The blocking of the posterior tibial, sural, saphenous, superficial peroneal, and the deep peroneal nerves with possible alternative approaches is discussed. Digital blocks, Mayo blocks, and intravenous regional anesthesia are also discussed. The placement of the tourniquet above the ankle but below the calf muscles will avoid deep muscle pain. Lidocaine and bupivacaine cause vasodilatation in the foot.

Key words: Intravenous regional anesthesia; Mayo block; regional anesthesia, foot.

This article focuses on blocks that can be used for emergency room repair of trauma of the foot or for operations on the foot. Peripheral nerve block anesthesia can be gratifying to the patient, because intraoperatively, the patient can maintain control, thereby avoiding the complications of general anesthesia and major conduction anesthesia, and postoperatively, the patient can have continuing pain relief with the possible benefit of early discharge. The blocks discussed are the individual nerve blocks at the ankle, digital block, Mayo block, and intravenous regional anesthesia.

The practice of using nerve paresthesias to assure proximity to a nerve is probably best avoided in the foot because of the risk of permanent nerve injury. If a paresthesia occurs during needle placement, withdraw the needle 2 mm before injecting to avoid intraneural placement of the drug. With the exception of the posterior tibial nerve and possibly the deep peroneal nerve, the nerves at the ankle are superficial and the infiltration needs to be just below the skin. If the skin is somewhat elevated by the injected solution, then it is most likely in the correct plane. Because the anesthetic agent is being placed in the area of the nerve, not right on the nerve or within a neural sheath, there is some delay in onset of anesthesia. A "tincture of time" is necessary to allow sufficient anesthetic agent to diffuse from the surrounding tissue into the nerve. The surrounding fat and other tissues tend to absorb the anesthetic agent, thereby decreasing the total amount of drug available to the nerve. This absorption necessitates the time allowance to facilitate the buildup of anesthetic concentration within the nerve tissue. Local anesthetics act upon nerves in the following order: pain, temperature, touch, and proprioception. Therefore, a patient can have complete anesthesia and still have some sensation of touch or pressure within the foot.

The use of 27- to 30-gauge needles and the slower injection speed caused by this needle size will help to decrease the patient's discomfort during insertion of the needle and during injection. A 1-inch needle is of sufficient length to do all five blocks at the ankle. A 1½-in needle will be needed for the Mayo block.

The various anesthetic solutions are sold by the manufacturers with a pH of 4.5 to 6.5 to prolong their shelf life, but this pH can cause discomfort when injected. Carbonation will bring the pH of the solution closer to the body's pH of 7.0 to 7.4, possibly lessening discomfort during injection. The pH change will also change the percentage of charged versus uncharged drug within the solution. The uncharged portion of the drug is important for diffusion through the nerve membrane, while the charged or ionized form blocks passage of the sodium ion through the sodium channel by
binding to the receptor proteins. The two local anesthetic drugs most frequently used for blocks in the foot are lidocaine and bupivacaine. The inherent potency, rapid onset, and moderate duration of action of lidocaine make it the most commonly used anesthetic agent in the United States. Bupivacaine is two to three times more toxic than lidocaine, but it has three times or greater the duration of lidocaine when used for peripheral nerve blockade. With an onset time of 10 to 20 minutes and a duration of approximately 400 minutes, bupivacaine will give the anesthetic duration needed for most surgical procedures. The range of duration for bupivacaine is such that it is not uncommon for the analgesia to last up to 24 hours.

One school of thought states patients with lower-extremity ischemia or diabetic foot disorders should not have medication injected into the foot. The fears are that infection might be spread or tissue necrosis may be precipitated. In a 127-procedure study looking expressly at this school of thought, it was observed that no complications were directly related to the use of local anesthesia.

**Individual nerve blocks at the ankle**

Sensory innervation of the foot depends on the following five nerves: posterior tibial (PT), sural (SU), saphenous (SA), superficial peroneal (SP), and the deep peroneal (DP). There is enough variation between patients in the sensory innervation patterns that it is beneficial to block the adjoining nerve or do local infiltration. If the area to be operated on is not obviously within a specific cutaneous sensory innervation, the blocks of the adjoining nerve should be done.

- **Posterior tibial.** The PT nerve is the largest branch of the sciatic nerve. It reaches the distal leg on the medial side of the Achilles tendon, where it lies just posterior to the posterior tibial artery. The PT nerve supplies the majority of the plantar surface of the foot and the tips of the toes via the medial and lateral plantar nerves (Figure 1). Therefore, any procedure involving the sole of the foot or the tips of the toes necessitates a PT nerve block.

  The PT nerve can easily be blocked with the patient in the supine or prone position. In the prone position, a roll or pillow is placed under the anterior ankle causing flexion of the knee and neutral positioning of the ankle and foot. In the emergency room, the patient with trauma to the sole of the foot is frequently lying prone. Having the patient slide down the stretcher until the foot is off the mattress will correctly position the patient for PT and SU nerve blocks. If the posterior tibial artery is not palpable, the needle insertion is to the medial side of the Achilles tendon, level with the lower border of the medial malleolus. The needle insertion is just lateral to the artery when it is palpable (Figure 2).

  With the patient in the supine position, all five nerves can be blocked. In the supine position, the knee is bent and the foot is rolled outward. The medial surface of the ankle between the medial malleolus and the Achilles tendon is palpated for the posterior tibial artery. The needle insertion site is approximately two finger breadths posterior to the medial malleolus and 1 to 1.5 cm anterior to the Achilles tendon. In practice, if the artery cannot be palpated, the point of injection is halfway between the medial malleolus and the tip of the calcaneus. The PT nerve can occasionally be palpated subcutaneously by rolling it gently at the level of the medial malleolus. This palpation is useful when the tibial artery cannot be found because of edema, obesity, or vascular insufficiency. If no paresthesia occurs, then 3 to 12 mL of the agent may be used as the local agent is fanned within the area. A third method of blocking the PT nerve when the artery cannot be palpated is to slide a finger perpendicularly down from the midpoint of the medial malleolus toward the sole of the heel until a bony ridge is found. The needle is inserted immediately posterior and inferior to this...
ridge until periosteum is felt, and then is withdrawn 2 mm before injection. If the artery is palpable, then maintain pressure on the artery with the nondominant hand while inserting the needle just posterior to the finger placed over the artery (Figure 3). If a paresthesia is elicited, 1 to 3 mL of agent is injected after a 1 to 3 mm withdrawal. Needle insertion is at right angles to the posterior aspect of the tibia, just posterior to the artery.5

- **Sural nerve.** The SU nerve is a combination of a branch from the tibial nerve and a branch from the common peroneal nerve and is purely sensory. It proceeds subcutaneously with the short saphenous vein behind and below the lateral malleolus. The SU and PT nerves follow a basically common pathway down the posterior calf, except that the PT nerve lies beneath the Achilles tendon. The SU nerve supplies the lateral side of the foot and lateral side of the fifth toe. One of the variations in innervation includes the SU nerve supplying the dorsal surface of the fifth toe and the dorsal lateral portion of the fourth toe (as shown in Figure 1). In another variation, the entire plantar surface of the heel is supplied by the SU nerve.6 These variations reinforce the need for blocking nerves adjacent to the proposed area of involvement.

If the patient is in the prone position, the SU nerve block is done at the same time as the block of the PT nerve (Figure 2). Insert the block needle lateral to the Achilles tendon symmetrically with the needle used to block the PT nerve. A fanning motion at the needle tip within the subcutaneous tissue will assure placement of the anesthetic drug near the SU nerve.7 Infiltration is 3 to 4 cm proximal to the ankle joint,3 with a maximum of 5 mL of anesthetic agent.8

If the patient is in the supine position with the foot in a neutral or slightly toe-in position, the needle is inserted just superior or just inferior to the lateral malleolus8 and advanced subcutaneously toward the Achilles tendon (Figure 4). With a 1-inch needle, infiltration will stop short of the Achilles tendon. An SU nerve branch to the posteriolateral Achilles tendon, which originates in this area, may or may not be blocked depending on its point of origin and the area where the block was placed.1

- **Saphenous nerve.** The SA nerve, the terminal sensory branch of the femoral nerve,3 is the only branch of the femoral nerve below the knee.2 It runs subcutaneously from the lateral side of the knee with the saphenous vein to the medial malleolus9 and supplies from the medial malleolus9 to as far as the metatarsophalangeal joint8 (see Figure 1). This innervation makes it one of the main nerves to block for bunionectomies of the medial foot.

The SA nerve is blocked with the patient in a supine position. The needle insertion point is subcutaneous, between the medial malleolus and the
hallucis longus tendon (Figure 5). Three to 5 mL of anesthetic agent is infiltrated subcutaneously around the great saphenous vein. Because of the proximity to the great saphenous vein, it is especially important to aspirate while blocking this nerve.

- **Superficial peroneal nerve.** The SP nerve runs subcutaneously down the anterior aspect of the distal two thirds of the leg to supply the dorsum of the foot and toes. The top of the foot, the areas of the web between the second and fifth digits, and the contiguous surfaces of the great and second toe are innervated by the SP nerve. In some cases, the entire fifth toe and the lateral aspect of the fourth toe are innervated by the SU nerve. This variation is shown in Figure 1. The superficial peroneal nerve is blocked subcutaneously immediately above and lateral to the lateral malleolus. A subcutaneous wheal, using 0.7 to 2 mL of local agent, is raised midway between the anterior tibial surface and the lateral malleolus (Figure 5).

- **Deep peroneal nerve.** The DP nerve travels down the anterior aspect of the interosseus membrane between the anterior tibial muscle and the extensor hallucis longus muscle. The anterior tibial artery and the DP nerve cross under the extensor hallucis longus tendon from the medial side to the lateral side at the level of the medial malleolus and continue between the malleoli into the dorsum of the foot. When the DP nerve reaches the ankle, it lies lateral and deep to the extensor hallucis longus tendon with the anterior tibial artery. Thus, if the acronym HAND is used from medial to lateral for hallucis longus, artery, nerve, and digitorum longus, it will facilitate remembering that the nerve lies on the lateral side of the artery after the nerve and artery cross under the hallucis longus. The nerve innervates the extensor digitorum brevis muscle of the toes and the adjacent skin surfaces of the first and second toe’s web space.

The block is accomplished by a perpendicular insertion of the needle lateral to the pulse of the anterior tibial artery and just medial to the digitorum longus tendon. The needle is advanced perpendicular until paresthesia occurs or the tibia is reached (Figure 5). Either way, the needle is retracted 1 mm and injection of 1 to 3 mL of the agent is initiated while the needle is retracted to the skin. A subcutaneous injection will frequently block this nerve, but if the nerve is still deep, a perpendicular injection from just above the periosteum to the skin will place the agent closer to the nerve.

A complete ankle block can be done with a single 10 mL syringe of the anesthetic agent and a 1-inch, 25-gauge, or smaller, needle after the first few patients. The volumes recommended in the previous paragraph can be reduced as experience imparts confidence to the anesthesia provider.
Digital blocks

For digital blocks, the needle is inserted twice on the dorsum of the foot, once on each side of the digit in question. This can be done in the distal third of the foot or into the web space of the digit to be blocked (Figure 6). The needle is advanced until it or the pressure it produces can just be felt by a finger on the plantar surface. Do not pierce the plantar surface. Approximately 0.5 to 1 mL of the anesthetic agent is deposited. Then the same amount or slightly less is deposited between the lateral aspect of the bone and the dorsal skin surface. The reason more anesthetic is deposited in the plantar area is that the larger plantar nerves supply a greater portion of the nerve distribution. One to 1.5 mL per side of the digit is sufficient. Use of excessive amounts has resulted in the creation of a fluid tourniquet of the digit. The use of digital blocks can be avoided by using a more proximal nerve block in the elderly or those with extensive injuries or with peripheral vascular disease.

Achilles tendon block

The Achilles tendon block is used for partial avulsions of the Achilles tendon and for operations on the posterior calcaneus bone. If a block of the Achilles tendon is needed, the anesthetic is administered circumferentially about the tendon. The agent is placed subcutaneously and deep into the retrocalcaneal space and proximally at the musculotendinous junction.

Mayo block

The Mayo block starts with needle insertions and injections the same as those for a block at the distal intermetatarsal space between the first and second metatarsals (Figure 6), then redirection of the needle into the subcutaneous plane. Next, inject from the medial aspect of the foot along the plantar surface the entire length of a 1 1/2-inch needle. There seems to be less need for intraoperative augmentation if the plantar surface blanches with injection. If blanching is not noted, there is the possibility that the drug is being placed too deep. This subcutaneous wheal covering one half of the circumference of the foot will block the plantar digital nerves and the superficial nerves. The DP nerve has not been anesthetized yet and needs to be blocked. The DP nerve can be blocked by injection at its site of innervation with a V-shaped pattern or pattern of injection medial to the first and second toe interspace. For the lateral side of the foot, the initial injection will be between the fourth and fifth metatarsals.

The Mayo block uses less injectant than if the field were to be infiltrated directly. This block can be used for hallux valgus correction or nail extraction.

Intravenous regional anesthesia

Since intravenous regional anesthesia (IVRA) was originally demonstrated by Bier in 1908, use in the leg and foot has not been as widely accepted as use in the upper extremity. The reasons for this could include fewer accessible veins in comparison with the arm, tourniquet pain when the tourniquet is placed at the thigh or calf level, uncertainty as to placement of the tourniquet, and possible toxic levels of anesthetics due to the higher volume needed for the lower extremity. Davies and Walford showed in 1986 that the ankle tourniquet was safe and allowed adequate compression of the tissue and vessels. Of the patients in a small study, 97% experienced no ischemic tourniquet pain during procedures lasting up to 95 minutes using single-barrel tourniquets placed just superior to the ankle.

The procedure for IVRA of the foot consists of placement of the intravenous access, placement of
the tourniquet above the ankle but below the calf muscles and over cast padding, and exsanguination via Eschmarch or elevation of the foot for more than 3 minutes. The tourniquet is usually inflated to a pressure of 100 mm above the systolic arterial pressure. One author routinely used 325 to 350 mmHg of pressure. After inflation of the tourniquet, 30 to 35 ml of anesthetic agent is injected through the venous access. While this small amount will not be sufficient for a lower extremity, it is sufficient to fill the foot when an ankle tourniquet is used.

One of the major negative factors of IVRA of the leg is the significantly greater ischemic tourniquet pain experienced by patients with thigh or calf tourniquets. This pain is not uncommon even in patients under spinal anesthesia with thigh tourniquets. The ischemic large muscle mass directly beneath the proximal thigh tourniquet is the cause of the pain. This can be negated by placing the tourniquet just superior to the ankle while staying distal to the calf muscles. Chu et al. showed that ankle tourniquets caused the expected temporary ischemic changes in four of the ankle nerves studied, but these changes were reversible with the resumption of normal blood flow.

A possible reason for the lack of vascular complications after injection of local anesthetic agents is that plain lidocaine resulted in vasodilation that lasts 1 to 2 hours with a return to baseline within 5 hours. Lidocaine with epinephrine shows initial vasoconstriction lasting less than 1 hour. This vasoconstriction is followed by a reactive hyperemia after the first hour. Plain bupivacaine shows a vasodilation that does not reach maximum until 3 to 5 hours after injection. The reason for this vasodilation is unknown, but it is postulated that periarterial blocks inhibit adrenergic impulses. This would result in a local sympathectomy.

Light-sensitive plethysmography shows that the addition of epinephrine causes a 50% decrease in blood flow for lidocaine and a 25% decrease for bupivacaine. The tissue vasoconstriction does not reach the ischemic levels routinely seen with a tourniquet unless an epinephrine concentration of greater than 1:200,000 is used or if a fluid tourniquet has been accidentally produced.

Some authors suggest that epinephrine not be used during ankle block, especially if the block is circumferential. The ankle block can be done as a circumferential subcutaneous block, excluding the Achilles tendon, but if it is done to block individual nerves, there are five areas without local infiltration, which will allow normal blood flow to proceed distally.

Conclusion

These blocks allow the patient to be discharged much more rapidly than if general or central neural blockade anesthesia had been used. The use of tourniquets distal to the calf muscles dramatically reduces the ischemic pain associated with tourniquets placed midcalf or on the calf muscles. The mixture of lidocaine and bupivacaine give the duration necessary for sufficient postoperative analgesia with an onset rapid enough to please the operative team. Twenty milliliters of injectant will be enough for the individual nerve blocks and a Mayo block once experience has been gained.

REFERENCES


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