Regional Anesthesia

What is regional anesthesia? Regional anesthesia or “nerve block” is a form of anesthesia in which only a portion of the body is anesthetized. A patient may be having surgery on a part of the body such as the hand, foot or shoulder and not even realize that the operation is occurring. This is accomplished by placing a local anesthetic medication near the nerves which go to that portion of the body. We will discuss many examples of regional blocks, but some examples include spinal, epidurals or peripheral nerve blocks.

A single-shot nerve block is the injection of local anesthetic to block a specific nerve distribution. It can be placed pre- or post-operatively to provide anesthesia and/or analgesia. The area affected will vary based on where the local anesthetic is injected. The onset and duration will vary based on the type of block, as well as the type of local anesthetic used. In addition, catheters with a continuous infusion may be placed to prolong analgesia.

There are many advantages of regional anesthesia compared to general anesthesia. Regional anesthetics have been associated with less post-operative pain and less nausea. More importantly, a lower incidence of blood clots, less blood loss, and less of a stress response by the body have also been reported. Finally, many patients who have experienced both general and regional anesthetics often prefer the “regional” experience. Regional anesthesia is particularly appealing to patients undergoing orthopedic procedures. These procedures often involve the limbs and are associated with a significant amount of post-operative pain.

Of course, there is more to regional anesthesia than placing a local anesthetic near a nerve. Some patients prefer to be awake during the surgery and some prefer to be asleep. Either is possible with regional anesthesia. The patient’s preferences can be discussed with the anesthesiologist prior to surgery.

As with general anesthesia, patients can react differently to regional anesthetics. Therefore, from the moment the patient enters the operating room until the time the patient is comfortable in the recovery room, the anesthetist is with the patient the entire time. This is done to ensure the anesthetic is working perfectly and the patient is calm, comfortable and stable.

As with any anesthetic, there are risks associated with the benefits of regional anesthetics. Fortunately: serious complications associated with regional blocks are exceedingly rare. Prior to performing a regional block the anesthetist will discuss common and uncommon risks associated with regional anesthesia.

NURSING CONSIDERATIONS

What are some nursing considerations when dealing with regional nerve blocks? It is very important to protect the affected area from harm. Patients will have minimal or no sensation to the blocked area. If a catheter is placed, a more dilute medication will be used than the concentrated solution used for placement of the block. Some numbness/tingling as well as decreased motor function are still common. If a lower extremity block is being performed, used extreme caution when ambulating the patient until the nerve block has worn off and/or the nerve catheter has been removed. If a femoral nerve catheter is placed, a knee immobilizer should be used during ambulation. The only exception is if physical therapy is working with the patient and determines that the quadriceps strength is sufficient.

It is very common for the nerve catheters to leak. In many cases this is just local anesthetic tracking back along the catheter. As long as the patient has good pain control, reinforce the dressing.

COMPLICATIONS

Rare, but possible complications from nerve blocks and/or nerve catheters include: infection, bleeding, vascular puncture, nerve injury, falls, shortness of breath, or Horner’s syndrome.

Horner's syndrome occurs when the nerve between the brain and the eye is affected, It can happen with any brachial plexus block, but is most common with the interscalene or supraclavicular. Symptoms include a drooping eyelid, decreased pupil size, and decreased sweating on the affected side of the face. This will resolve as the block wears off.

MEDICATIONS

A variety of local anesthetics may be used for the nerve block. The most common include lidocaine, ropivacaine, bupivacaine, and mepivacaine. The type of medication used, the concentration, the volume administered, and the location of the block will affect the onset and duration. Occasionally epinephrine may be added to a nerve block. Epinephrine causes vasoconstriction of the blood vessels near the injection site. This causes decreased uptake of local anesthetic into the vasculature, allowing the block to work for a longer duration. Opioids are rarely used in a nerve block. Local anesthetic alone will not cause problems with nausea/vomiting, or pruritis. In addition, they are not centrally acting, which means that they will not affect the blood pressure. If your patient is experiencing any of these symptoms, look for alternate causes.

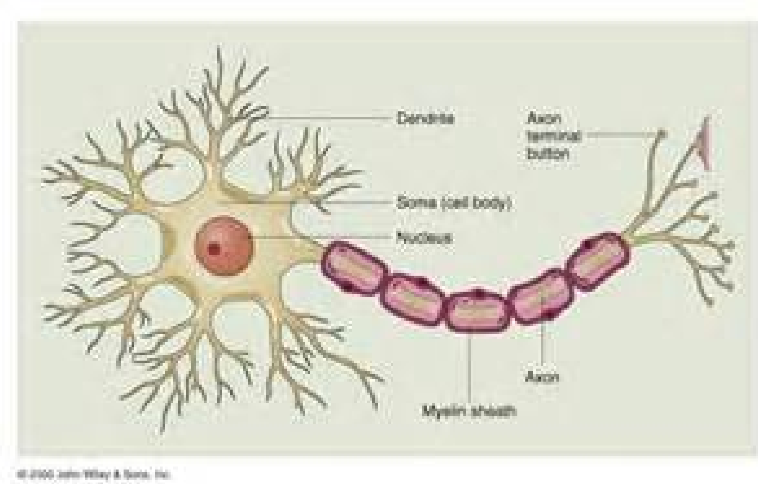
It is possible for a patient to develop local anesthetic toxicity from a nerve block or a nerve catheter. It may be caused by accidental injection directly into a blood vessel, or vascular reabsorption from around the injection site. Common symptoms of local anesthetic toxicity include numbness and tingling around the mouth, a metallic taste or ringing in the ears. If it progresses, it may lead to seizures, arrhythmias, and even cardiac arrest.

ANATOMY

What are the essentials of regional anesthesia anatomy? A good practical knowledge of anatomy is important for the successful and safe practice of regional anesthesia. In fact, just as surgical disciplines rely on surgical anatomy; regional anesthetists need to have a working knowledge of the anatomy of nerves and associated structures that does not include unnecessary details.

All peripheral nerves are similar in structure. The neuron is the basic functional unit responsible for the conduction of nerve impulses (Figure 1).

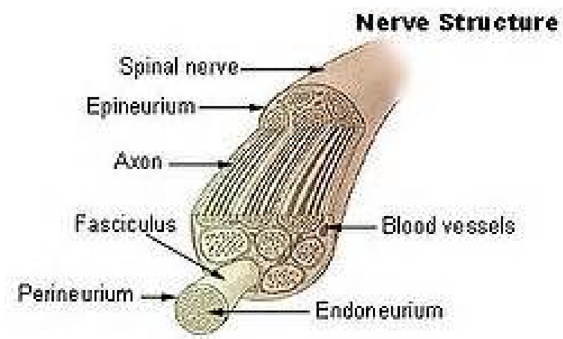
Figure 1



Neurons are the longest cells in the body, many reaching a meter in length. Most neurons are incapable of diving under normal circumstances, and they have a very limited ability to repair themselves after injury. A typical neuron consists of a cell body (soma) that contains a large nucleus. The cell body is attached to several branching processes, called dendrites, and a single axon. Dendrites receive incoming messages; axons conduct outgoing messages. Axons vary in length, and there is only one per neuron. In peripheral nerves, axons are very long and slender. They are also called nerve fibers.

The individual nerve fibers that make up a nerve, like individual wires in an electric cable, are bundled together by connective tissue. The connective tissue of a peripheral nerve is an important part of the nerve. According to its position in the nerve architecture, the connective tissue is called the epineurium, perineurium, or endoneurium (Figure 2).

Figure 2

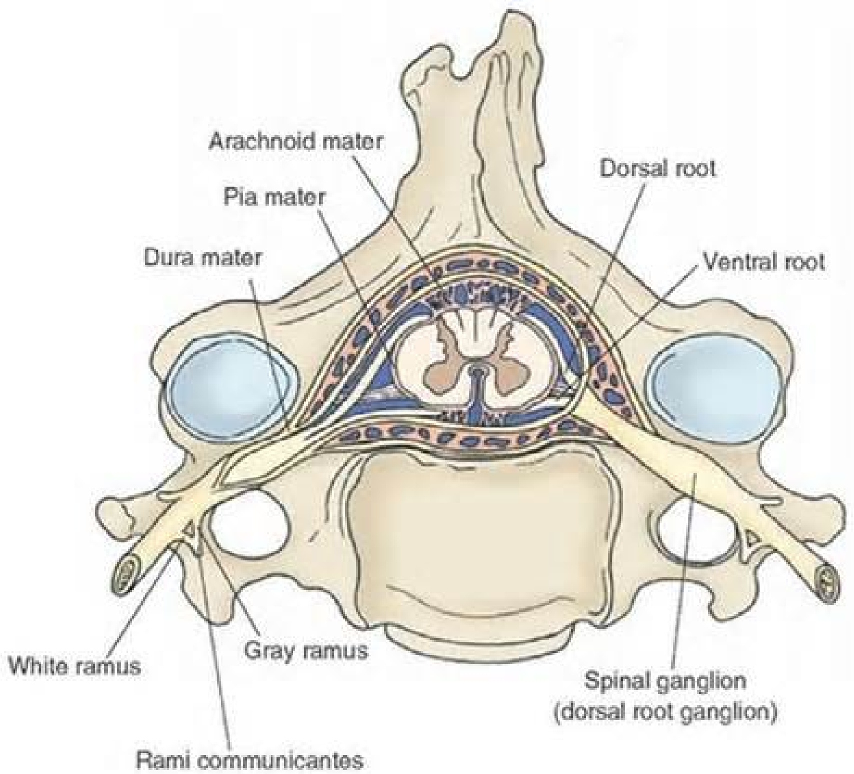


The epineurium surrounds the entire nerve and holds it loosely to the connective tissue through which it runs. Each group of axons that bundles together with in a nerve forms a fascicle, which is surrounded by perineurium. It is at this level that the nerve-blood barrier is located and constitutes the last protective barrier of the nerve tissue. The endoneurium is the fine connective tissue within a fascicle that surrounds every individual nerve fiber or axon.

Nerves receive blood from the adjacent blood vessels running along their course. Theses feeding branches to larger nerves are macroscopic and irregularly arranged, forming anastomoses to become longitudinally running vessel(s) that supply the nerve and give off subsidiary branches.

The nervous system consists of central and peripheral parts. The central nervous system includes the brain and spinal cord. The peripheral nervous system consists of the spinal, cranial, and autonomic nerves, and their associated ganglia. Nerves are bundles of nerve fibers that lie outside the central nervous system and serve to conduct electrical impulses from one region of the body to another. The nerves that make their exit through the skull are known as cranial nerves, and there are 12 pairs of them. The nerves that exit below the skull and between the vertebrae are called spinal nerves, and there are 31 pairs of them. Every spinal nerve has its regional number and can be identified by its association with the adjacent vertebrae (figure 3).

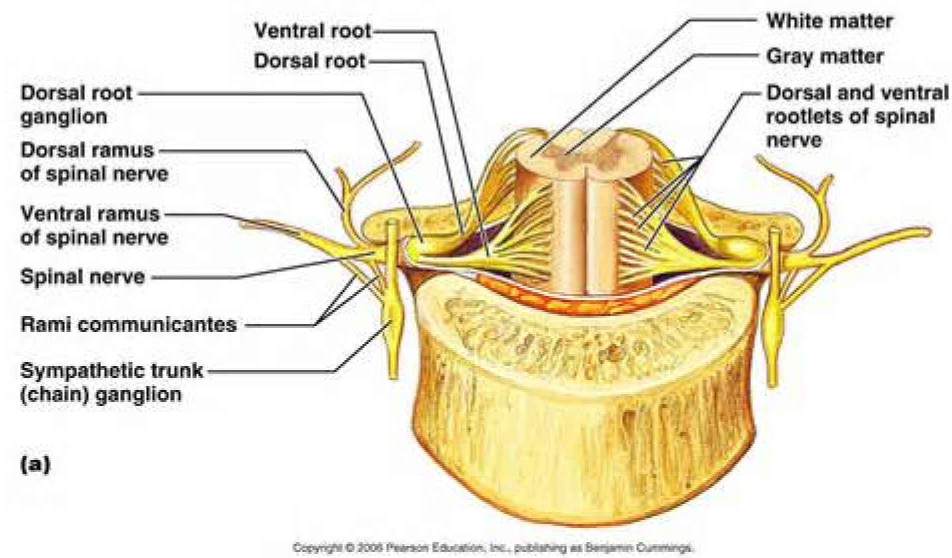
Figure 3



In the cervical region, the first pair of spinal nerves, C1, exits between the skull and the first vertebra. For this reason, a cervical spinal nerve takes its name from the vertebra below it. In other words, cervical nerve C2 precede vertebra C2, and the same system is used for the rest of the cervical series. The transition from this identification method occurs between the last cervical and first thoracic vertebra. The spinal nerve lying between these two vertebrae has been designated C8. Thus, there are seven cervical vertebrae, but eight cervical nerves. Spinal nerves caudal to the first thoracic vertebra take their names from the vertebra immediately preceding them. For instance, the spinal nerve T1 emerges immediately caudal to vertebra T1, spinal nerve T2 passes under vertebra T2 and so on.

Each spinal nerve is formed by a dorsal and a ventral root that come together at the level of the intervertebral foramen (Figure 3). In the thoracic and lumbar levels, the first branch of the spinal nerve carries visceral motor fibers to a nearby autonomic ganglion. Because preganglionic fibers are myelinated, they have a light color and are known as white rami (Figure 4).

Figure 4



Two groups of unmyelinated postganglionic fibers leave the ganglion. Those fibers innervating glands and smooth muscle in the body wall or limbs form the gray ramus that rejoins the spinal nerve. The gray and white rami are collectively called the rami communicantes. Preganglionic or postganglionic fibers that innervate internal organs do not rejoin the spinal nerves. Instead, they form a series of separate autonomic nerves and serve to regulate the activities of organs in the abdominal and pelvic cavities.

The dorsal ramus of each spinal nerve carries sensory innervations from, and motor innervations to, a specific segment of the skin and muscles of the back. The region innervated resembles a horizontal band that begins at the origin of the spinal nerve. The relatively larger ramus supplies the ventrolateral body surface, structures in the body wall, and the limbs. Each spinal nerve supplies a specific segment of the body surface, known as a dermatome.

A dermatome is an area of the skin supplied by the dorsal (sensory) root of the spinal nerve (Figure 5 & 6). Figure 5, dermatomes and corresponding peripheral nerves: front. Figure 6, dermatomes and corresponding peripheral nerves: back.

Figure 5

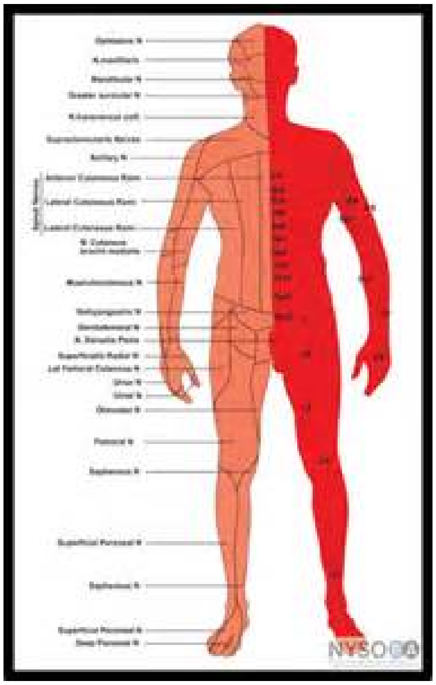
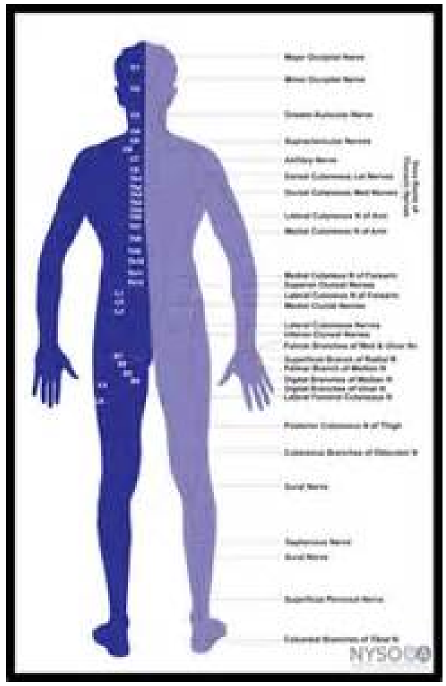


Figure 6



In the head and trunk, each segment is horizontally disposed, except C1, which does not have a sensory component. The dermatomes of the limbs from the fifth cervical to the first thoracic nerve, and from the third lumbar to the second sacral vertebra, form a more complicated arrangement due to rotation and growth during embryologic life. There is considerable overlapping of adjacent dermatomes; that is, each segmental nerve overlaps the territories of its neighbors. This pattern is variable among individuals, and it is more of a guide than a fixed map.

A myotome is the segmental innervations of skeletal muscle by a ventral root of a specific spinal nerve (Figure 7).

Figure 7

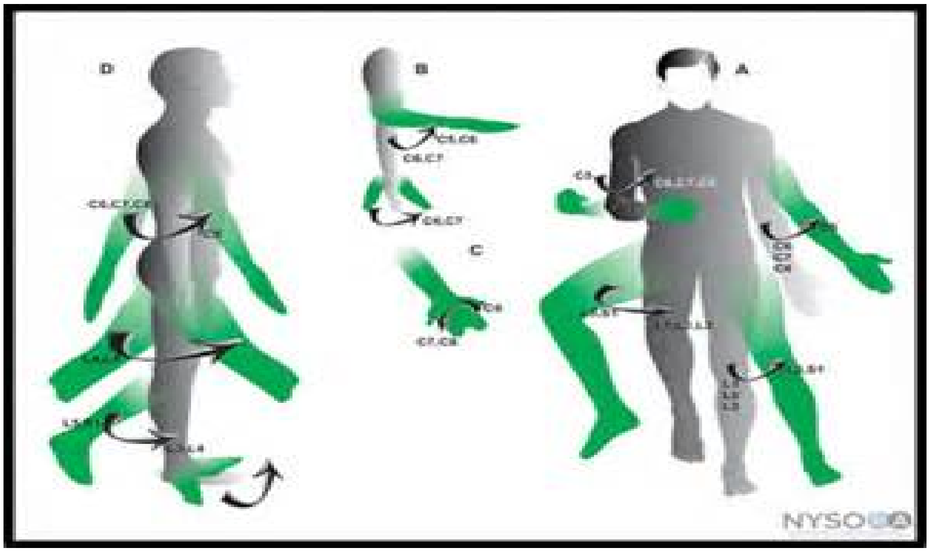


Figure 7: Motor innervations of the major muscle groups. A) Medial and lateral rotation of shoulder and hip. Abduction and adduction of shoulder and hip. B) Flexion and extension of elbow and wrist. C) Pronation and supination of forearm. D) Flexion and extension of shoulder, hip, and knee. Dorsiflexion and plantar flexion of ankle, lateral views.

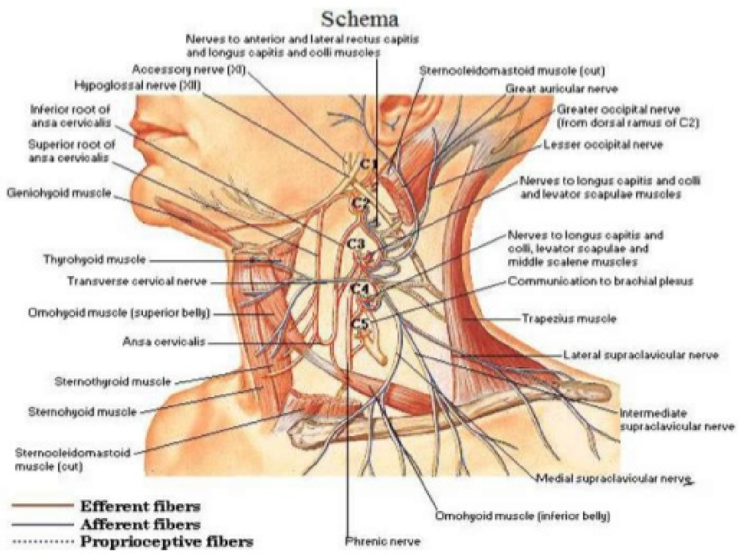
Although the dermatomal innervations of the trunk are simple, the innervations of the extremities, part of the neck, and pelvis is highly complex. In these areas, the ventral rami of the spinal nerves form as intricate neural network; nerve fibers coming from similar spinal segments easily reach different terminal nerves. The four major nerve plexuses are the cervical plexus, brachial plexus, lumbar plexus, and sacral plexus.

The Cervical Plexus

The cervical plexus originates from the ventral rami of C1-C5, which form three loops (Figure 8).

Figure 8

The cervical plexus is a network of nerves formed by communications between the anterior rami of the upper 4 cervical nerves.



Branches from the cervical plexus provide sensory innervations of part of the scalp, neck, and upper shoulder and motor innervations to some of the muscles of the neck, the thoracic cavity, and the skin. The phrenic nerve, one of the larger branches of the plexus, innervated the diaphragm.

Cervical plexus

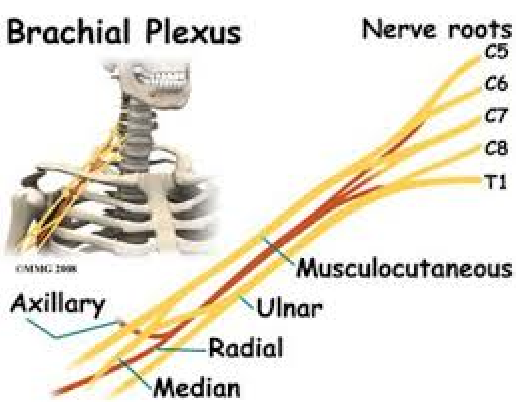
Nerves	**Spinal Segments**	**Distribution**
Ansa cervicalis (superior and Inferior branches)	C1-C4	Five of the extrinsic laryngeal muscles (sternothyroid, sternohyoid. Omohyoid, Geniohyoid, and thyrohyoid) by way of N X11
Lesser occipital, transverse cervical, superclavicular, and greater auricular nerves	C2-C3	Skin of upper chest, shoulder, neck and ear
Phrenic nerve	C3-C5	Diaphragm

Cervical nerves	C1-C5	Levator scapulae, scalene muscles, sternocleidomastoid, and trapezius muscles (with N XI)

The Brachial Plexus

The brachial plexus is both larger and more complex that the cervical plexus. It innervates the pectoral girdle and upper limb. The plexus is formed by five roots that originate from the ventral rami of spinal nerves C5-T1. The roots converge to form the superior (C5-C6), middle (C7), and inferior (C8-T1) trunks (Figure 9). The trunks give off three anterior and three posterior divisions as they approach the clavicle. The divisions rearrange their fibers to form the lateral, medial, and posterior cords. The cords give off the terminal branches. The lateral cord gives off the musculocutaneous nerve, and the lateral root of the median nerve. The medial cord gives off the medial root of the median nerve and the ulnar nerve. The posterior cord gives off the axillary and radial nerves.

Figure 9



Brachial plexus

Nerves	**Spinal Segments**	**Distribution**
Nerves to subclavius	C4-C6	Subclacious muscle
Dorsal scapular nerve	C5	Rhomboid muscles and levator muscle
Long thoracic nerve	C5-C7	Serratus anterior muscle

Suprascapular nerve	C5, C6	Supraspinatus and infraspinatus muscle
Pectoralis nerve (medial and lateral)	C5-T1	Pectoralis muscle
Subscapular nerves	C5, C6	Subscapularis and teres major muscles
Thoracodorsal nerve	C6-C8	Latissimus dorsi muscle
Axillary nerve	C5, C6	Deltoid and teres minor muscles, part of skin of shoulder
Radial nerve	C5-T1	Extensor muscle of the arm and forearm (triceps brachii, extensor carpi radialis, and extensor carpi ulnaris muscles) and brachioradialis muscle; digital extensors, and abductor pollicis muscle; skin over the posterolateral surface of the arm.
Musculocutaneous nerve	C5-C7	Flexor muscles on the arm (biceps brachii, brachialis, and coracobrachialis muscles); skin over lateral surface of forearm
Median nerve	C6-T1	Flexor muscles on the forearm (flexor carpi radialis and Palmaris longus muscles); pronator quadrates and pronator teres muscles; digital flexors (through the palmar interosseous nerve); skin over anterolateral surface of hand
Ulnar nerve	C8, T1	Flexor carpi ulnaris muscle, adductor pollicis muscle and small digital muscles; skin over medial surface of the hand

The Lumbar Plexus

The lumbar plexus is formed by the ventral rami of spinal nerves L1-L3 and the superior branch of L4. In about 50% of the cases, there is a contribution from T12. The inferior branch of L4, along with the entire ventral rami of L5, forms the lumbosacral trunk that contributes to the sacral plexus. Because the branches of both the lumbar and sacral plexuses are distributed to the lower limb, they are often collectively referred to as the lumbosacral plexus. The main branches for the lumbar plexus are the illohypogastric, ilioinguinal, genitofemoral, lateral femoral cutaneous, obturator, and femoral nerves.

Lumbar Plexus

Lliohypogastric nerve	T12-L1	Abdominal muscles (external and internal oblique muscles, transverse abdominis muscles); skin over inferior abdomen and buttocks
Llioinguinal nerve	Li	Abdominal muscles (with iliohypogastric nerve); skin over superior, medial thigh, and portions of external genitalis
Genitofemoral nerve	L1, L2	Skin over anteromedial surface of thigh and portions over genitalia
Lateral femoral cutaneous nerve	L2, L3	Skin over anterior, lateral, and posterior surfaces of thigh
Femoral nerve	L2-L4	Anterior muscles of thigh (Sartorius muscle and quadriceps group); adductor of thigh (pectineus and iliopsoas muscles); skin ovrt anteromedial surface of thigh, as well as the medial surface of leg, and foor through the spahenoud nerve.
Obturator nerve	L2-L4	Adductors of thigh (adductors magnus. Brevis and longus); gracilis muscle; skin over medical surface of thigh.

The Sacral Plexus

The sacral plexus arises from the lumbosacral trunk (L4-L5) plus the ventral rami of S1-S4. The main nerves of the sacral plexus are the sciatic nerve and the pudendal nerve. The sciatic nerve leaves the pelvis through the greater sciatic foramen to enter the gluteal area where it travels between the greater trochaneter and ischial tuberosity. In the proximal thigh it lies behind the lesser trochanter of the femur covered superficially by the long head of the bicept femoris muscle. As it approaches the popliteal fossa, the two components of the sciatic nerve diverge into two recognizable nerves: the common peroneal and the tibial nerve.

Sacral Plexus

Nerves	Spinal Segments	Distribution
Gluteal nerves Superior infoerior	L4-S2	Abductors of thigh (gluteus minimus, gluteous medius, and tensor fasciae latae); extensot of thigh (gluteus maximus
Posterior femoral cutaneous nerve	S1-S3	Skin perineum and posterior surface of thigh and leg
Sciatic nerve	L4-S3	Two hamstrings. Note: all three hamstrings are innervated by the sciatic nerve (only motor nerve of the poaterior thigh).
Tibioal nerve	L4-S3	Flexor of knee and plantar flexors of ankle. Flexors of toes; skin over posterior surface of leg, plantar surface of foot.
Common peroneal nerve	L4-S3	Biceps femoris muscle;peroneus, and tibi-alis anterior muscles; extensors of toes, skin over anterior surface of leg and dorsal surface of foot.
Pudendal nerve	S2-S4	Muscles of perineum, including urogenital diaphragm and external anal urethral spincter muscles; skin of external genitalia and related skeletal muscle

Thoracic Wall

The intercostals nerves originate from the ventral rami of the first 11 thoracic spinal nerves. Each intercostals nerve becomes part of the neurovascular bundle of the rib and provides sensory and motor innervations. Except for the first, each intercostals nerve gives off a lateral cutaneous branch that pierces the overlying muscle near the midaxillary line. This cutaneous nerve divides into anterior and posterior branches, which supply the adjacent skin. The intercostal nerves of the second to the sixth spaces reach the anterior thoracic wall and pierce the superficial fascia near the lateral border of the sternum and divide into medial and lateral cutaneous branches. Most of the fibers of the anterior ramus of the first thoracic spinal nerve join the brachial plexus for distribution to the upper limb. The small first intercostals nerve is in itself the lateral branch and supplies only the muscles of the intercostals space, not the overlying skin. The lower five intercostals nerves abandon the intercostal space at the costal margin to supply the muscles and skin of the abdominal wall.

Anterior Abdominal Wall

The skin, muscles and parietal peritoneum, to the anterior abdominal wall, are innervated by the lower six thoracic nerves and the first lumbar nerve. At the costal margin, the seventh to eleventh thoracic nerves leave their intercostals spaces and enter the abdominal wall in a fascial plane between the transverses abdominis and internal oblique muscles. The seventh and eighth intercostals nerves slope upward following the contour of the costal margin, the ninth runs horizontally, and the tenth and eleventh have a somewhat downward trajectory. Anteriorly, the nerves pierce the rectus abdominis muscle and the anterior layer of the rectus sheath to emerge as anterior cutaneous branches that supply the overlying skin.

The subcostal nerve (T12) takes the line of the twelfth rib across the posterior abdominal wall. It continues around the flank and terminates in a similar manner to the lower intercostals nerves. The seventh to twelfth thoracic nerves give off lateral cutaneous nerves that further divide into anterior and posterior branches. The anterior branches supply the skin as far forward as the lateral edge of rectus abdominis. The posterior branches supply the skin overlying the latissimus dorsi. The lateral cutaneous branch of the subcostal nerve is distributed to the skin on the side of the buttock.

The inferior part of the abdominal wall is supplied by the iliohypogastric and ilioinguinal nerves, both branches of L1. The iliohypogastric nerve divides, runs above the iliac crest, and splits into two terminal branches. The lateral cutaneous branch supplies the side of the buttock; the anterior cutaneous branch supplies the suprapubic region.

The ilioinguinal nerve leaves the intermuscular plane by piercing the internal oblique muscle above the iliac crest. It continues between the two oblique muscles eventually to enter the inguinal canal through the spermatic cord.

Emerging from the superficial inguinal ring, it gives cutaneous branches to the skin on the medial side of the root of the thigh, the proximal part of the penis, and the front of the scrotum in males and the mons pubis and the anterior part of the labium majus in females.

The parietal peritoneum of the abdominal wall is innervated by the lower thoracic and first lumbar nerves. The lower thoracic nerves also innervate the peritoneum that covers the periphery of the diaphragm. Inflammation of the peritoneum gives rise to pain in the lower thoracic wall and abdominal wall. By contrast, the peritoneum on the central part of the diaphragm receives sensory branches from the phrenic nerves (C3, C4, and C5), and irritation in this area may produce pain referred to the shoulder region.

Because much of the practice of peripheral nerve blocks involves orthopedic surgery, it is important to review the innervations of the major joints to have a better understanding of the nerves involved for a more rational approach to regional anesthesia.

- Shoulder joint – Innervation to the shoulder joints originates mostly from the axillary and suprascapular nerves, both of which can be blocked by an interscalene block.

- Elbow joint – Nerve supply to the elbow joint includes branches of all major nerves of the brachial plexus: musculocutaneous, radial, median, and ulnar nerves.
- Hip joint – Nerves to the hip joint include the nerve to the rectus femoris from the femoral nerve, branches from the anterior division of the obturator nerve, and the nerve to the quadrates femoris from the sacral plexus.
- Knee joint – The knee joint is innervated anteriorly by branches from the femoral nerve. On its medial side, it receives branches from the posterior division of the obturator nerve while both divisions of the sciatic nerve supply its posterior side.
- Ankle joint – The innervations of the ankle joint is complex and involves the terminal branches of the common peroneal (deep and superficial peroneal nerves), tibial (posterior tibial nerve), and femoral nerves (saphenous nerve). A more simplistic view is that the entire innervations of the ankle joint stems from the sciatic nerve, with the exception of the skin on the medial aspect around the medial malleolus (saphenous nerve, a branch of the femoral nerve).
- Wrist joint – The wrist joint and joints in the hand are innervated by most of the terminal branches of the brachial plexus including the radial, median, and ulnar nerves.

UPPER EXTREMITY NERVE BLOCKS

The interscalene, supraclavicular, infraclavicular, and axillary nerve blocks are used for surgeries of the upper extremity. They block the brachial plexus (a bundle of nerves to the upper extremity), but at different locations. Although coverage is similar among all 4 blocks, the type of surgery and patient characteristics influence which block is most likely to be performed. For example, a patient with a history of pulmonary disease would be less likely to receive an interscalene or supraclavicular nerve block (depending on the type of surgery) due to the risk of respiratory compromise. A patient with a thick neck, having wrist surgery, would be more likely to receive an infraclavicular or axillary nerve block.

LOCAL ANESTHETICS

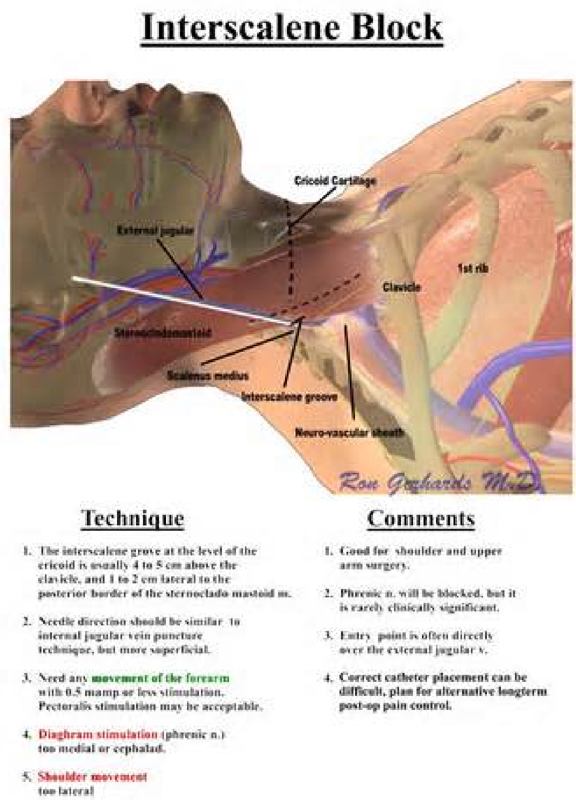
Due to the vasculature nature of the area, brachial plexus blocks (interscalene, supraclavicular, infraclavicular, or axillary) typically wear off fairly rapidly.

	Onset (min)	**Anesthesia (hrs)**	**Analgesia (hrs)**
1.5% Mepivacaine	10-20	2-3	2-4
1.5% Mepivacaine (+ epi)	5-15	2.5-4	3-6
2.0% Lidocaine	10-20	2.5-3	2-5
2.0% Lidocaine (+ epi)	5-15	3-6	5-8
0.5% Ropivacaine	15-20	6-8	8-12
0.5% Bupivacaine (+ epi)	20-30	8-10	16-18

INTERSCALENE

The interscalene nerve block is typically used for shoulder, clavicle, or upper arm surgeries because it covers higher up on the shoulder, The disadvantage is that patients will experience phrenic nerve blockade resulting in diaphragmatic paralysis. In most patients, this does not significantly compromise lung function. However, patients with underlying lung disease are at higher risk for respiratory compromise and should be monitored closely. The risk of pneumothorax is present, but minimal.

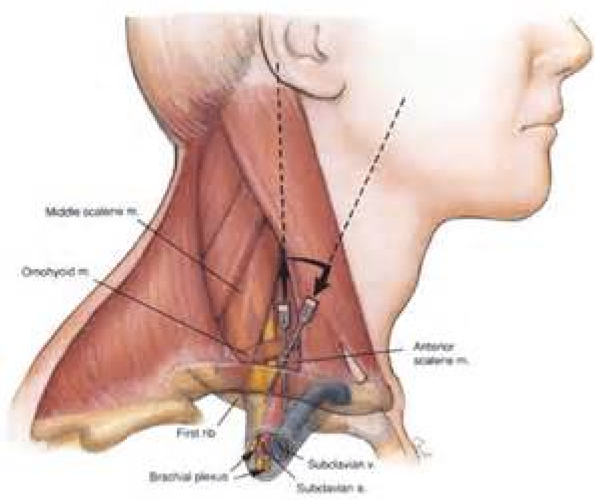
Figure 10



SUPRACLAVICULAR

The supraclavicular nerve block is ideal for procedures of the upper arm, from the mid-humeral level down to the hand. The area covered is similar to the interscalene block, but does not cover the upper part of the shoulder as well. It has a rapid onset, with a dense and predictable level of pain control. There is a slightly higher risk of pneomothorax than the interscalene nerve block. Signs and symptoms of a large pnerumothoraz include sudden cough and shortness of breath. In addition, approximately 50% of patients will have diaphragmatic hemiaparesis. See figure 11.

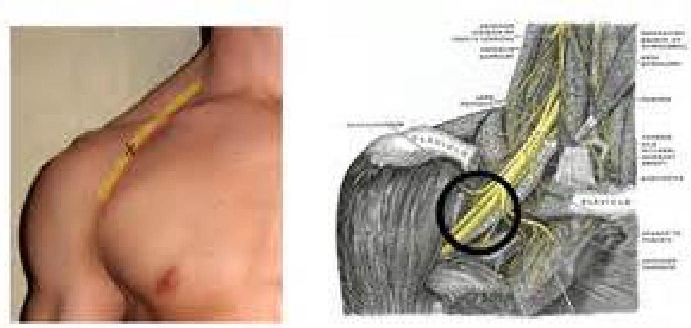
Figure 11



INFRACLAVICULAR

The infraclavicular nerve block is ideal for operations to the elbow and below. It has a lower risk of pneumothorax than the supraclavicular, although higher than the interscalene. This block has minimal risk of blocking the phrenic nerve. See figure 12.

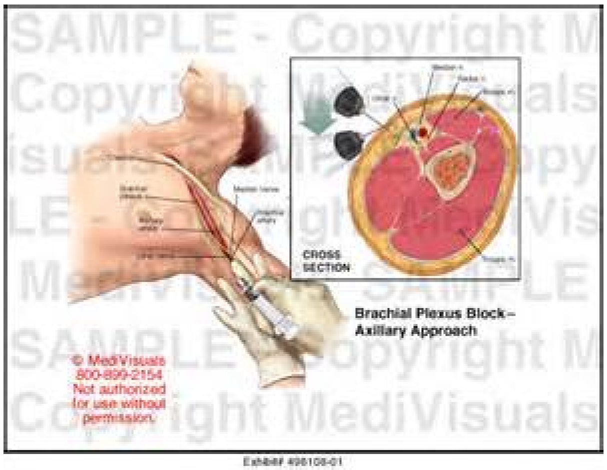
Figure 12



AXILLARY

The axillary block is the most distal block performed on the brachial plexus. Because of the distal location, the axillary block has minimal risk of respiratory compromise from either pneumothorax or phrenic nerve blockade. However, the axillary nerve block does not cover the lateral aspect of the forearm form the elbow to the thumb as well as the other blocks. Usually a block of the mucsulocutaneous nerve is also performed with this block. This provides ulnar coverage. See figure 13

Figure 13



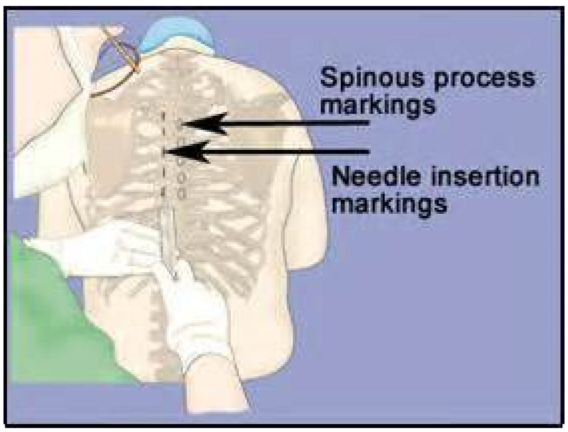
PARAVERTEBRAL

The paravertebral space is adjacent to the vertebral body. When a local anesthetic is injected into this space it blocks one or more nerve roots as they exit the spine. This leads to unilateral numbness of a specific area of the body. The most common indication is breast surgery, but it is also used for chest and abdominal surgeries. The area that is blocked will depend on which level the local anesthetic is injected at. Potential complications include inadvertent vascular puncture, hypotension, hematoma, epidural spread or intrathecal spread, pleural puncture, and pneumothorax. Bilateral blocks may be performed. A paravertebral block does not typically result in motor block of the lower extremities. The exception is if L2-L5 are blocked (not commonly done). Most guidelines recommend using a longer-acting anesthetic when possible. See figure 14.

	Onset (min)	**Anesthesia (hrs)**	**Analgesia (hrs)**
1.5% Mepivacaine (+HCO3+epi)	10-20	2-3	3-4

2.0% Lidocaine (+HCO3+epi)	10-15	2-3	3-4
0.5% Ropivacaine	15-25	3-5	8-12
0.5% Bupivacaine (+ epi)	15-25	4-6	12-18
0.5% l-Bupivacaine (+epi)	15-25	4-6	12-18

Figure 14



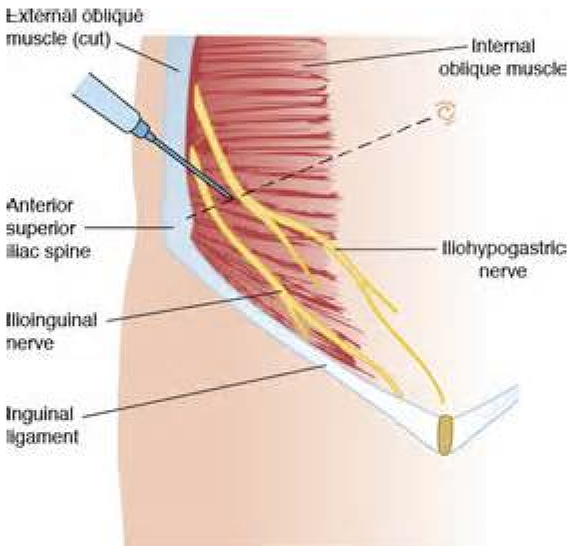
TRANSVERSUS ABDOMINIS PLANE

The Transversus Abdominis Plane (TAP) is a technique where local anesthetic is injected into a potential space between the internal oblique and transversus abdominis muscles. This plane contains the nerves that provide sensation to the anterolateral abdominal wall, approximately T10-L1, although in some patients the block will spread further up and/or down. The TAP Block is typically used for pain contril after lower abdominal surgery including bowel, prostate, obstetric, and gynecological surgery. Potential complications include intraperitoneal injection, bowel hematoma, transient femoral nerve palsy, liver laceration and local anesthetic toxicity. Theoretically these risks have greatly decreased now that most TAP blocks are placed under ultrasound guidance.

If surgery enters the peritoneal cavity, the dull visceral pain from spasm and/or inflammation may still be present. The TAP block primarily covers the incisional pain. Depending on the type of local anesthetic used, a TAP Block typically lasts

12-36 hours. The TAP Block can produce a relaxation of the abdominal wall muscles, which can result in a “flank bulge”, which may look like a hernia. This may be more pronounced in patients with low Body Mass Index (BMI). Any patient with significant abdominal distention following a TAP Block should be assessed for possible internal bleeding. See figure 15

Figure 15



LOWER EXTREMITY NERVE BLOCKS

LUMBAR PLEXUS

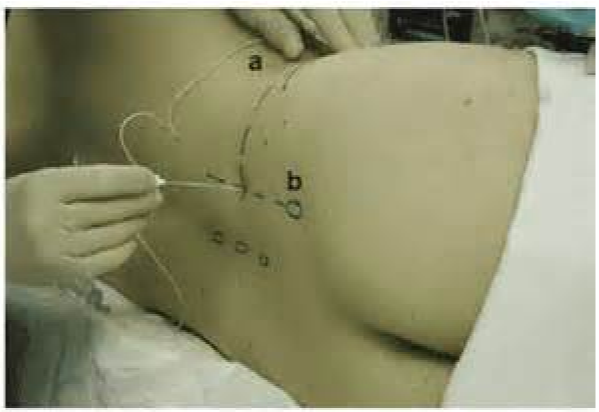
The lumbar plexus comprises 6 nerves that supply the lower extremity. When blocked at the level of the plexus, the majority of the front of the leg is covered including the anterolateral and medial thigh, knee, and the saphenous below the knee. Due to the placement of the needle in the deep muscle beds, the potential for systemic toxicity is greater than in many other blocks. In addition, the proximity of the lumbar nerve roots and epidural space carries a risk of epidural or spinal spread. The lumbar plexus block is most commonly used for hip arthroscopy, and other hip surgeries. See figure 16.

MEDICATIONS

Due to the increased vascularity surrounding the lumbar plexus, the duration of action of local anesthetics tends to be slightly less than for other lower extremity nerve blocks.

	Onset (min)	**Anesthesia (hrs)**	**Analgesia (hrs)**
1.5% Mepicacaine (+epi)	10-20	2-3	3-4
2% Lidocaine (+epi)	10-15	2-3	3-4
0.5% Ropivacaine	15-25	3-5	8-12
0.5% Bupivacaine (+epi)	15-25	4-6	12-18

Figure 16



3 Lumbar plexus block. **a** Tuffier's line, **b** posterior superior iliac spine. The distance from the midline is 4–6 cm.

FEMORAL

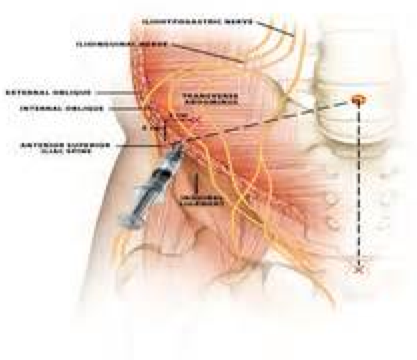
The femoral nerve is the largest branch of the lumbar plexus. A femoral block results in anesthesia of the entire anterior thigh and most of the femur and knee joint. It also blocks part of the hip joint. It is used for surgeries on the anterior thigh, knee, quadriceps tendon repair, and for postoperative pain management after femur and knee surgery, or hip fractures. A femoral nerve block will cover the front of the knee, but provides no coverage to the back of the knee. See Figure 17.

MEDICATIONS

	Onset (min)	Anesthesia (hrs)	Analgesia (hrs)
1.5% Mepivacaine	15-20	2-3	3-5
1.5% Mepivacaine (+epi)	15-20	2-5	3-8
2.0% Lidocaine (+epi)	10-20	2-5	3-8
0.5% Ropivacaine	15-30	4-8	5-12
0.5% Bupivacaine	15-30	5-15	6-30

Femoral nerve block can last for a significant period of time; therefore it is very important to consider what medication is being used. The major side-effect noted is quadriceps weakness.

Figure 17



SCIATIC

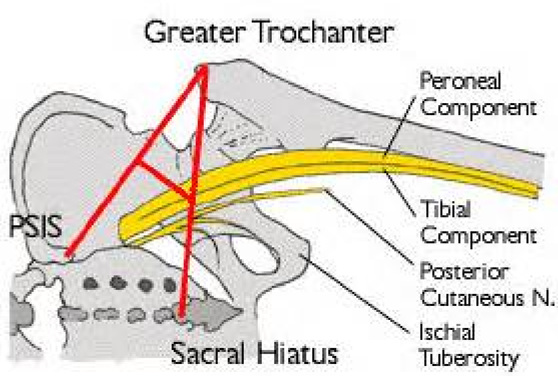
The sciatic nerve supplies motor and sensory innervations to the posterior aspect of the thigh as well as the entire lower leg, except for the medial leg, which is supplied by the saphenous nerve. The sciatic nerve is the largest nerve in the body. Because the sciatic nerve is so large, it can be blocked from several different locations along the lower extremity. The most common approaches are the popliteal and subgluteal. See Figure 18.

MEDICATION

A fairly small amount of local anesthetic is needed for a sciatic nerve block. The duration of a sciatic blockade is longer than for any other nerve block.

	Onset (min)	Anesthesia (hrs)	Analgesia (hrs)
1.5% Mepivacaine (+HCO3)	10-15	4-5	5-8
2.0% Lidocaine (+HCO3)	10-20	5-6	5-8
0.5% Ropivacaine	15-20	6-12	6-24
0.5% Bupivacaine (or l-bupivacaine)	15-30	8-16	10-48

Figure 18



ULTRASOUND -GUIDED NERVE BLOCKS

Most nerve blocks today are done with the help of an ultrasound and are called ultrasound-guided nerve blocks. Using an ultrasound allows for noninvasive visualization of tissue structures. Ultrasound scanning is an interactive procedure involving the operator, assistant (to push medication), patient, and ultrasound instruments. Ultrasound is high-frequency sound and refers to mechanical vibrations above 20 kHz. Human ears can hear sound frequencies between 20 Hz and 20 kHz.

As the ultrasound wave travels through tissue, it is subject to a number of interactions. The most important are as follows:

- Reflection
- Scatter
- Absorption

When an ultrasound wave encounters boundaries between different media, part of the ultrasound is reflected and other part is transmitted. The reflected and transmitted directions are give =n by the reflection angle and transmission angle.

During ultrasound scanning, a coupling medium must be used between the transducer and the skin to displace air from the transducer-skin interface. A variety of gels and oils are applied for this purpose. They also act as lubricants providing a smooth surface.

Ultrasound machines convert the echoes received by the transducer into visible dots, which from the anatomic image on the ultrasound screen. The brightness of each dot corresponds to the echo strength, producing an image.

Optimizing an image produced by ultrasound is an essential skill for performance of an ultrasound-guided nerve block. Anatomically, peripheral nerves are often located in the vicinity of an artery or between muscle layers. The echo texture of normal peripheral nerves can have a hyperechoic, hypoechoic, or honeycomb pattern.

Five function keys on an ultrasound machine are of crucial importance to achieve an optimal image during the performance of peripheral nerve imaging.

1. Depth: The depth of the nerve is the first consideration when ultrasound-guided nerve block is performed. The depth at which peripheral nerves are positioned and therefore imaged greatly varied and also depends on a patient's habitus. An optimal depth setting is important for proper focusing properties during imaging.
2. Frequency. The ultrasound transducer with the optimal frequency range should be selected to best visualize the target nerves. Ultrasound energy is absorbed gradually by the transmitted tissue; the higher the frequency of

ultrasound, the more rapid the absorption, and the less distance propagation.

3. Focusing. Lateral resolution can be improved by choosing the higher frequency as well as by focusing the ultrasound beam.
4. Gain. Screen brightness can be adjusted manually by two function buttons: gain and time-gain compensation. Excessive or inadequate gain can cause both a blurring of tissue boundaries and a loss of information.
5. Doppler. Doppler is used to detect vascular structures or the location of the spread of the local injection.
6. Two needle insertion techniques with relevance to the needle-transducer relationship are commonly used in ultrasound-guided nerve block: the in-plane and out-of-plane techniques. In-plane technique means the needle is placed in the plane of ultrasound beam; as a result, the needle shaft and the tip can be observed in the longitudinal view real time as the needle is advanced toward the target nerve. When the needle is not visualized on the image, the needle advancement should be stopped. Tilting or rotating the transducer can bring the ultrasound beam into alignment with the needle and help with its visualization. Additionally, a subtle, fast needle shake and or injection of small amount of injectate may help depict the needle location. The out-of-plane technique involves needle insertion perpendicularly to the transducer. The needle shaft is imaged in a cross-section plane and can be identified as a bright dot in the image. Visualization of the tip of the needle, however, is difficult and unreliable. The method used to visualize the tip of the needle is as follows: Once a bright dot (shaft) is seen on the image, the needle can be shaken slightly and/or transducer can be tilted toward the direction of needle insertion simultaneously until the dot disappears. Shaking the needle helps differentiate the echo as emanating from the needle or from the surrounding tissue. The last capture of the hyperechoic dot is in its tip. A small amount of injectate can be used to confirm the location of the needle. Whenever injectate is used to visualize the needle tip, attention must be paid to avoid resistance (pressure).

What procedures are done using ultrasound-guided techniques?

When talking about ultrasound-guided techniques, there are many procedures that this may include.

Upper Extremity

- Superficial cervical plexus block
- Interscalene brachial plexus block
- Supraclavicular brachial plexus block
- Infraclavicular brachial plexus block
- Axillary brachial plexus
- Forearm blocks
- Wrist blocks

Lower Extremity

- Femoral nerve block
- Fascia iliaca block
- Obturator nerve block
- Saphenous nerve block
- Adductor canal block
- Sciatic nerve block: Anterior/Transgluteal/Subgluteal approach
- Popliteal sciatic nerve block
- Ankle block

What is an ultrasound-guided femoral nerve block?

An ultrasound-guided femoral nerve block is when an ultrasound is used to provide anesthesia for the entire anterior thigh, knee and the femur. See figure 19.

Figure 19: Transducer position and needle insertion using an in-plane technique to block the femoral nerve at the femoral crease.

The ultrasound –guided technique of femoral nerve blockade differs from nerve stimulator or landmark-based techniques in several important aspects. Ultrasound application allows the practitioner to monitor the spread of local anesthetic and needle placement and make appropriate adjustments, should the initial spread be deemed inadequate. Also, because of the proximity to the relatively large femoral artery, ultrasound may reduce the risk of arterial puncture that often occurs with this block with the use of non-ultrasound techniques. Palpating the femoral pulse as a landmark for the block is not required with ultrasound guidance, a process that can be challenging in obese patients. Although the ability to visualize the needle and the relevant anatomy with ultrasound guidance renders nerve stimulation optional, motor response obtained during nerve stimulation often provides contributory information.

Orientation begins with the identification of the pulsating femoral artery at the level of the inguinal crease. If it is not immediately recognized, sliding the transducer medially and laterally will bring the vessel into view eventually. Immediately lateral to the vessel, and deep to the fascia iliaca is the femoral nerve, which is typically hyperechoic and roughly triangular or oval in shape. The nerve is positioned in a sulcus in the iliopsoas muscle underneath the fascia iliaca. Other structures that can be visualized are the femoral vein (medial to the artery) and occasionally the fascia lata (superficial in the subcutaneous layer). The femoral nerve typically is visualized at a depth of 2-4 cm.

Femoral nerve block results in anesthesia of the anterior and medial thigh down to the knee (the knee included), as well as a variable strip of skin on the medial leg and foot. It also contributes branches to the articular fibers to both the hip and knee. Obesity is a common problem in patients who present with an indication for femoral nerve block. Taping the adipose tissue away helps optimize the exposure to the femoral crease in patients with morbid obesity. Exposing the inguinal region in a patient with a large abdominal pannus can be challenging. Using a wide silk tape to retract the abdomen is a useful maneuver prior to skin preparation and scanning.

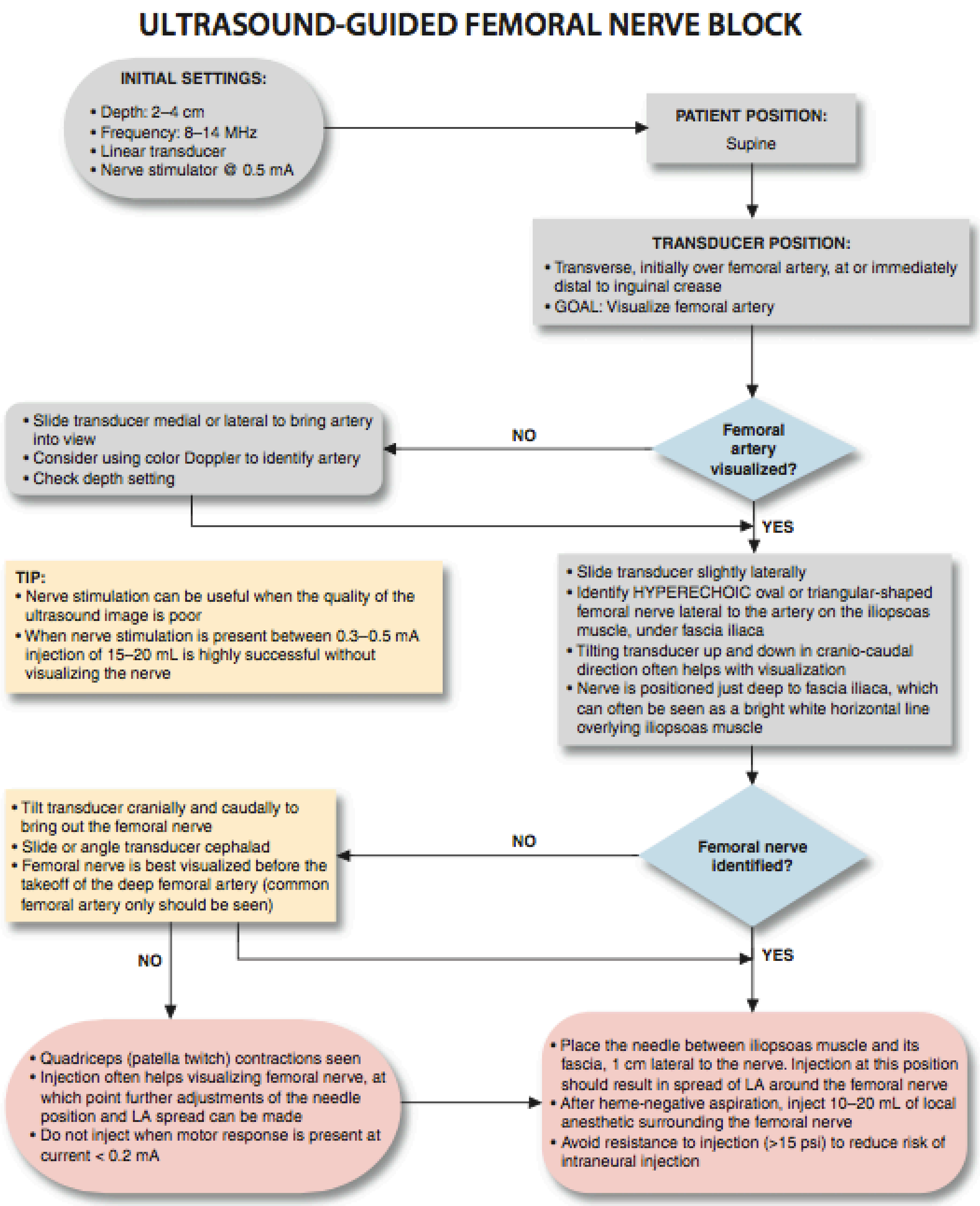
What equipment is needed for the ultrasound-guided femoral nerve block?

- Ultrasound machine with linear transducer (8-14 MHz), sterile sleeve, and gel
- Standard nerve block tray
- One 20-mL syringe containing local anesthetic
- A 50 – to 100 – mm, 22-guage short bevel insulated stimulating needle
- Peripheral nerve stimulator
- Sterile gloves

This block is typically performed with the patient in the supine position, with the bed or table flattened to maximize operator access to the inguinal area. Although palpation of the femoral pulse is a useful landmark, it is not required because the artery should be readily visualized by placing the transducer transversely on the inguinal crease followed by slow movement laterally or medially. If nerve stimulation is used simultaneously, exposure of the thigh and patella are required to monitor the appropriate motor responses (patella twitch).

The **goal** is to place the needle tip immediately adjacent to the lateral aspect of the femoral nerve, either below the fascia iliaca or between the two layers of the fascia iliaca, into the wedge-shaped tissue space lateral to the femoral artery. Proper deposition of local anesthetic is confirmed by observation of the femoral nerve being lifted off of the surface of the iliopsoas muscle or of the spread of the local anesthetic above in the wedge-shaped space to the artery.

Figure 20


ULTRASOUND-GUIDED FEMORAL NERVE BLOCK
INITIAL SETTINGS:
• Depth: 2–4 cm
• Frequency: 8–14 MHz
• Linear transducer
• Nerve stimulator @ 0.5 mA
PATIENT POSITION:
Supine
TRANSDUCER POSITION:
• Transverse, initially over femoral artery, at or immediately distal to inguinal crease
• GOAL: Visualize femoral artery
Femoral artery visualized?
NO
• Slide transducer medial or lateral to bring artery into view
• Consider using color Doppler to identify artery
• Check depth setting
YES
TIP:
• Nerve stimulation can be useful when the quality of the ultrasound image is poor
• When nerve stimulation is present between 0.3–0.5 mA injection of 15–20 mL is highly successful without visualizing the nerve
• Slide transducer slightly laterally
• Identify HYPERECHOIC oval or triangular-shaped femoral nerve lateral to the artery on the iliopsoas muscle, under fascia iliaca
• Tilting transducer up and down in cranio-caudal direction often helps with visualization
• Nerve is positioned just deep to fascia iliaca, which can often be seen as a bright white horizontal line overlying iliopsoas muscle
Femoral nerve identified?
NO
• Tilt transducer cranially and caudally to bring out the femoral nerve
• Slide or angle transducer cephalad
• Femoral nerve is best visualized before the takeoff of the deep femoral artery (common femoral artery only should be seen)
YES
NO
• Quadriceps (patella twitch) contractions seen
• Injection often helps visualizing femoral nerve, at which point further adjustments of the needle position and LA spread can be made
• Do not inject when motor response is present at current < 0.2 mA
• Place the needle between iliopsoas muscle and its fascia, 1 cm lateral to the nerve. Injection at this position should result in spread of LA around the femoral nerve
• After heme-negative aspiration, inject 10–20 mL of local anesthetic surrounding the femoral nerve
• Avoid resistance to injection (>15 psi) to reduce risk of intraneural injection

With the patient in the supine position, the skin over the femoral crease is disinfected and the transducer is positioned to identify the femoral artery and/or nerve. If the nerve is not immediately apparent lateral to the artery, tilting the transducer proximally or distally often helps to image and highlight the nerve from the rest of the iliopsoas muscle and the more superficial adipose tissue. In doing so, an effort should be made to identify the iliopsoas muscle and its fascia as well as the fascia lata because injection underneath a wrong fascial sheath may not result in spread of the local anesthetic in the desired plane. Once the femoral nerve is identified, a skin wheal of local anesthetic is made on the lateral aspect of the thigh 1 cm away from the lateral edge of the transducer. The needle is inserted in-plane in a lateral-to-medial orientation and advanced toward the femoral nerve. If nerve stimulation is used, the passage of the needle through the fascia iliaca and contact of the needle tip with the femoral nerve usually is associated with a motor response of the quadriceps muscle group. In addition, a needle passage through the fascia iliaca is often felt as a “pop” sensation. Once the needle tip is witnesses adjacent (either above, below, or lateral) to the nerve, and after careful aspiration, 1 to 2 mL of local anesthetic is injected to confirm the proper needle placement. When injection of the local anesthetic does not appear to result in a spread close to the femoral nerve, additional needle repositions and injections may be necessary. In an adult patient, 10 to 20 mL of local anesthetic is adequate for a successful block.

The goal of the continuous femoral nerve block is similar to that of the non-ultrasound-based techniques: placement of the catheter in the vicinity of the femoral nerve just deep to the fascia iliaca. The procedure consists of three phases: needle placement, catheter advancement, and securing the catheter. For the first two phases of the procedure, ultrasound can be used to ensure accuracy in most patients. The needle typically is inserted in-plane from the lateral-to-medial direction and underneath the nerve. Some clinicians prefer inserting the catheter in the longitudinal plane (inferior-to-superior), analogous to the nerve stimulation-guided technique. No data exist on whether or not one technique is superior to the other.

The needle is advanced until the tip is adjacent to the nerve. Proper placement of the needle can be confirmed by obtaining a motor response of the quadriceps/patella, at which point 5 mL of local anesthetic is injected. This small dose of local anesthetic serves to ensure adequate distribution of the local anesthetic, as well as to make the advancement of the catheter easier. This first phase of the procedure does not significantly differ from the single-injection technique. The second phase of the procedure involves maintaining the needle in the proper position and inserting the catheter 2 to 4 cm into the space surrounding the femoral nerve. Insertion of the catheter can be accomplished by either a single operator or with a helper. Catheter position is observed on ultrasound as the catheter is being inserted and/or with an injection through the catheter to document its proper location.

The catheter is secured by either taping it to the skin or tunneling. Preference of one technique over the other varies among clinicians, although no data exist on which one is a more secure method. The decision regarding which method to use could be based on the patient's age (no tunneling for younger patients: less mobile skin, avoidance of post tunneling scar formation), duration of the catheter therapy, and anatomy. In general, the inguinal area is quite mobile and the femoral nerve is not particularly deep, two factors that predispose to catheter dislodgement.

There are many types of regional anesthesia where medication is injected near a cluster of nerves to numb only the area of body that is chosen. Frequently, there is less nausea from regional blocks and patients generally awaken faster after regional blocks than a general anesthetic. Regional blocks can also be used to reduce the pain after surgery. Patients will have minimal or no sensation to the blocked area. It is vital for us as healthcare providers to understand regional blocks so that we can protect the affected area from harm, thus, protecting the patient.

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