Abstract
Due to frequent complications, especially pneumothorax, supraclavicular brachial plexus block became less popular. Ultrasonography is a very powerful tool in modern medicine and a real milestone in regional anaesthesia. Ultrasound-guided supraclavicular brachial plexus block reduces the probability of major complications occurrence (like pneumothorax, Horner’s syndrome, phrenic nerve palsy). In this review we present the usefulness of ultrasonographic imaging and how to perform efficient ultrasound-guided blockade safely.

Key words: anaesthetic techniques, regional, brachial plexus; anaesthetic techniques, ultrasonography

The supraclavicular approach is the oldest way to accomplish anaesthesia of the brachial plexus. This percutaneous method was used for the first time by German surgeon Kulenkampff in 1911 [1]. The procedure was performed with the patient in the supine position and the needle was inserted about 1 cm above the clavicle in the mid-clavicular line and directed almost parallel to the skin surface towards the first rib. To obtain effective blockade, paresthesia had to be induced [2]. In Poland, one of the first studies dealing with this approach was the study conducted by Wiktor Przybora [3]; its findings demonstrated high effectiveness of the method (85%) at a relatively low incidence of complications. In successive years, numerous modifications of this technique were developed (e.g. “plumb bob” approach or Winnie technique) whose main aim was to simplify the identification of anatomical landmarks; however, the basis of all of them was the induction of unpleasant paresthesias [4]. The use of electrostimulation to identify the brachial plexus was a substantial advance yet the procedure was still carried out blindly. Due to a high risk of complications, e.g. pneumothorax developing in up to 6% of cases, the supraclavicular approach technique lost its popularity [5].

A real milestone in regional anaesthesia was the introduction of ultrasound imaging. This auxiliary method enables bedside imaging and evaluation of nerves, adjacent structures (vessels, pleura), needle location and above all spread of anaesthetics. The method is particularly useful in patients in whom classical methods may be ineffective (obesity — lack of anatomical landmarks, anatomical variability, difficulties in nerve stimulation, e.g. neuropathies).

Historically, the first attempt to use this technique was the subclavian artery location using Doppler sonography [6], which initiated the use of ultrasound-guided regional anaesthesia (UGRA).

ANATOMY
The brachial plexus is the structure formed by rami of spinal C5–T1 nerves (in some anatomical variants C4 and T2 can also be involved). Between the anterior and middle scalene nerves, the nerves merge into three trunks — upper, middle and lower, which head towards the first rib. At the level of the clavicle, the ventral and dorsal roots form and three bundles originate from them in the axillary fossa. Depending on their location in relation to the axillary artery, the posterior, lateral and medial bundles are distinguished. At the level of the coracoid process, peripheral nerves are formed supplying the upper limb [7]. In the supraclavicular region, the entire brachial plexus is grouped relatively superficially within the limited area (Fig. 1). Nerve trunks or beginnings of divisions into bundles can be reliably and quickly blocked. Thanks to ultrasound, the supraclavicular approach is “back in grace” as extremely comprehensive anaesthesia for procedures involving the upper limbs, except for the shoulder (the suprascapular nerve is not usually...
TECHNIQUE OF BRACHIAL PLEXUS BLOCK

Supraclavicular brachial plexus block is considered moderately difficult [8]. Due to proximity of the brachial plexus to the pleural cavity and blood vessels, the method requires certain manual skills and dexterity in directing the needle in the ultrasound beam.

Many techniques of ultrasound-guided supraclavicular brachial plexus block have been developed, which differ in the way of inserting the needle and in places of local anaesthetic administration. One of the most popular and effective methods is presented in the further part [9–11].

The first step is to choose a suitable transducer. The brachial plexus is located quite superficially even in obese patients (1.5–2 cm). Therefore, the best choice is a high-frequency linear transducer (considering the compact structure of this region, some authors postulate the use of small, convex cardiologic transducers) [10]. The next step is prescan, i.e. initial imaging to optimise the image. At this stage the frequency (the highest one giving the satisfying image), focusing and time-amplitude compensation function are adjusted. Additionally, the course of vessels in the bundle region is worth evaluating to avoid their injection [12]. The transducer is placed in the supraclavicular fossa parallel to the mid-clavicle (the tracer is usually directed medially) and an attempt is made to visualize the subclavian artery in transverse section.

The US-visualised subclavian artery is round, pulsating and resistant to external pressure (in the case of doubts, the Doppler function is useful). The brachial plexus is visible as a collection of hypoechoic (black) points surrounded by the hyperechoic (white) sheath. The bundle shape in the transverse section at this level is usually the triangle with the base resting on the artery. The line of the first rib and pleura are visible below (Fig. 2).

When the subclavian artery is difficult to be visualized, the transducer suitable manoeuvres should be applied, amongst them pressure, angling, rotation, tilting and sliding (PARTS) [13]. In the US-guided technique, the place of needle insertion is different from the one in the classical approach (definitely closer to the end of the shoulder clavicle). The needle is introduced in-plane from the lateral to the medial side, and its course is continuously controlled. Subsequently, the sheath is penetrated with the needle and part of solution is administered to the bundle itself (obviously, this does not mean the administration into nerves). To increase the probability of blocking the fibres originating from C8–Th1 (mainly the ulnar nerve), the second part of the dose is given to the corner pocket [14] — the term

Figure 1. The brachial plexus in the supraclavicular space (modified by the authors from Grey’s Anatomy [1918] — source: public domain)

Figure 2. Ultrasound image of the brachial plexus and adjacent structures (A). The circle shows the subclavian artery whereas the triangle — the brachial plexus (B)
The dominating hand inserts the needle in the ultrasound target structures is maintained and likely fatigue prevented. The hand should be stabilized by delicate resting on the patient or the bed. Thanks to that, the unaltered image of the location of an anesthetiologist, patient and ultrasound devices necessary to treat possible complications. Moreover, the operating suite are higher. The room in question should be fully equipped with standard monitoring appliances and special sets for continuous blocks are available designed for US-guided procedures. They contain needles of increased echogenicity and catheters, whose structure favours their better visualization. However, due to high prices of such devices, classical sets for continuous epidural blocks are usually used. The diameter of Touhy needle is bigger, therefore more extensive local anaesthesia or sedation of the patient should be considered. One of the techniques is to introduce the Touhy needle to the bundle and to administer part of the local anaesthetic dose to provide the space for catheter insertion. The catheter should be inserted 2 to 3 cm behind the needle tip and fixed in this position by tunnelling or sticking with a transparent dressing to the patient’s skin (complete surgical clothing, full draping of the block place).

The choice of a particular local anaesthetic depends mainly on the expected time of action in relation to the duration of surgery and anticipated postoperative pain. The use of mixtures of various substances is a controversial issue. However, such mixtures combine the advantages of quick onset of action and long analgesic effects. One of the examples is the mixture of 2% lidocaine with 0.5% bupivacaine (with the addition of adrenaline). The effective block is generally obtained after 20–30 min (the more precise the agent administration, the quicker the onset of its action). The use of agents in the same concentration guarantees reliable motor block, which is highly appraised by operators. Generally, 30–35 mL of solution is administered [9, 15–17], although markedly lower doses have also been recommended as effective and reducing the risk of complications [18].

Ergonomics of its performance is also essential for effective block. Wherever possible, it is more beneficial to perform regional anaesthesia in the spacious, separated room rather than in the operating theatre (work comfort and capacity of the operating suite are higher). The room in question should be fully equipped with standard monitoring appliances and devices necessary to treat possible complications. Moreover, the location of an anesthesiologist, patient and ultrasound device towards one another is important. The US device should be situated opposite the physician, along the line formed by the needle and the transducer long axis, which is particularly relevant in in-plane approach. The dominating hand should hold the transducer; once the optimal image is found, the hand should be stabilized by delicate resting on the patient or the bed. Thanks to that, the unaltered image of target structures is maintained and likely fatigue prevented. The dominating hand inserts the needle in the ultrasound beam plane, which visualizes it in real time and reduces the risk of contact with the blood vessels or the pleura.

To verify the effectiveness of block, the sensations of cold and pressure (or prick sensibility) are checked in places innervated independently by individual nerves [19]. This allows detecting the nerve insufficiently blocked and performing rescue block. As its name indicates, this is to “rescue” the block (so as conversion to general anaesthesia is not needed). Depending on the extent of surgery, unblocked nerves can be blocked at characteristic places at the level of the arm and forearm. In general, complete envelopment of the nerve is provided with 6 mL of local anaesthetic solution [20].

**CONTINUOUS BLOCK**

In cases of procedures at risk of severe postoperative pain, the continuous block should be performed. This block is administered under restrictively aseptic conditions (complete surgical clothing, full draping of the block place). Special sets for continuous blocks are available designed for US-guided procedures. They contain needles of increased echogenicity and catheters, whose structure favours their better visualization. However, due to high prices of such devices, classical sets for continuous epidural blocks are usually used. The diameter of Touhy needle is bigger, therefore more extensive local anaesthesia or sedation of the patient should be considered. One of the techniques is to introduce the Touhy needle to the bundle and to administer part of the local anaesthetic dose to provide the space for catheter insertion. The catheter should be inserted 2 to 3 cm behind the needle tip and fixed in this position by tunnelling or sticking with a transparent dressing to the patient’s skin [21]. Anaesthesia can be maintained using the technique of repeated doses or infusion, preferably patient-controlled analgesia (PCA). In such cases, lower concentrations of local anaesthetics should be used to reduce the motor block-related inconveniences.

A controversial issue is the usefulness of electrostimulation during UGRA. The majority of literature data suggest lack of increased effectiveness of the block at simultaneous lengthening of its provision [22]. In many centres, stimulation is used only in situations where there is no complete certainty as to the structure observed. Electrostimulation is an extremely unpleasant sensation, particularly for patients after trauma. Moreover, the motor response is obviously impossible in cases of solely sensory nerves (e.g. the femoral-crural nerve). The use of needles of increased echogenicity (special cuts better reflecting ultrasound waves towards the transducer) substantially improves their visualization, increasing work comfort and safety of patients. Thanks to good-quality equipment and experiences in nerve

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**Figure 3.** Local anaesthetic administration to the corner pocket. The continuous line symbolises the needle, the acute angle — the corner pocket.
identification, the use of electrostimulation can be limited to a minimum.

LIMITATIONS OF THE METHOD

The limitations concerning the use of ultrasound-guided regional anaesthesia are worth mentioning. The major problem is associated with high costs of ultrasound devices. The purchase of a mobile, compact ultrasound device with suitable software and good-quality transducers (mainly the linear one) is a considerable investment. On the other hand, it is a one-time expense and the device is useful not only for regional anaesthesia. An ultrasonograph is increasing applied in intensive care units, both for diagnostic purposes, e.g. exclusion of pneumothorax, bedside lung ultrasonography in emergency (BLUE) [23], extended focused assessment with sonography in trauma (eFAST), optic nerve sheath diameter (INSD) [24], and for invasive procedures (insertion of vascular accesses). Targeted ultrasound examinations can be performed by the trained personnel as well as radiologists with similar experience [25].

The education-related issues are a great challenge. Ultrasound-guided regional anaesthesia seems to be difficult to master. The courses with practical classes are helpful (evaluation of structures in live models, more realistic phantoms) so are Internet sources (many websites and You Tube service) as well as increasingly numerous monographs (also in Polish) describing the technique in question. Moreover, international guidelines regarding education and trainings are available [26].

CONTRAINDICATIONS AND Complications

The contraindications for supraclavicular brachial plexus block include lack of patient’s consent or cooperation, pneumothorax or pleural drainage on the opposite side, inflammatory lesions in the insertion place, allergy to local anaesthetics and severe clotting abnormalities.

Potential complications are as follows:

1. Pneumothorax — the main reason behind decreased popularity of this approach. Before the introduction of visualization, the incidence of this severe event was up to 6% [5]. The use of US for observation of the first rib and pleura markedly reduced the incidence of this complication and made the technique safe even for outpatient cases [27].

2. The Horner’s syndrome — in this case, it is induced by the block of sympathetic fibres between the ciliospinal centre (C8–T2) and smooth muscles of the orbit. This mainly concerns the stellate ganglion blocks. The characteristic symptoms of the syndrome include myosis, ptosis, and enophthalmus. Besides this classic triad, disorders of sweat secretion and congestion of the face skin on the side blocked can be observed [28]. This complication is extremely common; when high volumes of anaesthetics are used, its incidence reaches 90% [29]. The Horner’s syndrome does not require treatment and subsides spontaneously.

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 [30]. The disputable issue regards patients after lung resection on the side opposite to the block or with baseline, limited efficacy 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 [31].

4. Nerve injury — contrary to common fears of patients, direct mechanical, chemical or ischaemic nerve injury is extremely rare. The incidence of long-term neurological deficits induced by blocks is about 0.04% [32]. Nerve structures are more commonly injured by other factors, e.g. improper placement of the patient, stasis, or intraoperative injuries. Considering direct nerve injuries, it should be remembered that it is difficult to introduce the needle into the nerve when the nerve is not fixed (the nerve is moved rather than injected) [33]. To prevent nerve injuries, the injection of anaesthetic under high pressure should be avoided or the injection should be discontinued when patients report strong paresthesia or sudden severe pain. Moreover, an increase in the diameter of the injected structure is likely to evidence the injection into the nerve.

5. Puncture of blood vessels — another complication whose reduced incidence was demonstrated during UGRA [31]. Besides the subclavian artery which is commonly excellently visualised, the dorsal scapular artery should be closely observed.

6. Injection site infections — usually associated with continuous methods and attributable to catheter colonization [34]. There are no clear-cut guidelines concerning possible antibiotic preventive measures.

7. Local anaesthetic systemic toxicity (LAST) 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 [35]. The optimal timing for the infusion of fatty emulsions has not been explicitly determined. The anaesthesiological teams should undergo trainings regarding LAST; a suitable checklist should be helpful [36]. Ultrasound-guided regional blocks have been demonstrated to reduce the incidence of LASR by even 65% [37].

CONCLUSION

The supraclavicular brachial plexus block is an extremely comprehensive anaesthesia. The relatively common severe complications resulted in transient decrease in its popularity. The introduction of ultrasound imaging rescued it from oblivion. The method enables to provide quick and reliable sensory and motor block as well as good tolerance to stasis. Compared to general anaesthesia for upper limb surgery, the supraclavicular brachial plexus block enables better control of postoperative pain, reduces the risk of nausea and vomiting as well as the incidence of cognitive disorders [38]. In many centres, this approach is almost "the treatment of choice" for upper limb orthopaedic surgeries [39, 40].

References:


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