

Lower Extremity Nerve Blocks

Nihar V. Patel

A family vacationing in the mountains experienced a motor vehicle accident (MVA) involving their six-year-old daughter and four-year-old son. Both were taken to the local hospital for treatment of non-life-threatening orthopedic injuries sustained in the MVA.

The six-year-old girl was complaining of bilateral leg pain for which X-rays demonstrated a right-sided femoral neck fracture.

Her orthopedic surgeon wishes to repair her fracture with surgical pinning and asks if there is a regional block that can be performed to assist in her postoperative pain relief.

What Is the Innervation to the Lower Extremity?

The entire lower extremity is innervated by the lumbar and sacral plexus and their corresponding terminal nerves. The lumbar plexus arises from the L1–L4 spinal nerves (with some patients adding T12) and innervates mostly the ventral aspect of the lower extremity while the sacral plexus arising from S1–S4 innervates mostly the dorsal aspect. Figures 52.1–52.3 and Table 52.1 demonstrate the lower extremity innervation.

What Are the Regional Anesthesia Options for This Procedure?

Femoral neck fractures are high enough on the femur that the typical injection site of a femoral nerve block at the inguinal crease will not provide blockade at the surgical site. A proximal femoral nerve block in combination with a lateral femoral cutaneous nerve block can be performed to cover the sensory area overlying the surgical site. Historically, the three-in-one femoral nerve block, where a large volume femoral nerve block injection in combination with applied distal

pressure would cause the local anesthetic to spread proximally in a retrograde fashion and block the femoral, obturator, and lateral femoral cutaneous nerves, was thought to accomplish anesthesia of proximal femur/hip. Several studies have questioned the reliability of that technique. A fascia iliaca block could reliably block the lateral femoral cutaneous nerve as well as femoral nerve providing good coverage to the fracture. A lumbar plexus block where the femoral, lateral femoral cutaneous, and obturator nerves are blocked at their proximal plexus would also provide coverage. Lastly, a lumbar epidural block would likely provide excellent coverage at the expense of obtaining a bilateral block, and unnecessarily involving the unaffected side, and other possible side effects such as loss of motor control, and urinary retention.

How Is a Lumbar Plexus Block Performed?

Lumbar plexus blockade was traditionally done using anatomical landmarks to locate the plexus whose depth could be deep with vital organs in close proximity. With the patient in lateral position, a line was drawn connecting the iliac crest laterally and the spinous processes in the midline (at approximately the level of L3–L4). A spot is marked approximately 4–5 cm lateral to the midline on that line where the needle would be inserted in a perpendicular fashion. With a nerve stimulator set at 1.5 mA, a quadriceps twitch should be elicited. Once done, the current should be reduced to obtain stimulation between 0.5 and 1.0 mA.

The current standard of care is to use ultrasound to perform a lumbar plexus block as vital organs and adjacent structures can be visualized and avoided, such as the kidney, peritoneum, and intervertebral foramen. The most common views to visualize the lumbar plexus are the paramedian sagittal (Trident sign), the paramedian transverse oblique (Wave sign).

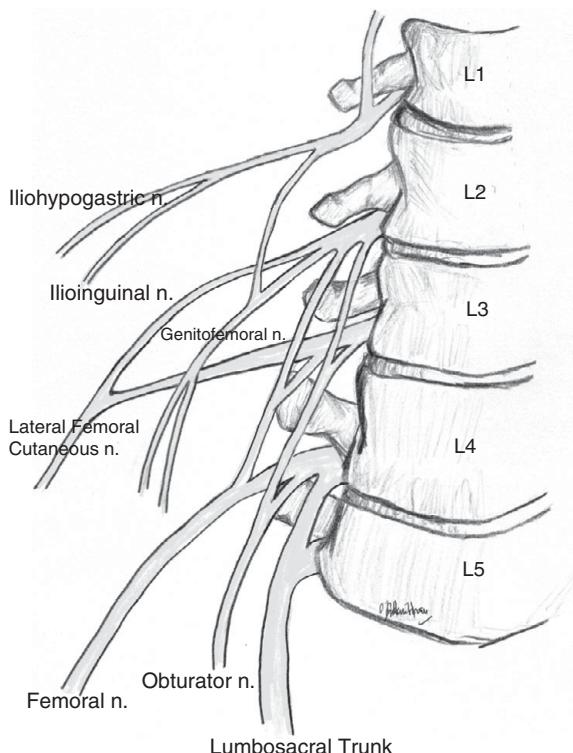


Figure 52.1 Lumbar plexus nerve distribution. Reproduced with permission from Arbona FL, Khabiri B, Norton JA (eds.) 2011. *Ultrasound-Guided Regional Anesthesia: A Practical Approach to Peripheral Nerve Blocks and Perineural Catheters*. Cambridge, UK: Cambridge University Press

and the transverse (Shamrock sign) scan. In the paramedian scan, the probe is placed longitudinally adjacent to the spinous processes (Figures 52.4–52.6). The resultant spinous processes can then be identified, including the desired L3 and L4 spinous processes. The view that results appears like a “trident” with the psoas muscle in between the transverse processes (spears of the trident). The lumbar plexus lies in the posterior third of the body of the psoas muscles which will appear to be the most superficial third of the muscle in this view.

In the paramedian transverse view, the ultrasound probe is placed transversely in the paramedian posterior regional at the level of L3/4. The desired view is termed the “wave sign” as the hyperechoic periosteum of the vertebral body, facet joint, and spinous process appear similar to a wave.

Lastly, the transverse scan with probe placement on the iliac crest produces an image where the three muscle bellies of the erector spinae, psoas, and quadratus lumborum muscles surround the L4 transverse

process to mimic a “Shamrock.” The lumbar plexus lies in the posterior third of the psoas adjacent to the transverse process. This approach allows for full in-plane view of the needle as it approximates the plexus.

What Are the Local Anesthetic Dosing Options for a Lumbar Plexus Block?

The lumbar plexus block is a large-volume block with no widely accepted universal dosing regimen. Generally speaking, 0.2–0.5 cc/kg of 0.25% bupivacaine or 0.2% ropivacaine can be used depending on the desired block duration. Careful attention should be paid to not exceed the maximum toxic dose of local anesthetic.

Case continued: In addition to the child’s right lower extremity injury, left leg X-rays of the daughter showed a mid-shaft fracture of the femur.

What Are the Regional Anesthesia Options for This Portion of the Surgery?

Given that the innervation of the femur is the femoral nerve, the options for regional anesthesia include the aforementioned lumbar plexus block, femoral nerve block, fascia iliaca block, and if the fracture is low lying enough, an adductor canal block. All three blocks reliably block the femoral nerve.

How Is a Femoral Block Performed?

A femoral block is performed utilizing the knowledge that the femoral nerve lies adjacent and lateral to the femoral artery and vein in the orientation lateral to medial (vein being medial) (Figure 52.7). In the nerve stimulator technique, the inguinal ligament is identified, and the femoral artery is palpated just distal to the inguinal crease. The needle with nerve stimulator should be inserted just lateral to the artery and a twitch of the quadriceps muscle should be elicited at current of 1 mA initially and then dialed down to 0.5 mA or below.

Ultrasound guidance is now more commonplace as the triad of the femoral vein, femoral artery, and femoral nerve can be directly visualized under the fascia iliaca in a medial to lateral fashion, respectively. The optimal image is as shown in Figures 52.8–52.9.

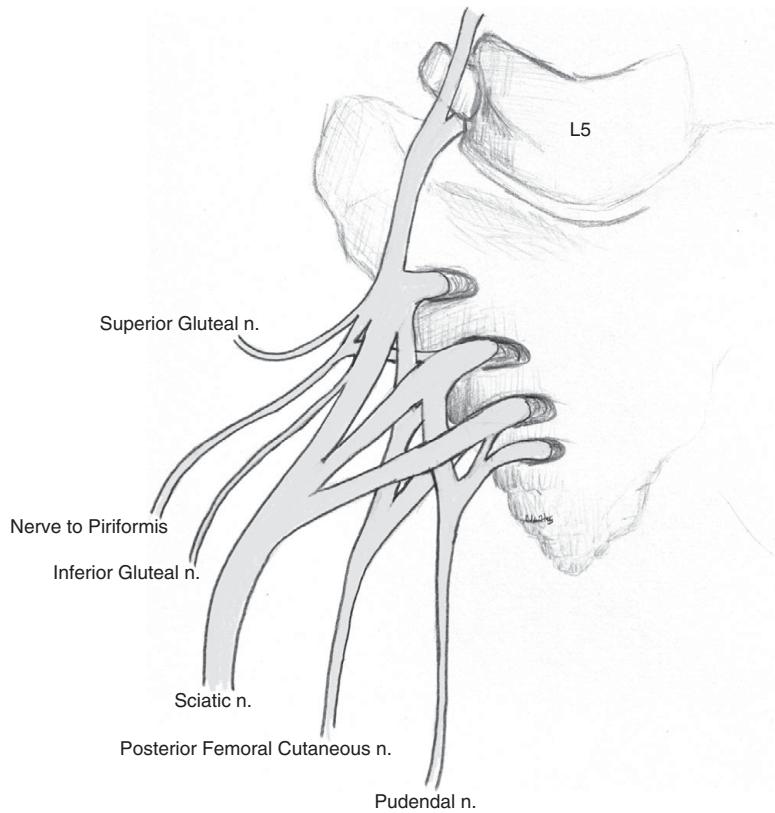
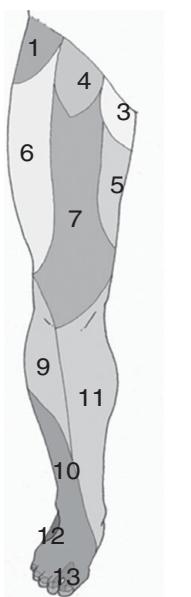


Figure 52.2 Sacral plexus nerve distribution. Reproduced with permission from Arbona FL, Khabiri B, Norton JA (eds.) 2011. *Ultrasound-Guided Regional Anesthesia: A Practical Approach to Peripheral Nerve Blocks and Perineural Catheters*. Cambridge, UK: Cambridge University Press



1. Thoracic T12 nerve
2. Iliohypogastric
3. Ilioinguinal
4. Genitofemoral
5. Obturator
6. Lateral cutaneous nerve of thigh
7. Anterior cutaneous nerve of thigh
8. Posterior cutaneous nerve of thigh
9. Lateral cutaneous nerve of calf
10. Superficial peroneal nerve
11. Saphenous nerve
12. Sural
13. Deep peroneal nerve
14. Plantar
15. Calcaneal nerve

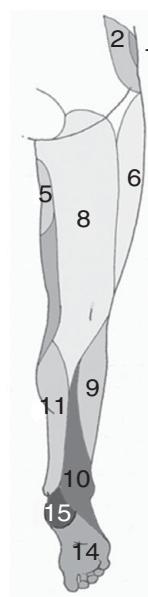


Figure 52.3 Cutaneous innervation of the lower extremity. Reproduced with permission from Arthurs G, Nicholls B (eds.) 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

Table 52.1 Summary of the lumbo-sacral plexus terminal nerve functions. Reproduced with permission from Arbona FL, Khabiri B, Norton JA (eds). 2011. *Ultrasound-Guided Regional Anesthesia: A Practical Approach to Peripheral Nerve Blocks and Perineural Catheters*. Cambridge, UK: Cambridge University Press.

Lumbo-sacral plexus terminal branch	Cutaneous sensation	Joint sensation	Motor action
<i>Iliohypogastric nerve (L1, +/−T12)</i>	Inferior abdomen Anterior hip	None	Abdominal muscles (transverse abdominus and obliques)
<i>Ilioinguinal nerve (L1)</i>	Medial, proximal thigh Anterior scrotum/labia majora	None	Abdominal muscles (transverse abdominus and obliques)
<i>Genitofemoral nerve (L1, L2)</i>	Over femoral triangle Fascia and skin of scrotum/ labia majora	None	Elevation of scrotum (cremaster muscle)
<i>Obturator nerve (L2–L4)</i>	Medial aspect of thigh Medial aspect of knee	Anteromedial hip, flexion of thigh	Adduction of thigh Extension of thigh
<i>Femoral nerve (L2–L4)</i>	Anterior thigh Medial leg and ankle, +/− medial foot	Anterior hip, knee	Flexion and lateral rotation of thigh, extension of leg Flexion of leg
<i>Lateral femoral cutaneous nerve (L2, L3)</i>	Lateral thigh	None	None
<i>Pudendal nerve (S2–S4)</i>	Much of external genitalia	None	Muscles of perineum
<i>Posterior cutaneous nerve of thigh (S1–S3)</i>	Posterior thigh Posterior leg	None	None
<i>Sciatic nerve (L4–S3)</i>	See below for terminal branches	Posterior and posteromedial hip, Posterior knee, ankle, foot	Flexion of thigh, adduction of thigh Flexion of leg See below for terminal branches
<i>Superficial peroneal nerve (L4–S2)</i>	Lateral leg Dorsal foot	None	Eversion of foot Plantarflexion of foot
<i>Deep peroneal nerve (L4–S2)</i>	Webspace between first and second toes	Ankle	Inversion of foot Dorsiflexion of foot Extension of toes
<i>Tibial nerve (L4–S3)</i>	Plantar surface of foot	Ankle Foot	Flexion of leg, plantarflexion of foot, flexion of toes Adduction and abduction of toes
<i>Sural nerve (S1)</i>	Lateral foot and fifth toe	Lateral ankle	None

What Are the Local Anesthetic Dosing Options for a Femoral Block?

Local anesthetic for a femoral block is typically dosed based on expected duration of blockade. 0.2 to 0.5 cc/kg of 0.25% bupivacaine or 0.2% ropivacaine are typical. Studies have shown that lower doses can be

used with the ultrasound technique versus the nerve-stimulator-based landmark techniques.

How Is a Fascia Iliaca Block Performed?

A fascia iliaca block involves blockade of the lateral femoral cutaneous nerve by depositing local anesthetic

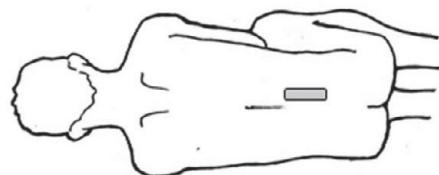
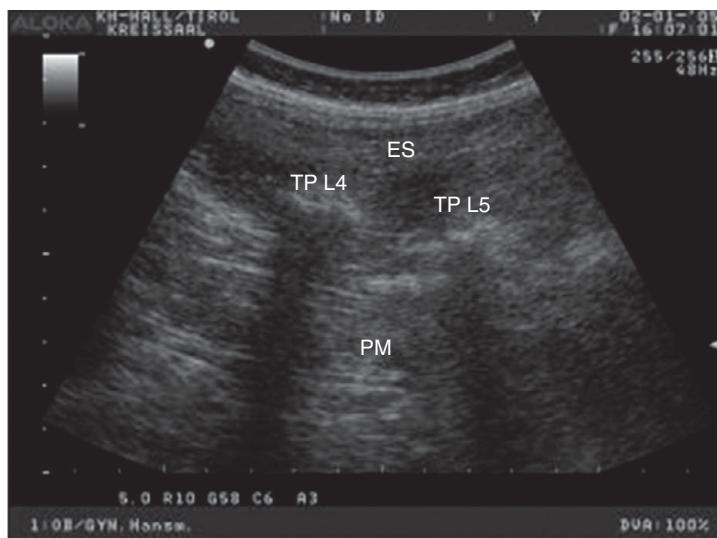


Figure 52.4 Lumbar plexus paravertebral region longitudinal view. TP, transverse process; ES, erector spinae; PM, psoas major. Reproduced with permission from Arthurs G, Nicholls B (eds.) 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

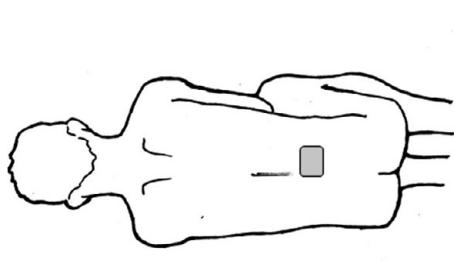


Figure 52.5 Lumbar plexus block with patient and probe positioning. Reproduced with permission from Arthurs G, Nicholls B (eds.) 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

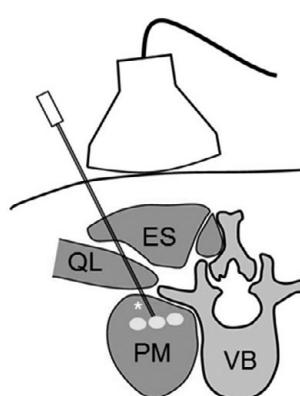


Figure 52.6 Cross-sectional view of lumbar plexus with "shamrock" sign. ES, erector spinae; PM, psoas major; QL, quadratus lumborum; VB, vertebral body. Reproduced with permission from Arthurs G, Nicholls B (eds.) 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

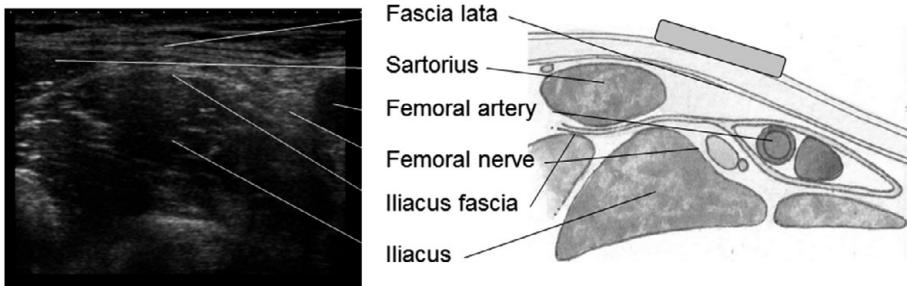


Figure 52.7 Femoral nerve anatomy. Reproduced with permission from Arthurs G, Nicholls B (eds.) 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

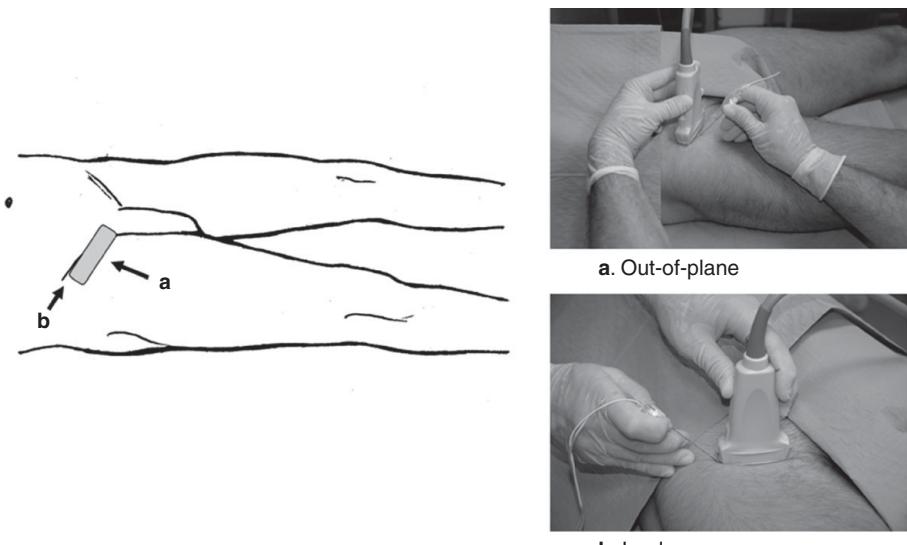


Figure 52.8 Patient and probe positioning for femoral nerve block. Reproduced with permission from Arthurs G, Nicholls B (eds.) 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

below the fascia iliaca lateral to where a femoral nerve block would be performed. With injection at that site, one can block the lateral femoral cutaneous as well as femoral nerve and, less reliably, the obturator nerve.

In the landmark-based technique, one draws a line from the anterior superior iliac spine (ASIS) to the pubic tubercle and divides the line into thirds (Figure 52.10). At one-third from the ASIS, one advances a needle perpendicularly until two pops are felt, which deposits the local anesthetic. The two pops correspond to the fascia lata and fascia iliaca.

In the ultrasound technique, the probe is placed in a transverse position, angled slightly caudad as shown in Figure 52.11. The resulting ultrasound image will show the fascia iliaca as it overlies the iliacus muscle and ileum (Figure 52.11). The local anesthetic is

deposited immediately below the fascia iliaca but not in the belly of the iliacus muscle.

Case continued: Her four-year-old brother was complaining of left lower leg pain and sustained an open tibial-fibular fracture above the ankle which was posted for open-reduction/internal fixation.

Given the Injury, What Would Be the Regional Anesthesia Options for This Procedure?

With both bones of the lower extremity fractured and a need for complete, circumferential analgesia of the

left lower leg, one can see that both the terminal branches of the sciatic and femoral nerve (saphenous) need to be blocked to provide 100% analgesia to the lower extremity. Since the injury is at the distal aspect of the extremity, proximal nerve blocks, such as lumbar plexus or sacral/subgluteal sciatic, would be poor choices as they would cause motor weakness of the entirety of the extremity. Instead, a targeted approach of the nerves innervating the structures below the knee would be most prudent. Namely, an adductor canal nerve block to block the sphenous

nerve combined with a mid-thigh or popliteal sciatic nerve block.

What Is the Difference between a Femoral Block and an Adductor Canal Block? Which Would Be Preferable in This Instance?

The femoral nerve block is used to block the femoral nerve at a relatively proximal position from its emergence from the lumbar plexus, causing blockade of all the quadriceps muscles in addition to blockade of the majority of the femur. The adductor canal, on the other hand, blocks the terminal branch of the femoral nerve, the sphenous nerve, which is a purely sensory nerve of the medial aspect of the leg below the knee. There is no associated motor block with the blockade of the sphenous nerve. Since this patient has an injury below the knee, there is no discernable advantage to blocking the femoral nerve and causing quadriceps weakness in this patient.

How Would You Perform the Adductor Canal Block with Ultrasound?

With the patient supine and leg slightly abducted and externally rotated, an ultrasound probe is placed in a transverse orientation at a distance slightly past mid-thigh (Figure 52.12). The target structure that is

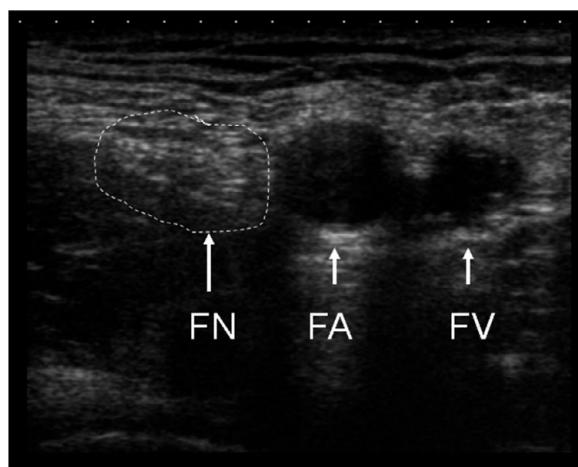


Figure 52.9 Cross-sectional anatomy of the femoral anatomy. FN, femoral nerve; FA, femoral artery; FV, femoral vein. Reproduced with permission from Arthurs G, Nicholls B (eds). 2016. *Ultrasound in Anesthesia, Critical Care, and Pain Management*. Cambridge, UK: Cambridge University Press

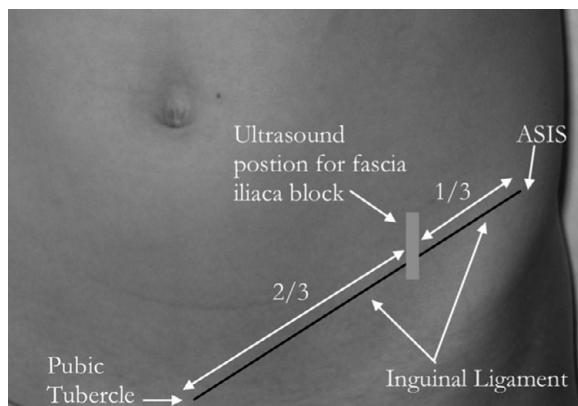


Figure 52.10 Anatomic placement of the ultrasound probe (grey box) one-third the distance from the anterior superior iliac spine (ASIS) and two-thirds the distance from the pubic tubercle along the inguinal ligament

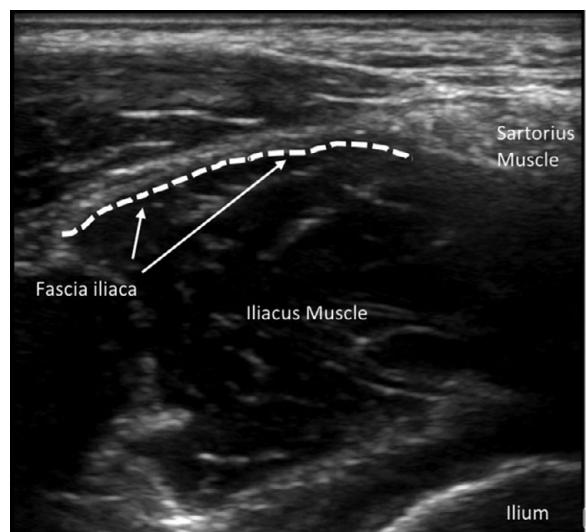


Figure 52.11 Ultrasound anatomy of the fascia iliaca plane

sought out is the adductor (or Hunter's) canal where the femoral artery immediately under the sartorius muscle lies in close proximity to the saphenous nerve (Figure 52.13).

Local anesthetic dosing volumes are similar to that of femoral nerve blocks, with 0.2–0.5 cc/kg of 0.25% bupivacaine or 0.2% ropivacaine used.

How Would You Perform the Sciatic Nerve Block?

The sciatic nerve, the largest peripheral nerve in the human body, can be blocked at one of many locations

along its path: sacral, subgluteal, midthigh, or popliteal. In the case of our patient, a popliteal nerve block or mid-thigh sciatic would make the most sense as they would spare motor weakness of the hamstring muscles that would result from the sacral or subgluteal sciatic block.

The popliteal sciatic block can be performed in either the supine or prone position (Figures 52.14–52.17). Since the patient would be induced in a supine fashion, it is the practice of the author to perform the sciatic block in the supine position by elevating the leg with either towels or a table stand. With the leg elevated, the ultrasound probe can be placed on the underside of the leg to scan the leg from a posterior position as shown in



Figure 52.12 Probe and needle position for saphenous nerve block/adductor canal block. Reproduced with permission from Mannion S, Iohom G, Dadure C, Reisbig MD, Ganesh A (eds.) 2015. *Ultrasound-Guided Regional Anesthesia in Children*. Cambridge, UK: Cambridge University Press



Figure 52.14 Ultrasound and needle positioning for distal sciatic nerve block with the patient in the supine position. Reproduced with permission from Mannion S, Iohom G, Dadure C, Reisbig MD, Ganesh A (eds.) 2015. *Ultrasound-Guided Regional Anesthesia in Children*. Cambridge, UK: Cambridge University Press



Figure 52.13 Ultrasound image of adductor canal block. A, femoral artery; N, saphenous nerve.

Figures 52.15–52.17. The resulting image will demonstrate the popliteal artery and vein in close proximity to the branches of the sciatic nerve: the common peroneal and the tibial nerve. The nerves can be blocked separately at that site or the probe can be moved more proximal until the nerves coalesce to become the sciatic, approximately 6–10 cm above the popliteal crease.

Upon completing the surgery with successful nerve blockade, you are called to the PACU to address a

patient who underwent open reduction and internal fixation (ORIF) of 4 metatarsal bones who is in severe pain.



Figure 52.15 Ultrasound and needle positioning for distal sciatic nerve block with the patient in the prone position. Reproduced with permission from Mannion S, Iohom G, Dadure C, Reisbig MD, Ganesh A (eds). 2015. *Ultrasound-Guided Regional Anesthesia in Children*. Cambridge, UK: Cambridge University Press

How Can You Perform an Ankle Block?

The ankle block is a basic landmark-based block that can be easily performed by novice regional anesthesiologists. After thorough sterile prep and drape with towels, the medial and lateral malleoli are identified,



Figure 52.17 Ultrasound and needle positioning for proximal sciatic nerve block (subgluteal) with the patient in the lateral position. Reproduced with permission from Mannion S, Iohom G, Dadure C, Reisbig MD, Ganesh A (eds). 2015. *Ultrasound-Guided Regional Anesthesia in Children*. Cambridge, UK: Cambridge University Press

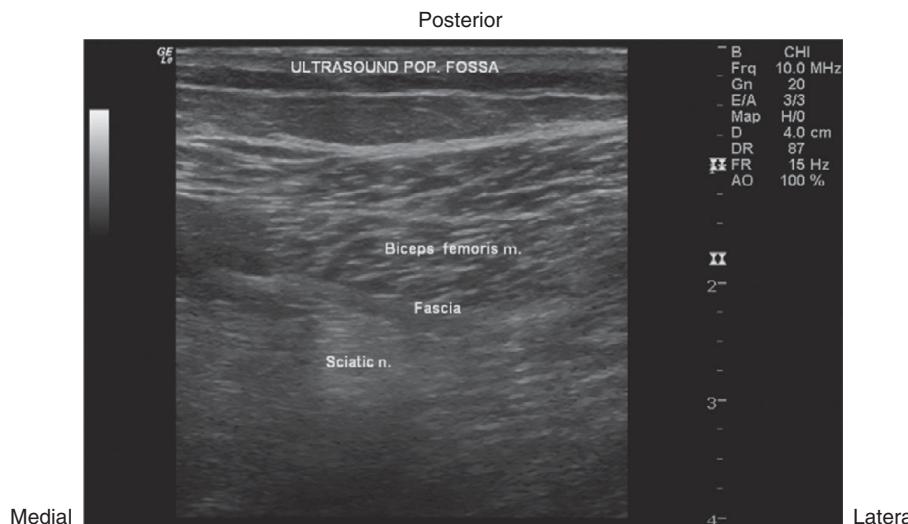


Figure 52.16 Ultrasound image if sciatic nerve block at the level of the prepopliteal space. Reproduced with permission from Arbona FL, Khabiri B, Norton JA (eds.). 2011. *Ultrasound-Guided Regional Anesthesia: A Practical Approach to Peripheral Nerve Blocks and Perineural Catheters*. Cambridge, UK: Cambridge University Press

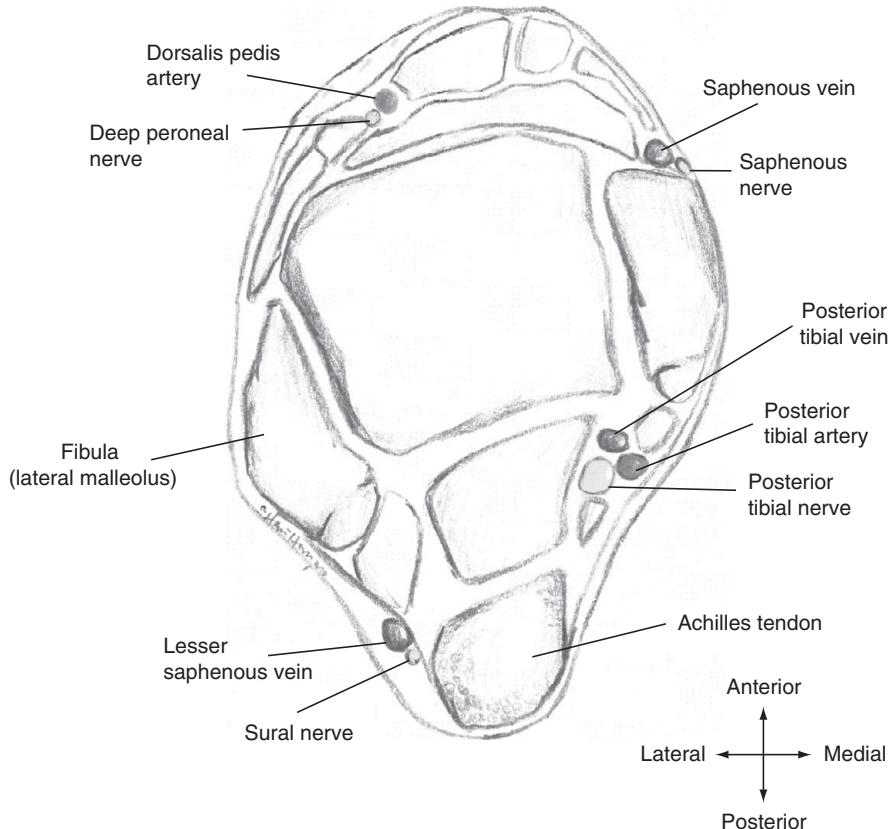


Figure 52.18 Cross-section drawing of ankle anatomy. Reproduced with permission from Arbona FL, Khabiri B, Norton JA (eds.) 2011. *Ultrasound-Guided Regional Anesthesia: A Practical Approach to Peripheral Nerve Blocks and Perineural Catheters*. Cambridge, UK: Cambridge University Press

and a line is drawn connecting them. Approximately mid-length along that line, lateral to the extensor hallucis longus tendon lies the deep peroneal nerve. A 25–27G needle can be inserted immediately perpendicular to that spot until contact is made with periosteum. Withdraw the needle 1 mm and aspirate and inject one-fifth of your local anesthetic. Then take your needle and withdraw to beneath the surface of the skin and aim for the medial malleolus subcutaneously with your needle and upon withdrawing towards the needle entry site (adjacent to extensor hallucis longus tendon) inject one-fifth of the local anesthetic creating a skin wheel. This will block the saphenous nerve. Repeat the same subcutaneous injection towards the lateral malleolus and block the superficial peroneal nerve with one-fifth of your local anesthetic. Next, palpate the fossa immediately posterior to the medial malleolus where the tibial artery can be felt pulsating. Insert the needle

into the fossa, taking care to avoid the artery or vein (by aspirating) and contact the periosteum. Withdraw the needle 1 mm and inject one-fifth of your local anesthetic to block the posterior tibial nerve. Lastly, palpate the lateral malleolus and locate the fossa immediately posterior. Insert your needle until periosteum is contacted. Withdraw your needle 1 mm and inject the remaining one-fifth of your local anesthetic solution. This circumferential ring block at the level of the malleoli provides complete blockade of the foot distal to the ankle block (Figure 52.18).

What Is the Typical Dosing of Ankle Block?

0.1 cc/kg of 0.25% bupivacaine or 0.2% ropivacaine can be used to dose the ankle block. Epinephrine should *not* be added to the local anesthetic.

Suggested Reading

- Arbona FL, Khabiri B, Norton JA. *Ultrasound-Guided Regional Anesthesia*. Cambridge: Cambridge University Press; 2011.
- Hadzic A. *Textbook of Regional Anesthesia and Acute Pain*

Management. 2nd Edition. New York, NY: McGraw-Hill Education; 2017.

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