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Ultrasound imaging in brachial plexus blockade

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Ultrasonography has provided anesthesiologists with the opportunity to visualize anatomy and guide needle insertion to peripheral nerves, as well as ensuring deposition of local anesthetic solutions accurately. Potential benefits include improved efficiency of nerve blockade, reduced patient discomfort, improved block efficacy, and avoidance of undesirable needle trauma or injection trauma to nerves or surrounding structures. Methods of blocking the brachial plexus using ultrasound guidance are reviewed and the existing literature summarized.

Brachial plexus nerve blockade has many potential benefits, including optimal pain control, reduced use of opioids, improved range of motion after joint surgery, and facilitation of early discharge after ambulatory procedures.[1-4] Ultrasound facilitates brachial plexus blockade, providing images of the plexus and surrounding structures, allowing real-time guidance of the needle to the nerve target, and permitting accurate deposition of the local anesthetic solution under constant observation.[5] At interscalene, supraclavicular, infraclavicular, and axillary levels, as well as distally in the arm, ultrasound has been used to guide peripheral nerve blockade.

Interscalene brachial plexus block

More than two decades ago, Winnie described a brachial plexus block at the level of the interscalene (ISB) groove,[6] which represents the most proximal approach to the nerves of the upper extremity. The scalene muscles and their investing fascia provide a well-demarcated potential space into which local anesthetic solutions may be injected, producing brachial plexus anesthesia. This approach to the plexus has several advantages for upper arm and shoulder surgery, including ulnar nerve sparing with preserved hand motion, and anesthesia of at least portions of the cervical plexus, which provides cutaneous innervation to the top of the shoulder.[7]

The interscalene groove lies posterolateral to the clavicular head of the sternocleidomastoid muscle. Most regional anesthesia atlases suggest that the most superficial elements of the brachial plexus should not be deeper from the skin surface than 1-2 cm at this level.[7,8] In a sonographic assessment of the anatomy of the brachial plexus, Yang reported an even shallower average depth from skin to plexus of 5.5 mm.[9]

Data on the conduct of ISB with ultrasound (US) guidance is largely descriptive. Chan describes the use of US-guided ISB to rescue a block which failed after nerve stimulation was used for guidance.[10] In a volunteer study of 15 subjects, Perlas and coworkers[11] described the anatomy of the brachial plexus at several levels, including the interscalene groove. The authors used the axial oblique plane of section at this level to visualize the plexus. They described it as consisting of hypoechoic nodules, which may be visualized between the scalene muscles, deep to the posterior border of the sternocleidomastoid muscle. Nearby vascular structures, including the internal jugular vein and vertebral artery, are well visualized.

Kessler and Gray[12] conducted a study of volunteers in which the plexus and its surrounding anatomy were visual-

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ized in the interscalene region with ultrasonography. In 13% of plexuses, variations from the typical relationship of the scalene muscles and brachial plexus roots were present, the most common being the C5 nerve root running through or outside the anterior scalene muscle. The authors postulate that this arrangement may be responsible for occasional incomplete interscalene blocks.

To evaluate the existence of a brachial plexus "sheath" at proximal levels, Yang and coworkers inserted catheters into the interscalene groove under real-time ultrasound guidance.[9] Injection of contrast under fluoroscopy was used to confirm catheter position, and the movement of contrast was studied as evidence of the conformation and integrity of the sheath enveloping the brachial plexus at this region. Injected contrast collected in the interscalene groove, but also made its way out of the apparent fascial confines of this space, enveloping the scalene muscles in 90% of subjects, and abutting the carotid sheath in half. The authors concluded that the connective tissue sheath surrounding the brachial plexus is discontinuous.

ISB with US is simple. Because the nerves are superficial, a high-frequency (10-15 MHz) probe is most useful. Imaging should begin at the base of the neck, in the supraclavicular fossa, with the long axis of the probe parallel to the clavicle, in a coronal oblique orientation. Here, the artery is readily visualized on top of the first rib and provides a reliable landmark for location of the plexus, which lies dorsal and superior to the vessel.[11] After locating the nerves adjacent to the vessel, the probe is used to trace the nerves proximally, with gradual assumption of an axial oblique orientation (Figure 1), in which the fascicles within the nerve roots are seen as dark (hypoechoic) nodules. They usually align vertically as they emerge from the spine, lying between the anterior and middle scalene muscles. As noted above, nerve roots may take an aberrant course and run outside of this groove in some individuals.[12]

The level of US-guided ISB will usually be between C5 and C7. It is not necessary to perform the block at exactly C6, as is usually directed with PNS-guided block. Many authors advocate confirmation of the nerve structures with use of a nerve stimulator, but there is not universal agreement on this point, nor is this technique established to be more reliable than use of US alone for guidance. The needle is inserted in-plane, posterolateral, or antero-medial to the probe, and its tip directed to the nerve structures. The stimulator may be turned on at this point (or may be on throughout needle insertion) if PNS is used. The exact magnitude of current is not established; a setting which reliably produces stimulation with approximation of needle tip to nerve should be chosen, probably in the 0.5- to 1.0-mA range. The in-plane needle introduction allows the operator to visualize the shaft and tip of the needle throughout insertion (see Figure 1). After confirmation of anatomy by PNS, or by visualization of appropriate anatomy, a small volume of local anesthetic solution, 1-2 ml, is injected to ascertain that the tip of the needle is not intraneural and not intravascular.[13] This also confirms that the tip is adjacent to the neural structure in question. Small aliquots of local anesthetic solution are then injected into the interscalene space, to produce a "halo" surrounding the nerves in the interval. This is usually accomplished with one needle position, but occasionally requires adjustment of the position of the tip to ascertain flow throughout the space.

As the block proceeds, the solution typically outlines the nerve roots and branches, highlighting them. After injection is completed, the probe can be moved caudad and cephalad along the IS groove to evaluate the nerves and confirm that the space has been successfully filled with local anesthetic. Anecdotally, specific injection into the interscalene groove with US visualization has allowed our group to reduce volumes of local anesthetic (0.75% ropivacaine) from 40 ml to approximately 25 ml with little effect on duration.

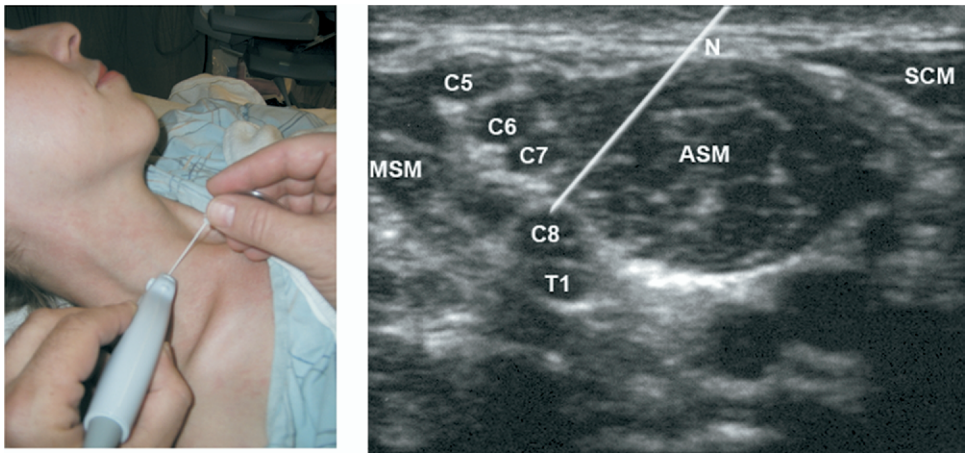

Figure 1 Ultrasound-guided interscalene block. (A) In this example, the needle is introduced from an antero-medial to postero-lateral direction, in-plane with the transducer, which is held in an axial oblique orientation. (B) Ultrasound scan of real-time needle guidance during interscalene block. N = needle (enhanced with photo editing for emphasis); C5-T1 = cervical and first thoracic nerve roots; ASM = anterior scalene muscle; MSM = middle scalene muscle; SCM = sternocleidomastoid muscle. (Color version of figure is available online.)