Ultrasound Guided Regional Anesthesia: Current State of the Art

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Objectives
For the target audience to:
1. Describe strengths and weaknesses of ultrasound guided approaches to regional blocks.
2. Identify specific ultrasound anatomy for common regional blocks.
3. Be able to recognize and prevent adverse events that can occur during ultrasound guided regional anesthesia.

Approaches
There are many approaches to regional blocks with ultrasound guidance. Here are some common techniques and some comments on their utility.

Offline Markings. This means making skin markings based on ultrasound scans (but not imaging while the needle is placed). This method is limited by changes in patient position, skin mobility, elastic properties of soft tissue, distortion by local anesthetic injection and overall accuracy of the markings. Furthermore, although the required depth can be noted it is difficult to mark the anticipated angle of needle insertion. It is most commonly used today for spinal and epidural blocks.

Online approaches (live realtime imaging while the needle is placed) are generally classified as either out-of-plane or in-plane.

Out-of-plane (OOP). With this approach the needle tip crosses the plane of imaging as an echogenic dot. This approach is mostly used for shallow blocks and sometimes used for catheter insertion. The advantage is that the needle paths are short but one concern is that anatomic structures may be punctured outside the plane of imaging. In-plane (IP). With in-plane technique the entire shaft and needle tip are within the plane of imaging. This is an increasingly popular technique for regional blockade and provides the most direct form of guidance. The downsides are the longer needle paths and partial lineups are possible (when the shaft is mistaken for the needle tip). The most common error for novices with in-plane technique is to advance the needle without adequately identifying the tip.

Hand on needle hub. This technique uses extension tubing and a reservoir syringe. It has the advantage of being a very precise method for needle control.

Hand on syringe. This technique is often used with out-of-plane approaches to regional blocks and allows one operator to easily control the injection while the needle is moving.

Needle tip visibility. Needle tip visibility is primarily influenced by the needle diameter and angle of insertion. Echogenic needles can be an advantage when steep angles of needle insertion are necessary. Spatial compound imaging also can help improve needle tip visibility over a limited range of angles. The needle bevel is easiest to identify when oriented to face the transducer.

Solutions for injection. Injections of clinically degassed solutions of local anesthetic (all visible air removed) are recommended to help outline the visible borders of peripheral nerves with anechoic fluid.

Examples of Commonly Performed Regional Blocks

Femoral Nerve Block. The femoral nerve has a limited range of sonographic visibility. Proximally the nerve lies deep on the surface of the iliopsoas muscle in its retroperitoneal location. Distally the nerve divides into multiple small branches that are not easily imaged. The femoral nerve is most visible within one or two cm from the inguinal crease. Nerve visibility can be enhanced by rotating the transducer so that it lies along the crease and then tilting the transducer to maximize nerve echoes. Sometimes the femoral nerve is only visible as an oval or triangular indentation in the muscle as it lies in the groove between the iliacus and psoas. The nerve has a slight inclination over the surface of the muscle that is more superficial laterally. The needle tip is placed under the fascia iliaca at the lateral corner of the femoral nerve. The lateral circumflex femoral artery (LCFA) can sometimes be identified overlying the femoral nerve and occasionally lies near the needle path.
Saphenous Nerve Block. The saphenous nerve is the largest and longest branch of the femoral nerve. There are a large variety of approaches to saphenous nerve block. One common approach is at the level of the mid-thigh where the saphenous nerve lies under the sartorius muscle on the anterior side of the superficial femoral artery. This transsartorial approach to subsartorial plexus block is popular because it is relatively easy to place the needle tip under the muscle for complete block.

Popliteal Block (see figure). The key to popliteal block is to place the needle tip between the common peroneal and tibial nerves at the point of bifurcation of the sciatic nerve in the popliteal fossa. This allows a single injection to surround both common peroneal and tibial nerves where there is a large amount of nerve surface area to promote favorable block characteristics. In this relatively distal location the nerves are superficial which makes nerve imaging and needle manipulation easiest. These blocks are usually performed using a lateral approach in supine position with the leg elevated to allow imaging from the posterior surface of the leg. Success of popliteal blocks is easily confirmed by sliding the transducer distally to verify that the injection tracks along both the common peroneal and tibial nerves.

Proximal Sciatic Nerve Block. Proximal sciatic nerve block is usually performed in the subgluteal region. It can be difficult to image the sciatic nerve in this location. The sciatic nerve lies lateral to the tendon of the semimembranosus muscle. The conjoint tendon of the biceps femoris and semitendinosus points to the medial aspect of the sciatic nerve because the nerve lies in the crease between these two muscles. Perforating arteries can be seen crossing the anterior side of the sciatic nerve. Sometimes the sciatic nerve must be traced proximally from its bifurcation in the popliteal fossa. At our institution proximal sciatic nerve block is usually performed in lateral position.

Axillary Block. Axillary block is performed at the level of the conjoint tendon of the teres major and latissimus dorsi because four terminal branches of the brachial plexus (median, radial, ulnar, musculocutaneous) lie superficial to this tendon. Axillary block has the advantage of being very superficial and feasible even in morbidly obese patients. Anatomic variation of the brachial plexus is very common in the axilla, especially median-musculocutaneous nerve fusion (a low lying lateral cord).

Infraclavicular Block. Infraclavicular block of the brachial plexus is performed at the level on the pectoralis minor muscle. In this location the brachial plexus consists of three cords that compactly hug the walls of the second part of the axillary artery. The infraclavicular region has the advantage of being a secure place for a catheter that provides complete brachial plexus anesthesia. Another advantage is that anatomic variation is relatively uncommon in this region. In the infraclavicular region the subscapularis muscle forms the margin of safety between the neurovascular bundle and the chest. The needle tip is usually placed between the lateral cord and artery to inject local anesthetic that results in a “U” shaped distribution under the posterior aspect of the artery. Some retraction of the lateral cord with the needle may be necessary to pull the cord further laterally away from the axillary artery. The cephalic vein can lie over the axillary artery in the infraclavicular region and can be recognized by its “tadpole” shape.

Where the operator and ultrasound machine are positioned for a particular block will depend upon whether the display is fixed on a cart stand or is freely mobile on an articulating arm.

Efficacy and Performance

Ultrasound guided regional anesthetics have been reported to have superior block characteristics than those guided by nerve stimulation. Furthermore, most studies have found faster and more consistent block performance times when ultrasound is used. One criticism of these studies is that most have simply measured the needle insertion time because this is what matters most to patients and it is relatively easy to quantitate. However, this does not include equipment and machine setup time, which is important to the practitioner. When setup times are included.
performance times for ultrasound and nerve stimulation appear to be similar. Combined techniques that use both ultrasound and nerve stimulation have uniformly been reported to take longer than straight ultrasound techniques.

Safety

Given the low incidence of serious complications that can occur after regional anesthesia, it is difficult to show in controlled trials that ultrasound guidance reduces these adverse events. However, several large clinical series now suggest that ultrasound guidance is at least as safe as traditional landmark and nerve stimulation approaches as the historical controls. These series have examined important outcomes including intervention related nerve injury, systemic toxicity, vascular puncture, hemidiaphragmatic paresis, and pneumothorax. Meta-analysis of the vascular access literature has suggested that ultrasound guidance reduces complications associated with line placement. Together with significant education and training, in the future we are likely to find similar results regarding ultrasound guidance for regional anesthesia.

There are many distinct patterns and morphologies of intraneural injections. The incidence of unintentional intraneural injection during ultrasound guided regional blocks has been estimated to be as high as 17%. These reported intraneural injections are likely to be subepineurial and have not been associated with functional nerve damage. However, intraneural needle tip placement with disruption of the perineurium is believed to be a risk factor for peripheral nerve injury.

Many clinicians reassure patients that by using ultrasound imaging to guide regional anesthesia the procedures will be safe and effective. However, there are now many cases reports of intravascular injection of local anesthetic and systemic toxicity (LAST) occurring despite the use of ultrasound guidance. In a large clinical series of regional blocks, there was no reduction of local anesthetic systemic toxicity with ultrasound guidance. Both major and minor toxicity continued to occur, albeit with low incidence (approximately 1 per 1000 regional anesthetics, consistent with other clinical series). A recent ASRA practice advisory concluded that the overall effectiveness of ultrasound guidance in reducing the frequency of local anesthetic systemic toxicity remains to be determined.

Ultrasound has tremendous potential for reducing systemic toxicity of local anesthetics for several reasons. First, lower volumes of drug are likely to be used than with alternative modes of regional block guidance. Second, there is some evidence that blood vessels are less likely to be punctured. Third, in the event that vascular puncture occurs, it should be easily and rapidly detectable by the intraluminal injection contrast.

References


Disclosure

This speaker has indicated that he or she has no significant financial relationship with the manufacturer of a commercial product or provider of a commercial service that may be discussed in this presentation.