Overview: Ultrasound is not new to the specialty of anesthesiology (1,6,7). TEE has been a regular part of cardiothoracic monitoring since the late 1980’s. Nor is the use of ultrasound new in regional anesthesia (1,2,3,6,7). LeGrange first described the use of Doppler to facilitate the placement of a supraclavicular block by localizing the subclavian artery (1). However, the use of real-time ultrasound guidance for regional anesthesia did not begin until the early 1990’s when two dimensional ultrasound technology became available(1,2,3,6,7). Although practitioners have slowly been developing ultrasound-guided regional techniques for a better part of a decade, there still are a very limited number of randomized controlled trials.

Equipment: The different regions of the body demand different type of probes both for ergonomics and image quality. We like to have several different probes of different lengths to tailor the approach to the patient’s anatomy. We use a couple different sized linear array probes between 25 and 38cm in length and find that we can perform a majority of our blocks successfully within this probe range. It is crucial, in our opinion, to have an ultrasound machine capable of generating frequencies of 8 to 12 MHz (or greater) to give the practitioner the variability needed to perform all major nerve blocks. Higher frequency probes are certainly better for imaging the brachial plexus and are desirable, but not absolutely necessary. The higher resolution frequencies are used primarily for superficial structures such as the brachial plexus when performing the interscalene or supraclavicular approach. The lower, better penetrating frequencies are usually required for imaging deeper structures, primarily in the lower extremity such as the femoral and sciatic nerves. The deeper, lower extremity nerves tend to be much larger in size than the brachial plexus nerve bundle, thus higher resolution is not required to accurately image these structures.

Ultrasound machines come in many sizes with many capabilities. We use both portable and conventional stand-alone machines. The portable machines give us an advantage of ready transport to different areas of the hospital to perform “rescue” blocks or IV placement. The image generated is more than adequate with portable machines, however the stand-alone machines we found tend to have slightly better image quality. At Dartmouth, we use B-bevel needles exclusively. Although B-bevel needles have never been statistically shown to be “safer” than conventional needles in terms of preventing nerve injury, we have observed that tissue moves out of the path of the needle when not adherent to surrounding structures more readily when compared to a traditional cutting or pencil point needle.

Techniques: The two larger subgroups of techniques for ultrasound-guided regional anesthesia are the marking technique and real time technique. For the marking technique, the probe is placed on the skin surface over object of interest and then a line is place on
the skin to note the object. An example would be drawing the course of the femoral artery before placing a femoral nerve block. Once the skin is marked, the probe is removed and the nerve block is placed in the conventional fashion. The drawback with this technique is that the advancement of the needle is not visualized through its course in the body. However, with this technique you can ascertain where certain structures are that need to be avoided which may enhance the safety of the procedure. However, we have mostly abandoned this method in favor of the real-time method.

With the real-time method, the needle is advanced within the longitudinal plane of the ultrasound beam that enables visualization of the needle in its course to the target nerve. This technique is highly effective and we postulate safer because you can see your target structures, but more importantly, you can image structures to avoid such as blood vessels. For this technique to be successful, the practitioner must place and maintain the needle in its entirety within the ultrasound beam. If the practitioner fails in this one aspect then the inherent safety of this technique is lost since the tip is not being visualized thus its location is in doubt. The other benefit of this technique is that you can visualize the spread of local anesthetic around the target nerve or what is referred to as the “donut sign”. The real time technique also allows you to correct your needle placement if your local anesthetic is not obtaining the circumferential spread. This will enable you to “save” the block.

The needle must always be advanced within the transverse plane of the probe when possible. This allows one to visualize the needle over its entire course, but more importantly, if the needle is not visualized in its entirety the tip’s whereabouts is unknown. This can lead to block failure at the very least and potentially serious patient morbidity and mortality.

Summary of various techniques of real-time ultrasound guidance (All needles are b-bevel, the actual size depends on body habitués):

- **Interscalene:** Image 3-4 dark circles in between the scalene muscles on axial section. Use the highest frequency (MHz) probe as possible. We prefer a linear probe. Insert the needle in the longitudinal plane either through the middle scalene muscle. Visualize local spreading between muscles around the nerves. If you are having trouble with space to maneuver the probe and needle simply roll the patient onto the non-operative side. You can also perform an “anterior approach” through the anterior scalene muscle however be aware that the risk of phrenic nerve injury is increased with the anterior approach as is the risk of penetrating the carotid artery or internal jugular vein in a petit patient. Personally, I try to avoid the anterior approach unless absolutely necessary.

We also place interscalene catheters at Dartmouth. To facilitate placement, we will have the patient placed on the non-operative side down. We usually will use a probe stabilization device to facilitate placement. The approach we use is the posterior approach for the single-shot technique where we approach the plexus through the middle scalene muscle. Our target is the placement of the needle tip between the C5 and C6 nerve roots. If the catheter does no thread out of the needle, a ninety-degree turn of the bevel caudad will facilitate catheter placement. The catheter usually will only thread a couple centimeters from the needle tip.
• **Supraclavicular:** This has become our most popular block. In fact, it has essentially replaced axillary nerve blocks. It has been referred to as the “spinal of the arm.” This block gets excellent tourniquet coverage and definitively anesthetizes the musculocutaneous nerve. We use a linear probe (25 or 38 mm), with greater than 10 MHz resolution, and place it in the supraclavicular fossa such that the subclavian artery is imaged on axial section. Just superior-lateral to the artery appears a grape like cluster of hypoechoic circles with hyperechoic rings. A 2 inch stimulating needle is inserted from the lateral aspect of the probe and directed between the artery and the nerve complex. A distinct pop is palpated and visualized on the screen. If using nerve stimulation, a corresponding twitch will ensue and the injection commences. The local anesthesia should be visualized filling the brachial plexus sheath and not spreading above visualized facial planes. If this occurs, the needle is repositioned. The inherent “safety” of this block using ultrasound can be postulated as the 1st rib, subclavian artery, and lung are all visualized!

• **Infraclavicular:** Image the brachial plexus 1 cm lateral to the corocoid process. There is a natural fossa here. The probe which we prefer is a 25 mm linear transducer with a frequency of 5-10 MHz which fits nicely into this fossa and allows easy visualization of the structures in cross-section. The nerves appear as hypodense grape like structures with hyperechoic rings. The needle is inserted so that it appears in the longitudinal plane of the ultrasound. The exact entrance site will depend on the individual anatomy. As with the interscalene block, one should visualize the local making a “doughnut sign.” If using the nerve stimulator technique with ultrasound, one can easy stimulate the various cords of the brachial plexus that are imaged surrounding the subclavian artery.

  When placing a catheter in the infraclavicular fossa we have found the most success when the needle enters from the superior aspect of the probe, in-plane with the ultrasound beam. The probe should be manipulated to “form” the subclavian artery as a circle (instead of a tube) before placing the block. Our goal is to enter the sheath at the inferior border of the artery on the side of the artery that does not contact the subclavian vein. This allows the catheter to thread in a more natural trajectory around the artery. Usually the catheter only needs to thread about 3cm beyond the needle tip to be effective if the needle is placed properly.

• **Axillary.** Any probe and frequency will do. For this block, we try to visualize the individual branches of the brachial plexus. The needle is inserted from inferior to superior and in the longitudinal plane of the ultrasound beam. The needle is directed towards each branch of the brachial plexus separately, thus you will need to make multiple needle passes (This is why we do not perform this technique very frequently. Instead we prefer the supraclavicular approach, which usually requires only one needle pass). A nerve stimulator can be very helpful for confirmation of each branch. The local anesthetic is then injected and the doughnut sign is generated around each branch of the brachial plexus. If a complete doughnut sign is not generated, then the needle is repositioned as needed to create a circumferential spread of local anesthetic around each branch. We refer to this as “painting” the local anesthetic.
• **Femoral:** The probe of choice is a linear probe with a frequency of anywhere between 4-8 MHz. If there is a pannus, it is secured out of the field using epidural tape. The femoral artery and nerve are visualized on cross-section just below the inguinal ligament. The needle is inserted from lateral to medial in the longitudinal plane of the ultrasound beam. Because this nerve is the hardest of all to visualize, we usually use concomitant nerve stimulation to generate a quad snap prior to injection. The nerve structure appears as hyperechoic (often triangular in structure) just lateral to the femoral artery. Once again, a doughnut sign should be visualized and the needle should be redirected if the local anesthetic appears to be dissecting away from the nerve.

• **Saphenous:** Prior to the use of ultrasound, this block was not reliable (for us) in terms of generating surgical anesthetic conditions. We often couple this block to a popliteal block for complete anesthesia distal to the knee. Originally we would place a tourniquet around the thigh to help visualize the saphenous vein distal to the knee and then inject directly under this structure. However, cadaver studies at our institution have shown that the saphenous nerve is not always reliably attached to the saphenous vein and that branches can emerge more proximal to the knee. Our current technique, developed and named SFAST (Superficial Femoral Artery Saphenous Technique) by Dr. Brian Sites involves tracing the femoral artery, from the groin distal about 4cm from the inguinal ligament. You must see the profunda come off of the femoral artery, if you do not proceed more distal down the leg. The nerve lies just lateral to the superficial femoral artery, underneath a perivascular fascial layer. We use the in-line approach and inject using a perivascular technique with 5 to 10cc’s of local anesthetic. (Note you may not see the nerve structure clearly.)

• **Transgluteal sciatic.** We do not recommend using ultrasound for this block, as it is difficult to image this structure due to its depth.

• **Infragluteal sciatic.** We prefer the small foot print (25 mm) probe with 5-10 MHz of resolution. The patient is placed in the prone position. The gluteal crease is identified and the biceps femoris tendon is palpated at this level. The nerve is imaged on cross-section approximately 1 cm lateral to this tendon which appears as a hyperechoic (bright) single structure. The needle is inserted from lateral to medial and in the longitudinal plane of the ultrasound beam. Because this nerve can be difficult to visualize, we will often use nerve stimulation as an adjunct.

• **Popliteal.** This is our favorite lower extremity block and technically the easiest with ultrasound. The sciatic nerve in the popliteal fossa is an ideal structure to be localized by ultrasound. This is because the nerve is surrounded by adipose tissue, which creates a strong echo interface. The nerve appears as a bright (hyperechoic) structure surrounded by the dark (hypoechoic) adipose tissue. The same probe set up is used as for the infragluteal approach. We examine the popliteal fossa between 5-10 cm proximal to the popliteal crease. The division point of the sciatic nerve is identified by imaging the common peroneal-tibial nerve complex on cross section. We then visualize the sciatic nerve 1-2 cm proximal to this division point. The needle is inserted from lateral to medial and in the longitudinal plane of the ultrasound beam. When the needle is just about to touch the nerve, the local is injected. The doughnut sign should be visualized.
The needle is readjusted as necessary and local anesthetic is injected so as to circumferentially surround the nerve.

- **Wrist Blocks**: The median and ulnar nerves are all easily imaged with high-resolution linear probes in the mid-forearm. We have replaced the need for bier blocks for carpal tunnel releases. We image the median nerve approximately 6 cm from the radial-lunate articulation. A 2 inch b-bevel needle is inserted from either the ulnar or radial aspect of the probe until it just contacts the median nerve. 5 ml of 0.25% bupivacaine is injected. The needle is repositioned if needed to force local anesthetic to spread circumferentially around the nerve. At the same proximal location of above the wrist, the probe is moved to the ulnar side, such that the ulnar artery is imaged with the nerve lying on the ulnar side of the artery. The same injection sequence is repeated for the ulnar nerve. The wrist block is completed by placing a subcutaneous wheal of local in the anterior-lateral aspect of the wrist to cover the superficial radial nerve.

- **Transversus Abdominis Plane (TAP) Block**: This is a recent addition to our regional armamentarium. This block is easily performed with ultrasound as the different fascial planes are easily imaged since they are highly echogenic. A great description of the technique can be found at Heartweb.com.au.

References:


