Clinical Protocols of the Anesthesiology Department at the Dartmouth-Hitchcock Medical Center: Techniques for lower extremity nerve blocks.

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Philosophy:

We believe that vision is the best of the primary human senses. Ultrasound allows the anesthesiologist the ability to evaluate complex and varied neural anatomy prior to needle insertion. In addition to real-time guidance of the needle towards a nerve or plexus, ultrasound allows the anesthesiologist to witness (and alter) the spread of local anesthesia after the initiation an injection. Ultimately, it is this visual confirmation of the perineural spread of local anesthesia that generates a rapid and successful block.

Equipment specification:

1) ultrasound machine 2) ultrasound probe 3) probe specifications: linear with variable resolution settings 5-12 MHZ 4) stimulating needles 5) ultrasound gel (sterile and non-sterile) 6) sterile probe cover 7) nerve block kit which contains sterile drape, skin wheal needles, extension tubing, syringes of choice.

Optional equipment:

A) needle guide systems B) probe stabilizing device

In-line versus out-of-line technique: (Figure 1)

There are two ways to insert the needle with respect to the ultrasound beam. Because state of the art clinical imaging is still two dimensional, the inserted needle can either be
visualized in the long or short axis. When the needle is inserted in the long axis view, the entire needle can be visualized. This is known as the in-line technique. When the needle is inserted on short axis, a cross-sectional view of the needle will be obtained. This is known as the out-of-line technique. The important point is that with the in-line technique the entire needle and the tip can be visualized, allowing the operator to make very precise real-time adjustments. The out-of-line technique results in the needle being imaged on cross-section. A 22 to 18 gauge needle imaged on cross-section will appear as a small dot which can be difficult to see in real time. In addition, the needle will cross the ultrasound beam only once. Therefore, when the needle is visualized and depending on the angle of the insertion, it may be well above or below the target nerve. For single injection nerve blocks, we prefer the in-line technique. The out-of-line technique is preferred for continuous catheter placement. When using the out-of-line technique, it is helpful to inject small amounts of saline, local, or D5 to help define the location of the needle tip as it is being advanced. The major learning obstacle for the in-line technique is the ability to keep the needle in the path of the ultrasound beam.

**General clinical points:**

1. Use a high frequency ultrasound system ($\geq 12$ MHz) for superficial blocks that are $\leq 3$ cm deep. This allows the best resolution of the neural structures and surrounding tissue. Deeper blocks will require lower frequency systems that result in better penetration of the ultrasound beam into the tissue.

2. The needle should be visualized before being advanced when using the in-line technique. The ultrasound beam is very thin which means that subtle movements can bring the needle in and out of visualization.

3. Subtle pressure or angulation of the probe can dramatically improve or worsen your image.

4. Practice your needle skills using a turkey breast with an olive placed in it. This popular model used by interventional radiologists mimics a human breast cyst.

5. Ask the experts at your institution for clinical pearls and insights. We have gained many tricks of the trade by speaking with radiologists and ultrasonographers. Specifically, the operator should be familiar with color flow indicators, gain, focus, frequency settings, and image storing.

6. Keep a database of your cases, you will quickly realize the improvement in efficiency and efficacy of your regional anesthesia service.

7. Many ultrasound systems come with needle guide devices for their probes. These are devices that secure the needle to the probe and allow the operator to follow a predetermined course to the target of interest. Although on the surface these devices may sound attractive, we have found that they often limit the options of the anesthesiologist. That is, once the needle is secured into the needle guide device, one can not change
angles and approaches to the nerve that would allow generation of the circumferential spread of local anesthetic around the nerve.

8. The probe should be held in the operator’s non-dominant hand and the needle in the dominant hand. The ability to use both hands to drive the needle will give those fortunate individuals an ergonomic advantage.

9. Place the ultrasound machine on the contralateral side of the patient and to have the operator stand on the ipsilateral side of the extremity to be blocked. We have standardized our practice in that the top of the screen should be the side closest to the probe. Screen left should be the right side of the patient. Screen right should be the left side of the patient. This has generated the ability for us to clearly communicate and teach the techniques to residents and students alike.


**Femoral Nerve Block Single Injection:** (Figures 2-5)

**PATIENT POSITION:** Supine  
**PROBE LOCATION:** Infrainguinal  
**FREQUENCY:** High to intermediate depending on body habitus  
**IN-LINE/OUT-OF-LINE:** Either  
**NERVE IMAGE:** Triangular and hyperechoic, lateral to femoral artery  
**NEEDLE SIZE:** 50 to 100 mm  
**LOCAL VOLUME:** 20-30 ml

1. Place the probe in the infra-inguinal regional. Probe specifications: Linear: 25 mm to 38 mm in footprint length. The frequency settings should allow high to intermediate resolution.
2. Image femoral artery on short axis.
3. Use color doppler if needed to help identify the femoral artery.
4. Image femoral nerve just lateral to the femoral artery.
5. Key structures to identify besides the nerve include iliacus muscle, psoas muscle, and fascia iliaca. The fascia iliaca, the key landmark, appears as a horizontal tissue plain found just anterior to the vessels and nerve.
6. Infra-inguinal short-axis view of the femoral nerve usually appears as a hyperechoic (bright) triangular structure with internal hypoechoic small circles.
7. Our preference is to insert the needle in-line with the ultrasound beam from lateral to medial (Figure 3).
8. An alternative approach would be to insert the needle in the middle of the probe such that the needle is imaged on short axis as it approaches the nerve (Figure 4).
9. Inject the local anesthetic.

Clinical Pearls:

1. The major objective of real-time ultrasound imaging for this block is to assure that the needle and the spread of local anesthesia is located below the fascia iliaca and lateral to the femoral artery. Needle adjustments should be made (usually to advance) if local anesthesia is seen spreading superficial to this layer.

2. While nerve stimulation is an excellent physiological test of needle proximity to the femoral nerve, our experience suggests that (provided the conditions in clinical pearl number 1 are met) successful blocks result regardless of the twitch status. Given the fact that there is a known false negative rate of all diagnostic devices (including nerve stimulation), demanding a specific motor response pattern despite correct needle location may result in an unnecessary increase in the number of needle passes.

3. Rapid and profound blocks occur when local anesthetic spreads circumferentially around the femoral nerve. This has been described as the “doughnut sign” (Figure 5).

4. We have reduced our volumes of injection down to 30-50% of traditional approaches.

5. If you are performing the out-of-line technique, it is helpful to inject small amounts of local, saline, or D5 as you advance the needle. This helps to identify the location of the tip of the needle.

6. Look for associated femoral artery pathology. A femoral artery atherosclerotic plaque appears as a hyperechoic structure lying within the normally hypoechoic lumen. Often there is a dark drop out shadow posterior to the lumen. This is because the calcium filled plaque prevents ultrasound from penetrating through the lumen.

**Femoral Nerve Block: Continuous catheter technique: (Figures 4,6,7)**

*PATIENT POSITION:* Supine  
*PROBE LOCATION:* Infrainguinal  
*FREQUENCY:* High to intermediate depending on body habitus  
*IN-LINE/OUT-OF-LINE:* Out-of-line  
*NERVE IMAGE:* Triangular and hyperechoic, lateral to femoral artery  
*NEEDLE SIZE:* 50-100 mm  
*LOCAL VOLUME:* 10 ml bolus dose

Steps 1-6 are the same.

7. Insert the needle in the middle of the probe (out-of-line technique) and slightly angled towards the midline. The needle should be hooked up to extension tubing with the bolus
dose ready to inject. The needle should be advanced and visualized crossing the ultrasound beam below the fascia iliaca and over the femoral nerve (Figure 4).

8. A bolus injection of 10 ml of either saline or local anesthetic is utilized to confirm that the needle tip is correctly located above the femoral nerve and below the fascia iliaca. This is the critical endpoint. The needle is in the correct location when the hypoechoic local anesthesia forces the fascia iliaca anteriorly towards the probe and the femoral nerve posteriorly away from the probe. Many practitioners may choose to also use nerve stimulation.

9. The probe is then put aside if it is not being held in a stabilizing device (see clinical pearls).

10. The catheter is then inserted and advanced 10-15 cm (Figure 6). The ultrasound image will demonstrate the catheter entering under the fascia. However, since the femoral nerve and catheter are being imaged on short-axis, you will not see the catheter traveling proximally.

11. If you choose to utilize a stimulating catheter, you may desire to bolus with a dextrose solution to maintain the ability to use the nerve stimulator.

Clinical Pearls:

1. Catheters advanced following confirmed correct needle location under the fascia iliaca (via the bolus injection) will be in one of three locations: A. At the level of the lumbar plexus B. Under the fascia iliaca over the psoas muscle C. Under the fascia iliaca over the iliacus muscle (Capdevila X. et al. "Continuous three-in-one block for postoperative pain after lower limb orthopedic surgery: Where do the catheters go?" Anesth Analg 2002;94:101-6.) All locations should work to generate a femoral block. The highest likelihood of a continuous 3-in-1 blockade will occur with Type A.

2. Because there are many steps in performing this technique: holding the probe, inserting the needle, bolus injection, disconnecting extension tubing, stabilizing the needle, and threading the catheter, it can be challenging for one person to perform this procedure by themselves. It is for this reason that we prefer to use a probe stabilizing device. This is essentially a mechanical arm that fixes the probe on the patient and allows the operator the freedom to dedicate both hands towards the placement of the catheter (Figure 7).

**Sub-gluteal sciatic block: (Figures 8-11)**

*PATIENT POSITION:* Prone  
*PROBE LOCATION:* Sub-gluteal crease  
*FREQUENCY:* Intermediate to low depending on body habitus  
*IN-LINE/OUT-OF-LINE:* Either  
*NERVE IMAGE:* Triangular and hyperechoic, lateral to BFM/STM
**NEEDLE SIZE:** 50-100 mm  
**LOCAL VOLUME:** 20-30 ml

1. Ideally, have the patient in the prone position. This block is performed at or just below the gluteal crease. Usually, the block is performed just inferior to the ischial tuberosity.

2. Start by palpating the skin crease made by the gluteus maximus muscle.

3. A large rope-like muscle complex should be easily palpated. This complex is the biceps femoris muscle (BFM) and the semitendinosus muscle (STM). These muscles originate from the ischial tuberosity.

4. Place the probe in the sub-gluteal crease and over the BFM-STM complex. Probe specifications: Linear with a lower frequency setting between 5-10 MHz (Figure 8).

5. The BFM-STM muscle complex should appear on short axis as a hypoechoic structure with internal fascial components that appear hyperechoic. Lying just lateral to this muscle will be the sciatic nerve. The sciatic nerve appears as an oval or triangular hyperechoic structure (Figure 9).

6. Use either the in-line technique or the out-of-line technique to insert the block needle (Figures 10, 11).

7. Nerve stimulation may be used as with a traditional approach.

8. Local anesthetic is injected such that it spreads circumferentially around the sciatic nerve.

**Clinical Pearls:**

1. This is a more challenging block given the general similarity of the ultrasound appearance of perineural structures and the lack of consistent vascular relationships.

2. If the image is poor, identify the sciatic nerve in the popliteal fossa and trace it back proximally to the sub-gluteal region.

3. The sciatic nerve in this region is easier to image in more obese patients because the adipose tissue serves as a “contrast agent” for the nerve. That is, adipose tissue lining the sciatic nerve generates a nice echo interface in which the white nerve stands out in contrast to the darker fat.

4. Probe pressure on the skin often improves this image.
5. We favor this block over the transgluteal approach, since the nerve is located at a more superficial depth. This results in a better neural image and less discomfort with needle insertion.

**The popliteal block: prone positioning technique.** (Figures 12-19)

*PATIENT POSITION:* Prone  
*PROBE LOCATION:* Variable distance above popliteal crease  
*FREQUENCY:* Intermediate to low depending on body habitus  
*IN-LINE/OUT-OF-LINE:* Either  
*NERVE IMAGE:* Hyperechoic circle with internal hypoechoic dots  
*NEEDLE SIZE:* 50-100 mm  
*LOCAL VOLUME:* 20-30 ml

1. Start by placing the probe in the popliteal fossa at the level of the popliteal crease.

2. Image the popliteal artery on short axis at this level utilizing a linear probe with a variable frequency (8-12 MHz) depending on body habitus.

3. The tibial nerve will lie just posterior and medial to the popliteal artery. It appears as a hyperechoic oval or circular structure with internal hypoechoic small circles. The common peroneal nerve will appear as a hyperechoic circle or oval just lateral to the popliteal artery (Figure 12).

4. Move the probe proximally until you see the common peroneal nerve joining the tibial nerve (Figure 13). The common peroneal nerve tends to be smaller than the tibial nerve. As the probe is moved proximally the common peroneal nerve will travel from the lateral aspect of the screen towards the middle of the screen.

5. The target for the nerve block is the site at which the common peroneal and tibial nerves join together (Figure 14).

6. The needle can be inserted either using the in-line or out-of-line technique (Figure 15 and 16). Once again, the benefit of the in-line technique is that the needle can be visualized in its full course. When using the in-line technique, insert the needle from lateral to medial. The end point of the injection should be circumferential spread of local anesthesia around the sciatic nerve (Figure 14).

**Continuous Popliteal Catheter**

*PATIENT POSITION:* Prone  
*PROBE LOCATION:* Variable distance above popliteal crease  
*FREQUENCY:* Intermediate to low depending on body habitus
IN-LINE/OUT-OF-LINE: Either
NERVE IMAGE: Short axis: Hyperechoic circle; Long axis: Hyperechoic tube
NEEDLE SIZE: 50-100 mm
LOCAL VOLUME: 10 ml for the bolus injection

1. For catheter insertion, steps 1-5 are the same.

2. The stimulating needle is inserted via the out-of-line technique. Following appropriate motor response, 10 ml of local anesthesia is injected through the needle. The catheter is then threaded 3-5 cm.

3. An alternative approach is to visualize the sciatic nerve on long axis (Figure 17 and 18) and insert the needle via the in-line technique from distal to proximal. This technique allows the possibility of visualizing the catheter traveling perineurally in a cephalad direction.

Clinical Pearls:

1. More adipose tissue in the popliteal fossa makes the nerves easier to visualize. This is because adipose tissue has a different acoustic impedance compared to the common peroneal, tibial, and sciatic nerves. Fat appears dark or hypoechoic, whereas the nerves are bright or hyperechoic.

2. It is because of this fat/nerve relationship that the nerves are easier to image at the level of the popliteal crease. Therefore, if the sciatic nerve is too difficult to image more proximally (less fat, Figure 19), then simply inject local anesthetic individually around the common peroneal nerve and tibial nerves more distally in the popliteal fossa. They are extremely easy to image at this location.

3. The image of the sciatic nerve can often be greatly improved by pushing the probe harder onto the skin (anteriorly) and tilting the handle of the probe towards the patient’s feet.

The popliteal block: supine positioning technique. (Figures 20,21)

PATIENT POSITION: Supine with leg on adjustable table
PROBE LOCATION: Behind the leg and above the popliteal crease
FREQUENCY: Intermediate to low depending on body habitus
IN-LINE/OUT-OF-LINE: In-line
NERVE IMAGE: Hyperechoic circle with internal hypoechoic dots
NEEDLE SIZE: 100 mm
LOCAL VOLUME: 20-30 ml
1. The patient’s leg is placed on an adjustable table, such that there is an area exposed behind the knee which will easily accommodate a probe.

2. The same probe is used as for the prone position.

3. The probe is placed behind the knee and the same imaging objectives exist as for the prone approach.

4. Once the sciatic nerve is identified, the software on the ultrasound machine is used to measure the distance from the skin to the nerve.

5. This distance is used to define the site of the needle insertion.

6. A 100 mm needle should then be inserted completely perpendicular to the ultrasound beam (Figure 21).

7. The goal of the injection should be circumferential spread of local anesthetic around the sciatic nerve.

Clinical Pearls:

1. This is a fun block to perform. Since the needle is being inserted in a perpendicular fashion to the ultrasound beam it appears very bright, thus allowing the operator the utmost fidelity to direct the needle to the target.

2. Sometimes the distance measured in step 5 results in the needle needing to transgress the semitendinosus muscle. This can be somewhat uncomfortable for patients and may require more intravenous analgesia.

3. If the operator commonly performs the popliteal block in the prone position, then the ultrasound image will appear “backwards” on the screen. That is, moves that would normally (in the prone position) drive the needle in a more anterior fashion, now will direct the needle more posteriorly. Pre-block knowledge of this difference can help the operator anticipate the correct hand moves. In addition, toggle switches on the ultrasound machine can rearrange the image to virtually create a prone position scenario.

**Saphenous nerve block** (Figures 22-24)

*PATIENT POSITION:* Supine  
*PROBE LOCATION:* Medial aspect of lower leg and below the knee  
*FREQUENCY:* Highest frequency  
*IN-LINE/OUT-OF-LINE:* In-line  
*NERVE IMAGE:* Hyperechoic circle lateral to the saphenous vein  
*NEEDLE SIZE:* 50 mm  
*LOCAL VOLUME:* 5 ml
1. The saphenous nerve is usually targeted proximal to the mid tibial level; however, any site along the leg distal to the knee joint should suffice.

2. A high frequency linear probe with a small footprint is preferred.

3. The block is based on the intimate association of the saphenous nerve with the saphenous vein. The goal is to visualize these structures on short axis (Figure 22).

4. The nerve does not have to be visualized for a successful block.

5. When visualized, the nerve appears as a hyperechoic circle usually smaller than the vein. Using true anatomical position the nerve should be just lateral to the saphenous vein. The vein appears as a circular anechoic structure (Figure 23).

6. The needle is inserted using the in-line technique.

7. An induced paresthesia or a stimulated paresthesia can been sought.

8. Alternatively, local anesthetic can be injected circumferentially around the vein.

9. Only 5 ml is needed.

Clinical Pearls:

1. Since this block relies on the close relationship of the saphenous nerve and vein, if a patient does not have a saphenous vein (status post CABG surgery), then the ultrasound technique can be difficult and a conventional approach may be more appropriate.

2. Placing a venous tourniquet proximal to the site of the block will help identify the saphenous vein by making it increase in size.

3. The saphenous nerve is the terminal branch of the femoral nerve supplying sensation to the medial aspect of the leg and ankle. Therefore, we often couple this block to a popliteal block for foot and ankle surgery.

4. Very light probe pressure should be used. The smallest degree of pressure can compress the vein and make it difficult to find.

5. We often leave the doppler color on during the injection. This is because as the injection commences, the vein will collapse and become lost to the operator. By keeping the color flow on the vein, the continuous monitoring of the spread of local anesthetic around this structure can be achieved (Figure 24).

**Ankle Block** : (Figures 25-28)
**Tibial**  
PATIENT POSITION: Supine  
PROBE LOCATION: Above the medial malleolus, medial aspect of leg  
FREQUENCY: Highest frequency  
IN-LINE/OUT-OF-LINE: In-line  
NERVE IMAGE: Short axis, hyperechoic circle, posterior to the PTA  
NEEDLE SIZE: 50 mm  
LOCAL VOLUME: 5 ml

**Deep Peroneal**  
PATIENT POSITION: Supine  
PROBE LOCATION: Above the medial malleolus, anterior aspect of leg  
FREQUENCY: Highest frequency  
IN-LINE/OUT-OF-LINE: In-line  
NERVE IMAGE: Short axis, hyperechoic circle, lateral to the DPA  
NEEDLE SIZE: 50 mm  
LOCAL VOLUME: 5 ml

1. There are four distal nerve branches of the sciatic nerve. Of these, two are easily visible with ultrasound: the tibial nerve and the deep peroneal nerve.

2. For this block, a small footprint probe and high frequency are very helpful. We utilize the HS (hockey stick probe) scanning at 15 MHz.

3. For the tibial nerve, we place the probe 1-2 cm above the medial malleolus. The first goal is to image the posterior tibial artery on short axis. This structure appears as a hypoechoic circle lying approximately 0.5 cm medial and posterior to the tibia (Figure 25).

4. The tibial nerve appears as a hyperechoic circle lying just posterior to the posterior tibial artery (PTA) (Figure 26).

5. Insert a 50 mm needle from the posterior aspect of the probe and via in-line technique.

6. 5 ml of a plain local anesthetic should generate a sufficient block.

7. For the deep peroneal nerve, the same probe is placed on the skin at the level 1-2 cm above the superior border of the medial malleolus (Figure 27). While imaging on short-axis, the dorsalis pedis artery (DPA) is found as a small hypoechoic and pulsatile structure. Color doppler may be used to help identify this artery.

8. The nerve appears as a small hyperechoic circular structure lying just lateral to the artery (Figure 28).

9. Insert a 50 mm needle from either aspect of the probe and using the in-line technique.
10. 5 ml of plain local anesthetic will generate a sufficient block.

Clinical pearls.

1. If the saphenous nerve is critical for the surgery, we perform this block as described above.

2. We perform the block of the superficial peroneal and sural nerves via traditional and non-ultrasound techniques.