Interscalene brachial plexus blockade - indications, anatomy, practical performance

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Interscalene brachial plexus block (ISB) can be performed either as a single-injection or as a continuous infusion using a catheter. The main indications for this technique are surgery on the upper arm and shoulder. In most cases it is not suitable for forearm and hand surgery because only the upper trunks are usually anaesthetised using the classical paraesthesia or nerve stimulator guided technique. The aim of this paper is to highlight the (sono)anatomy of the interscalene region, the side-effects and complications of ISB and to describe my practice of ultrasound-guided blockade.

Anatomy of the scalene region and the formation of the brachial plexus

The brachial plexus is formed from the anterior rami of the C5, C6, C7, C8 and T1 spinal nerves. The lower cervical nerve roots exit the spine through the intervertebral foramina before passing into the plane between the anterior and middle scalene muscles. The ventral rami of C5 & C6 can be seen to run in the u-shaped ‘canal’ formed by the transverse processes of their respective vertebrae. The ventral rami divide and join to form the trunks as they pass caudally in the interscalene space. The level at which the trunks form and then divide into the divisions is variable and results in significant anatomical variation in this region. The trunks/divisions pass over the first rib in close proximity to the subclavian artery passing under the clavicle to form the main nerves of the arm in the axilla.

The neuronal structures (usually the ventral rami) can be seen by scanning the interscalene region by ultrasound. Figures 1-3 show the variable appearance of the plexus in this region. In obese patients, identification of these landmarks can be difficult, furthermore anatomical variation in this region is common and the lateral border of the sternocleidomastoid muscle (serving as a landmark to find the interscalene groove) can either overlay the groove or end more anterior in many patients. If the roots are difficult to see, identifying the transverse processes of C5, C6 and C7 first can help to visualise the roots and then allow them to be followed distally. Usually the C6 transverse process is the most prominent, showing impressive anterior and posterior tubercles (u-shape) and dorsal shadowing from the bone. Between the two tubercles the anterior part of the nerve root can be seen. Following this root distally one can identify the interscalene region, even if the two muscles are difficult to visualize with ultrasound. At the level of C7, the anterior tubercle is absent (Figure 1) and the vertebral artery may in its place. The use of colour Doppler is recommended; this will help to identify the correct vertebral level and corresponding nerve root, but one must be aware of the possible anatomical variation that can occur at C6 with an absent anterior tubercle too.

Ultrasound-guided vs nerve stimulation; single-shot vs catheter technique

Two randomized controlled studies have compared the success rate of ultrasound-guidance with nerve stimulator guided, single-shot interscalene brachial plexus block. In both studies the success rate was very high, 99 and 100%, respectively. Kapral et al showed an higher success rate with ultrasound (99 vs 91%) [1] but Liu et al failed to find a difference (100% in both groups) [2].

Using either paraesthesia or nerve stimulation almost 100% of patients have an unilateral phrenic nerve block [3]. This leads to a hemidiaphragmatic paresis and can cause respiratory distress in certain patients, such as those with COPD or contralateral phrenic nerve damage. The phrenic nerve passes caudally from posterior to anterior on the surface of the anterior scalene muscle, lying in close proximity to the superficial structures of the brachial plexus in the interscalene groove. Because the phrenic nerve is lying under the same fascia as the plexus (prevertebral or deep cervical fascia), local anaesthetic will commonly spread to block it. Renes et al showed that using an ultrasound–guided approach to place the needle deep and dorsal to the C7 root and then injecting 10 ml of ropivacaine 0.75%
reduces hemidiaphragmatic paresis from 91% to 13%, compared with a standard nerve stimulator guided approach [4]. In another study Riazi et al showed that by reducing the volume from 20 to 5 ml with the use of ultrasound, the incidence of diaphragmatic paralysis could be reduced from 100 to 45% without any difference in postoperative analgesia [5].

Three randomized controlled trials have shown better analgesia using ultrasound-guided interscalene catheters compared with ultrasound-guided single shot blocks [6-8]. Fredrickson et al found that interscalene catheters positioned with ultrasound demonstrated improved effectiveness during the first 24 h following shoulder surgery compared with nerve stimulator guided placements [9]. In the ultrasound group the patients reported less procedure related pain, shortened needle time under the skin, reduced use of ropivacaine and of tramadol rescue medication, and marginally lower catheter interventions in recovery. Postoperative pain ratings did not differ between groups. In my opinion this result does not show a clear benefit from using ultrasound guidance instead of nerve stimulator guidance for placing catheters. The reason for this maybe that even though the needle can be placed more accurately with ultrasound, the threading of the catheter and its final position cannot always be better controlled. An approach using long-axis ultrasound imaging of the nerves for placement of the catheter as reported by Koscielniak-Nielsen et al in four cases [10] may improve the success of ultrasound-guided catheter insertions in the future.

**Neurological complications after interscalene brachial plexus block**

The main fear related to regional anaesthetic techniques is the risk of permanent neurological damage. In many papers about ultrasound guidance the authors mention that ultrasound has the potential to lower neurological complications; however, the studies available to date are too small to prove statistical significance. In a prospective data collection of 200 ultrasound guided ISB Davis et al found temporary neurological deficit in two patients (1%) but no permanent neurological damage [11]. In another prospective data collection of 1010 ultrasound guided peripheral nerve blocks Fredrickson et al [12] found that the presence of paraesthesia during the procedure increased the incidence of neurological abnormalities (odds ratio 1.7). The rates of new neurological deficits were: 8.2% at day 10, 3.7% at 1 month and 0.6% after 6 months. These rates are comparable with those reported previously following nerve stimulator techniques [13]. Liu et al, in their randomized controlled trial (total 219 blocks) reported a rate of 11% of neurological abnormalities in the nerve stimulator group after 1 week vs 8% in the ultrasound group, and 7% after 4-6 weeks with nerve stimulator vs 6% with ultrasound guidance [2]. These differences were not significant.

**Practical performance and advantages of ultrasound-guided ISB**

For shoulder surgery the important interscalene neuronal structures to be blocked are the roots of C5 and C6. Using a nerve stimulator, contraction of the biceps or deltoid muscle is usually sought to enable local anaesthetic to be injected in close proximity to these structures. Using ultrasound we inject or introduce catheters under direct vision between or around these two nerve roots. The nerve stimulator guided approach is dependent on surface anatomical landmarks; usually the interscalene groove is palpated at the level of the cricoid cartilage, just dorsal of the lateral border of the sternocleidomastoid muscle.

The ultrasound guided approach is not so dependent on surface anatomical landmarks. Prescanning the patient before disinfecting and applying a sterile probe-cover allows you to visualize and locate all the important structures before commencing the procedure. The transducer is positioned transversally on the neck, slightly rotated from the sagittal plane (Figure 4) to optimize the angle of insonation, scanning the nerve at right angles to the ultrasound beam. The transducer is now moved slightly distally along the course of the brachial plexus, gently tilting the probe until the neuronal structures can be identified clearly. Ultrasound is a dynamic medium and the correct angle of the transducer is very important to ensure reflection of the ultrasound beam from the neuronal structures back to the transducer. This principle is called anisotropy. After disinfection of the skin, a sterile covering is applied to the transducer and also to the skin around the targeted area (important if introducing a catheter), the needle is introduced and the tip advanced in close proximity to the first and most superficial ventral ramus at C5. I prefer to use the short axis approach because the root is usually situated very superficially and there is more freedom to guide the needle and the needle has a shorter course. The long thoracic nerve may pierce and run in the middle scalene muscle and care must be taken when passing the needle as damage to this nerve will paralyze the serratus anterior muscle and produce a winged scapula. An injection around the roots C5 and C6 or injection of 5-10 ml of local anaesthetic solution between C5 and C7 is usually enough to block the nerves innervating the shoulder. At the level of C7, the ventral ramus of C7 lies in close proximity
to the vertebral artery anteriorly (see Figures 1 and 2) and care must be taken when introducing a needle in this region (the needle tip should always be dorsal to the C7 root at this level). When introducing a catheter the ideal position for shoulder surgery is between the C5 and C6 ventral ramus.

**Key learning points**

- Ultrasound offers the possibility to take into account the individual anatomy of the interscalene region
- Ultrasound-guided blockade, in trained hands, may augment the success rate of a single-shot ISB compared with nerve stimulator guided approach
- Ultrasound-guided interscalene catheter provides better postoperative analgesia than ultrasound-guided single-shot interscalene block
- Regional anaesthesia, even with ultrasound-guidance, can cause permanent neurologic damage, but the risk is extremely low
- The use of ultrasound-guidance may lower the incidence of inadvertent phrenic nerve block

**References**

Figure 1

Interscalene brachial plexus with large primary rami anterior appearing typically as 'black holes' (hypoechoic - like vessels, can be easily distinguished using Doppler ultrasound). 5 = C5; 6 = C6; 7 = C7; va = vertebral artery; asm = anterior scalene muscle; msm = middle scalene muscle; scm = sternocleidomastoid muscle; pttp = posterior tubercle of the transverse process of C7.

Figure 2

Doppler sonogram of the region showed in Figure 1. The blue colour represents the Doppler signal from the vertebral artery. 6 = C6; 7 = C7; scm = sternocleidomastoid muscle.
Figure 3

Interscalene brachial plexus with lots of small neuronal structures (*). The anterior rami of the roots are divided before forming the trunks in this image. asm = anterior scalene muscle; msm = middle scalene muscle; scm = sternocleidomastoid muscle.

Figure 4

Transducer and needle positions for interscalene brachial plexus block using a short axis approach.